

ROYAL MELBOURNE INSTITUTE OF TECHNOLOGY

FACULTY OF ENVIRONMENTAL DESIGN & CONSTRUCTION

DEPARTMENT OF BUILDING AND CONSTRUCTION ECONOMICS

*AN INVESTIGATION INTO FACTORS THAT DETERMINE BUILDING  
CONSTRUCTION TIME PERFORMANCE*

Thesis submitted for the Degree of Doctor of Philosophy

By

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## SUMMARY

This research explores the reasons why some buildings are constructed more quickly than others. Critical risk factors affecting project complexity and responses from construction managers to these risks are identified and tested. Construction time performance indicators are offered and 33 case studies of projects are analysed against identified benchmark criteria.

Project complexity factors and managerial responses to these factors are also examined in-depth. The work draws upon the literature pioneered by others both in Australia and overseas. Much of the previous research into this topic was undertaken during the late 1970's and early 1980's though reference is made to more current case history data drawn from reports undertaken in the UK and Australia (part of the Royal Commission into Productivity in the Building Industry in New South Wales in 1992, as well as a pilot study of 100 Australian building projects undertaken by Derek Walker in 1987).

The principal propositions investigated in this work is that *variance between actual performance to trend line performance can be substantially explained by managerial performance of the project team (more specifically the construction management team, client representative's team and to a more limited extent the communication effectiveness of the design teams). A limited number of factors outside the control of the construction management team (inherent site conditions, economic environmental complexity and project scope) also affects construction time performance.* The research indicated that CM team performance plays a pivotal role in determining CTP. The work also revealed an important relationship between sound CR management effectiveness and good CTP. Detailed findings provide useful performance indicators that may be used to assist in defining benchmark measures necessary to assess a project's performance relative to a representative population.

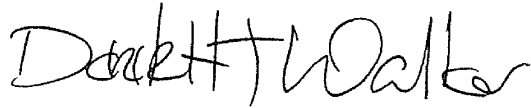
The objective of this work is to report upon the research undertaken as a contribution to the development of methodologies required to measure CTP and thus enable comparison of individual project performance against world best practice. Models are developed illustrating construction time performance of projects so that a better understanding of critical factors affecting construction time performance can be gained. The contribution that this work makes is that it assists in the development of measures that may be used for establishing best practice benchmark measures of construction time performance for use by builders and clients to improve construction time performance in the building industry.

**KEY WORDS:** *Construction Time Performance, Construction Management, Risk Analysis.*



## DECLARATION

I certify that this Doctor of Philosophy thesis contains no material which has been accepted for the award of any other degree or diploma in any institution, college or university, and that to the best of my knowledge and belief, it contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

A handwritten signature in black ink, reading "Derek H.T. Walker". The signature is written in a cursive style with a large, stylized 'D' and 'W'.

Derek H.T. Walker

## REFEREED PUBLICATIONS FLOWING FROM THE PILOT STUDY

Walker DHT (1990). '*Diversity in management structures on construction sites in Australia*', The Australian Institute of Building Papers, Volume 4, 3-22.

*Knowledge acquisition in the development of an expert system to determine the construction time of a project in Australia.* 1990, Expert Systems for Management and Engineering. Ed. E. Balagurusamy and J. Howe, Chapter 4, Ellis Horwood, London, 67-82.

## REFEREED PUBLICATIONS FLOWING FROM THE 33 CASE STUDY

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NOTE: In **Appendix 2** each sub-hypothesis is accompanied by a graph of CTP against the values of the variable concerned being tested.

## GENERAL NOTES AND TABLE OF ABBREVIATIONS AND SYMBOLS

### NOTE 1

A list of all variables used in this work can be found in Appendix 3, Data for hypothesis testing. Each variable in that appendix is cross referenced to the question generating the variable which is provided in Appendix 1, the questionnaire. Variables derived from others are clearly indicated in Appendix 3 (see Appendix 3 page 1 note 1 for details). Appendix 2 also contains an indication of each variable tested at the start of each sub-hypothesis tested by reference to the questionnaire question. In Appendix 2 page 11 for example reference to question Q1.7.1 is made next to the heading 'Sub-hypothesis Number 6'.

### NOTE 2

Construction time performance (CTP) is taken as meaning the ratio of predicted to actual construction time expressed as an index. Thus an index of less than one indicates that the project has a construction time performance lower than that trend for the representative sample, and an index greater than one indicates that the project's construction time performance higher than the sample.

The derivation of the index is explained in detail later.

## TABLE OF SYMBOLS

'+' - ordinal scale of significance of 1	SH+ - slightly high and higher
'++' - ordinal scale of significance of 2	VH - very high
'+++' - ordinal scale of significance of 3	
'++++' - ordinal scale of significance of 4	

est - estimated

exp - exponential

'p' - significance level measuring the confidence that a researcher has in results reported that can be associated with the variance in the other variable

$R^2$  - coefficient of determination i.e. the proportion of the variance in one variable that

$C_p$  - Pearson Product Moment Correlation

$C_s$  - Spearman Rank Correlation

sig - significance

DES - design

PROJ - project

AVG - average

AVG+ - average and better

HI - high

HI+ - high and better

SH - slightly high



## FREQUENTLY USED ABBREVIATIONS

ACS - Australian Construction Services	PRD - Royal Commission into Productivity
ACTU - Australian Council of Trade Unions	in the building industry in New South Wales
AIQS - Australian Institute of Quantity Surveyors	QC - quality circles
ANOVA - analysis of variance	QM - quality management
BCA - business council of Australia	UK - United Kingdom
BLF - Builders Labourers Federation	USA - United States of America
BRR - Building Regulatory Review	USSR - Union of Soviet Socialist Republics
CAD - computer aided drafting	VBIA - Victorian Building Agreement
CIDA - Construction Industry Development Association	VBIBD - Victorian Building Industry Dispute Board
CII - Construction Industry Institute	VTHC - Victorian Trades Hall Council
CM - construction management	
CPM - critical path method	
CR - client representative	
CTP - construction time performance	
DOL - Department of Labour	
DSS - decision support system	
EOT - extension of time	
GFA - gross floor area	
HRM - human resource management	
HSD - honest significance differences	
HY - hypothesis	
IR - industrial relations	
IT - information technologies	
KBES - knowledge based expert systems	
KEY S-C - key subcontractor	
LOB - line of balance	
LRA - linear responsibility analysis	
MCC - Melbourne city council	
MPU - major projects unit	
MVAV - Master Builders Association of Australia	
NEDO - National Economic Development Office	
NSW - New South Wales	
OHS - occupational health and safety	
PCG - project control group	

## TABLE OF VARIABLES

### PHDCHAR FILE (PROJECT CHARACTERISTICS)

1 *endval* - value of the project construction costs indexed from its construction mid-point to January 1990 Australian dollars using the AIQS cost index.

2 *wdact* - actual working days from project handover to practical completion using the ASC calendar of workdays which excludes weekends and agreed rostered days off.

3 *wdest* - estimated work days being the original working days at the time of tender.

4 *eotscope* - extension of time for approved scope changes in working days.

5 *eotweather* - extension of time for approved inclement weather delays in working days.

6 *eotir* - extension of time for approved IR dispute delays in working days.

7 *eotother* - extension of time for approved other delays in working days.

8 *eottotal* - sum of approved delays for eotscope, eotweather, eotir and eotother in working days.

9 *adjust* - adjusted estimate of construction time being the original estimated of construction time (*wdest*) + (*eottotal*) the sum of approved delays.

10 *gfa* - the project's gross floor area as measured by the AIQS definition measured in square metres.

11 *adjust\_act* - the ratio of the adjusted estimate (*adjust*) to actual construction time.

12 *eot\_act* - the ratio of total extensions of time (*eottotal*) to actual construction duration (*wdact*) and is zero for projects with no extensions of time.

13 *q3\_1* - general complexity impact of inherent site conditions.

14 *q4\_1* - general complexity impact of design buildability.

15 *q5\_1* - general complexity impact of design coordination.

16 *q6\_1* - general complexity impact of quality management procedures.

17 *q7\_1* - general complexity impact of quality site access to or within site.

18 *q7\_3* - overall complexity impact of project characteristics.

19 *q8\_1* - general complexity impact of the physical environment.

20 *q9\_1* - general complexity impact of the economic environment.

21 *q10\_1* - general complexity impact of the socio-political environment.

22 *q11\_1* - general complexity impact of the industrial relations environment.

23 *q11\_3* - general complexity impact of environmental characteristics.

24 *wdactvarnc* - variance in working day between actual time and predicted construction time, a negative answer implies a project performing below trend for the sample.

25 *wdpred\_act* - ratio of predicted to actual construction time. This is the construction time performance (CPD) index value for each project relative to the sample.

26 *phdchaflag* - flag variable for CTP index value range values - where [1] < 0.6; [2] 0.6 to 0.849; [3] 0.85 to 0.949; [4] 0.95 to 1.049; [5] 1.05 to 1.149; [6] 1.15 to 1.39; [7] 1.40 and greater.

27 *verntime* - number of workdays predicted using the data and Ireland's model (see chapter 2 section 2.8.2).

28 *bromtime* - number of workdays predicted using the data and Bromilow's model (see chapter 2 section 2.8.3).

29 *Valjun87* - indexed conversion of endval to June 1987 dollars using the AIQS construction cost index.

30 *floor\_bsmt* - number of floors below ground level.

31 *floor\_max* - maximum number of floors above ground.

32 *pred\_tm\_c1* - predicted time in working days for log end\_val based on the CTP prediction model (see page 33 for the predicted time formula).

33 *pred\_tm\_c2* - predicted time in working days for eot\_act based on the CTP prediction model (see page 33 for the predicted time formula).

34 *pred\_tm\_c3* - coefficient value for work\_type = 'fit' based on the construction time

prediction model if the work type is 'fitout' then value = 1 else = 0 (see page 33 for the predicted time formula).

35 *pred\_tm\_c4* - coefficient value for obj\_qual based on the construction time prediction model (see page 33 for the predicted time formula).

36 *pred\_tm\_c5* - coefficient value for cr\_people based on the construction time prediction model (see page 33 for the predicted time formula).

37 *pred\_tm\_c6* - coefficient value for cm\_des\_com based on the construction time prediction model (see page 33 for the predicted time formula).

38 *pred\_tm\_c7* - coefficient value for cm\_IT\_use based on the construction time prediction model (see page 33 for the predicted time formula).

39 *pred\_c2\_7* - total coefficient value for calculating the exponential value to be used in determining the predicted construction time based on the construction time prediction model (see page 33 for the predicted time formula).

40 *pred\_time* - the predicted construction time in working days based on the construction time prediction model (see page 33 for the predicted time formula).

41 *bldgtypnum* - building end-use where - [1] education, [2] office, [3] retail, [4] hospital, [5] industrial, [6] hotel, [7] transport, [8] entertainment.

42 *worktypnum* - type of construction work undertaken where - [1] fit-out work, [2] new work, [3] refurbishment, [4] mixture of 1-3.

43 *contypenum* - contract procurement method where - [1] traditional contract, [2] construction management, [3] project and construction management, [4] design and construct

44 *desdegnum* - stage of design development at construction start where - [1] some (under 25%), little (25% to 50%), [2] much (50% to 75%), [3] most (more than 75%), [4] re-designed.

45 *clientnum* - client type where - [1] private, [2] government, [3] private consultant (acting on behalf of a government department).

46 *cltsizenum* - client company size where - [1] small, [2] medium, [3] large.

47 *pred\_area* - predicted construction duration, is calculated in workdays from the GFA model (described in chapter 2 page 28).

48 *serv87pred* - predicted construction duration, is the predicted construction time based on regression model based on pilot study data (described in chapter 2 page 30).

49 *wdcat* - construction time category where - [1] less than 200 day, [2] is 200+ to 300 days, [3] is 300+ to 400 days, [4] is 400+ to 500 days and [5] is 500+ days.

50 *costcat* - construction cost indexed from mid-construction point back to January 1990 Australian dollars using the AIQS cost index where - [1] is \$4 million up to \$8 million, [2] is \$8+ million to \$14 million, [3] is \$14+ million to \$20 million, [4] \$20+ million to \$30 million, [5] is over \$30 million.

51 *adjustRK* - is derived from the variable *adjust\_act* (column 11) where values are -[1] 0.9 to 0.95; [2] 0.95 to 1.05; [3] 1.05 to 1.15; and [4] over 1.15.

#### **PHDCLCR FILE (CLIENT AND CLIENT REPRESENTATIVE CHARACTERISTICS)**

1 *work\_type* - type of construction work undertaken: fit-out work; new work; refurbishment; mixture of the above.

2 *org\_exp* - level of client organisation's experience with the building procurement process.

3 *cr\_exp* - level of client representative's experience with the building procurement process.

4 *cr\_confid* - level of client organisation's confidence in the client's representative.

5 *obj\_cost* - level of client's project objective for low construction cost.

6 *obj\_time* - level of client's project objective for quick construction time.

7 *obj\_qual* - level of client's project objective for quick construction time.

8 *obj\_stab* - level of stability of client's project objectives during the construction period.

9 *obj\_clar* - level of clarity of communicating the client's project objectives.

10 *obj\_cred* - level of credibility of being able to achieve the client's project objectives.

11 *cr\_infl* - degree of influence that the CR exercised on CTP.

12 *cr\_complex* - level of complexity generated by the level of CR influence exercised.

13 *q2\_61* - level of CR's understanding of the projects's constraints.

- 14 *q2\_62* - level of CR's ability to quickly make authoritative decisions.
- 15 *q2\_63* - level of CR's ability to effectively brief the design team.
- 16 *q2\_64* - level of CR's stability of decision making.
- 17 *q2\_65* - level of CR's ability to contribute ideas to the design process.
- 18 *q2\_66* - level of CR's ability to contribute ideas to the construction process.
- 19 *q2\_71* - level of design team's confidence in the CR's contribution.
- 20 *q2\_72* - level of the confidence of the CR in the design team.
- 21 *q2\_73* - level of construction team's confidence in the CR's contribution.
- 22 *q2\_74* - level of the confidence of the CR in the construction team.
- 23 *q2\_75* - level of the CR's ability to mould shared project goals and aspirations.
- 24 *q2\_76* - level of the CR's willingness to accept effective and positive ideas.
- 25 *q2\_77* - level of the CR's willingness to contribute effective and positive ideas.
- 26 *q2\_78* - level of the overall CR contribution to project team harmony.
- 27 *q12\_1* - complexity impact of working relationship developed between CR and CM teams.
- 28 *q12\_2* - effectiveness of CM team in influencing the CR team.
- 29 *q14\_3* - complexity impact of CR organisational structure to accept risk.
- 30 *cr\_mech* - degree of CR mechanistic organisation style.
- 31 *cr\_flex* - degree of CR flexible organisation style.
- 32 *cr\_task* - degree of CR task oriented management style.
- 33 *cr\_people* - degree of CR people oriented management style.
- 34 *cr\_power* - degree of CR's use of direct power in a management style.

35 *cr\_cm\_com* - level of communication effectiveness between the CR and CM teams for decision making.

36 *cr\_des\_com* - level of communication effectiveness between the CR and design teams for decision making.

37 *cr\_com* - level of communication effectiveness within the CR team for decision making.

38 *cr\_decisn* - level of CR team's organisational effectiveness for decision making, communicating and actioning.

39 *cr\_IT\_use* - level of effectiveness of the CR team's use of IT for planning and control.

#### **PHDCMGT FILE (CONSTRUCTION MANAGEMENT TEAM CHARACTERISTICS)**

1 *company* - code for the construction company responding to the questionnaire.

2 *q13\_1* - construction time performance impact of CM's use of management systems and procedures.

3 *q13\_31* - level of planning effectiveness of CM team's forecasting planning data.

4 *q13\_32* - level of planning effectiveness of CM team's analysing construction methods.

5 *q13\_33* - level of planning effectiveness of CM team's analysing resource movement to and within site.

6 *q13\_34* - level of planning effectiveness of CM team's work sequencing to achieve and maintain workflow.

7 *cm\_plan* - average of values for *q13\_31* to *q13\_34*.

8 *q13\_35* - level of planning effectiveness of CM team's monitoring and updating plans.

9 *q13\_36* - level of planning effectiveness of CM team's responsiveness to recover from problems or to take advantage of opportunities.

10 *q13\_37* - level of planning effectiveness of CM team's coordination of resources.

11 *q13\_38* - level of planning effectiveness of CM team's to structure an organisation to

maintain workflow.

*12 cm\_control* - level of effectiveness of CM team's in controlling using plans.

*13 q14\_1* - impact on construction time performance from appropriateness of CM team's organisational structure to manage risk.

*14 q15\_1* - impact on construction time performance from appropriateness of CM team's managing teams to optimise inter and intra team synergy and creatively manage conflict.

*15 cm\_mech* - degree of CM team leader's mechanistic organisation style.

*16 cm\_flex* - degree of CM team leader's flexible organisation style.

*17 cm\_task* - degree of CM team leader's task oriented management style.

*18 cm\_people* - degree of CM team leader's people oriented management style.

*19 cm\_power* - degree of CM team leader's use of direct power in a management style.

*20 cm\_com\_mgt* - level of communication effectiveness for decision making.

*21 cm\_des\_com* - level of communication effectiveness between the CM and design teams for decision making.

*22 cm\_com* - level of communication effectiveness within the CM team for decision making.

*23 cm\_decisn* - level of CM team's organisational effectiveness for decision making, communicating and actioning.

*24 cm\_IT\_use* - level of effectiveness of the CM team's use of IT for planning and control.

*25 cm\_perfor* - impact upon construction time performance impact of the general level of CM team's management performance

#### **PHDESIGN FILE (DESIGN TEAM CHARACTERISTICS)**

*1 q14\_2* - impact on construction time performance from appropriateness of design team's organisational structure to manage risk.



2 *des\_mech* - degree of design team leader's mechanistic organisation style.

3 *des\_flex* - degree of design team leader's flexible organisation style.

4 *des\_task* - degree of design team leader's task oriented management style.

5 *des\_people* - degree of design team leader's people oriented management style.

6 *des\_power* - degree of design team leader's use of direct power in a management style.

7 *des\_com* - level of communication effectiveness for decision making.

8 *cm\_com* - level of communication effectiveness within the design team for decision making.

9 *des\_decisn* - level of design team's organisational effectiveness for decision making, communicating and actioning.

10 *des\_IT\_use* - level of effectiveness of the design team's use of IT for planning and control.

#### **MOTIV FILE (TEAM MOTIVATION CHARACTERISTICS)**

1 *cr\_1551* - level of motivation of CR team leader from pay and allowances.

2 *cr\_1552* - level of motivation of CR team leader from achievement from meeting complex challenges.

3 *cr\_1553* - level of motivation of CR team leader from job security.

4 *cr\_1554* - level of motivation of CR team leader from a sense of belonging to the project team.

5 *cr\_1555* - level of motivation of CR team leader from recognition of contribution made.

6 *cr\_1556* - level of motivation of CR team leader from opportunities to extend skills and experience.

7 *cr\_1557* - level of motivation of CR team leader from being equitably rewarded relative to others.

8 *cr\_1558* - level of motivation of CR team leader from opportunity to exercise power.

9 *cr\_1559* - level of motivation of CR team leader from opportunity for career advancement.

*10 des\_1551* - level of motivation of design team leader from pay and allowances.

*11 des\_1552* - level of motivation of design team leader from achievement from meeting complex challenges.

*12 des\_1553* - level of motivation of design team leader from job security.

*13 des\_1554* - level of motivation of design team leader from a sense of belonging to the project team.

*14 des\_1555* - level of motivation of design team leader from recognition of contribution made.

*15 des\_1556* - level of motivation of design team leader from opportunities to extend skills and experience.

*16 des\_1557* - level of motivation of design team leader from being equitably rewarded relative to others.

*17 des\_1558* - level of motivation of design team leader from opportunity to exercise power.

*18 des\_1559* - level of motivation of design team leader from opportunity for career advancement.

*19 cm\_1551* - level of motivation of CM team leader from pay and allowances.

*20 cm\_1552* - level of motivation of CM team leader from achievement from meeting complex challenges.

*21 cm\_1553* - level of motivation of CM team leader from job security.

*22 cm\_1554* - level of motivation of CM team leader from a sense of belonging to the project team.

*23 cm\_1555* - level of motivation of CM team leader from recognition of contribution made.

*24 cm\_1556* - level of motivation of CM team leader from opportunities to extend skills and experience.

*25 cm\_1557* - level of motivation of CM team leader from being equitably rewarded relative to others.

26 *cm\_1558* - level of motivation of CM team leader from opportunity to exercise power.

27 *cm\_1559* - level of motivation of CM team leader from opportunity for career advancement.

28 *site\_1551* - level of motivation of on-site workforce from pay and allowances.

29 *site\_1552* - level of motivation of on-site workforce from achievement from meeting complex challenges.

30 *site\_1553* - level of motivation of on-site workforce from job security.

31 *site\_1554* - level of motivation of on-site workforce from a sense of belonging to the project team.

32 *site\_1555* - level of motivation of on-site workforce from recognition of contribution made.

33 *site\_1556* - level of motivation of on-site workforce from opportunities to extend skills and experience.

34 *site\_1557* - level of motivation of on-site workforce from being equitably rewarded relative to others.

35 *site\_1558* - level of motivation of on-site workforce from opportunity to exercise power.

36 *site\_1559* - level of motivation of on-site workforce from opportunity for career advancement.

#### **DEMOTIV FILE (TEAM DE-MOTIVATION CHARACTERISTICS)**

1 *cr\_1561* - level of de-motivation of CR team leader from pay and allowances.

2 *cr\_1562* - level of de-motivation of CR team leader from the physical working environment.

3 *cr\_1563* - level of de-motivation of CR team leader from being accountable for unclear or conflicting objectives.

4 *cr\_1564* - level of de-motivation of CR team leader from a sense of isolation.

5 *cr\_1565* - level of de-motivation of CR team leader from lack of recognition of contribution

made.

*6 cr\_1566* - level of de-motivation of CR team leader from having to re-do work.

*7 cr\_1567* - level of de-motivation of CR team leader from having to work to unreasonable time frames.

*8 cr\_1568* - level of de-motivation of CR team leader from having insufficient authority to meet ethical or contractual obligations.

*9 cr\_1569* - level of de-motivation of CR team leader from inter-team conflict or petty point scoring.

*10 des\_1561* - level of de-motivation of design team leader from pay and allowances.

*11 des\_1562* - level of de-motivation of design team leader from the physical working environment.

*12 des\_1563* - level of de-motivation of design team leader from being accountable for unclear or conflicting objectives.

*13 des\_1564* - level of de-motivation of design team leader from a sense of isolation.

*14 des\_1565* - level of de-motivation of design team leader from lack of recognition of contribution made.

*15 des\_1566* - level of de-motivation of design team leader from having to re-do work.

*16 des\_1567* - level of de-motivation of design team leader from having to work to unreasonable time frames.

*17 des\_1568* - level of de-motivation of design team leader from having insufficient authority to meet ethical or contractual obligations.

*18 des\_1569* - level of de-motivation of design team leader from inter-team conflict or petty point scoring.

*19 cm\_1561* - level of de-motivation of CM team leader from pay and allowances.

*20 cm\_1562* - level of de-motivation of CM team leader from the physical working environment.

21 *cm\_1563* - level of de-motivation of CM team leader from being accountable for unclear or conflicting objectives.

22 *cm\_1564* - level of de-motivation of CM team leader from a sense of isolation.

23 *cm\_1565* - level of de-motivation of CM team leader from lack of recognition of contribution made.

24 *cm\_1566* - level of de-motivation of CM team leader from having to re-do work.

25 *cm\_1567* - level of de-motivation of CM team leader from having to work to unreasonable time frames.

26 *cm\_1568* - level of de-motivation of CM team leader from having insufficient authority to meet ethical or contractual obligations.

27 *cm\_1569* - level of de-motivation of CM team leader from inter-team conflict or petty point scoring.

28 *site\_1561* - level of de-motivation of on-site workforce from pay and allowances.

29 *site\_1562* - level of de-motivation of on-site workforce from the physical working environment.

30 *site\_1563* - level of de-motivation of on-site workforce from being accountable for unclear or conflicting objectives.

31 *site\_1564* - level of de-motivation of on-site workforce from a sense of isolation.

32 *site\_1565* - level of de-motivation of on-site workforce from lack of recognition of contribution made.

33 *site\_1566* - level of de-motivation of on-site workforce from having to re-do work.

34 *site\_1567* - level of de-motivation of on-site workforce from having to work to unreasonable time frames.

35 *site\_1568* - level of de-motivation of on-site workforce from having insufficient authority to meet ethical or contractual obligations.

36 *site\_1569* - level of de-motivation of on-site workforce from inter-team conflict or petty point scoring.

## 1.0 INTRODUCTION

This research attempts to contribute to the body of knowledge relating to construction time performance (CTP) by delving more deeply into the reasons why some buildings are constructed more quickly than others. The work exposes a ranked hierarchy of factors which indicate the significance and relative strength of influences upon CTP. Furthermore, the work contributes an investigation approach to this area of research with which to analyse both factual and expert-opinion data.

### 1.1 BUILDING UPON THE WORK OF OTHERS - IDENTIFYING GAPS IN KNOWLEDGE

The research builds upon the work of Bromilow, Ireland, Sidwell, and groups and associations including the Royal Commission into Productivity in the building industry in New South Wales, Construction Industry Development Association (CIDA) in Australia, and National Economic Development Office (NEDO) of the UK. A consensus, regarding possible causes for poor CTP, has emerged from these and other researchers mentioned, however, as each step in a body of theory is developed it must be periodically tested because changed circumstances shift the elements of the theory and causal factors, deemed to be significant, to be deleted or replaced by others in the theoretical model.

Ireland (1983, p71) identifies 26 managerial actions of which 25 are related to construction time. His work relates to a sample of Australian projects, drawn from those completed in the late 1970's and early 1980's. The industrial relations and economic climate has, however, changed considerably from that time to the period covered by projects studied in this work. His work (1983) investigated cost and quality as well as time performance. Evidence presented in this work is used to investigate in greater depth and detail the strength of influence and the reason why identified factors affect CTP.

The work of other researchers such as Naoum (1991, p21-22) and (Nahapiet and Nahapiet 1985, p39) indicates but does not offer statistical supporting evidence to explain how or why identified causal factors affect CTP. A useful body of case study knowledge has emerged during the past decade (NEDO 1988; Stacey 1991; CIDA 1993; Walker 1988), (BCA 1993a) that helps identify factors affecting CTP. Contributions from industry

practitioners, however, have not included demonstrated causal links between identified factors and CTP other than by observation of experience and small sample case studies.

A body of research is needed to test hypotheses and assumptions made to validate speculated causal influences upon CTP or to extend and refine causal links. This research makes its contribution by exposing gaps in the body of knowledge related to CTP.

A model derived from the literature and other studies is tested in this work and a more refined explanation of CTP is derived. The principal gaps in knowledge addressed by this research is that of helping to answer the questions 'what factors affect CTP?', 'to what extent do these factors affect CTP?', and 'why do particular factors affect CTP while others do not?' The research methodology employed provides a new way of analysing CTP, widening available tools researchers may use to investigate such lines of inquiry.

## **1.2 IMPORTANCE OF THE ISSUE OF CTP**

This work is important because CTP has been identified as one of three crucial success factors for a construction project: time, cost and quality. The Royal Commission into Productivity in the building industry in New South Wales concludes that *'Through improving its productivity, the construction industry can have an important rôle in promoting national competitiveness, and therefore in defending living standards and achieving a satisfactory rate of growth. The benefits from such improvement would include increased attractiveness of Australia as a location for investment in new plants or projects and lower costs to domestic industry. Measures that prevent or slow steps toward improving building and construction industry productivity are, in effect, an attack on the employment prospects and future welfare of Australian workers. Such measures would also be an attack on the potential performance of Australian industry and the economy generally.'* (PRD 1991a, p32). This view is shared by industry organisations concerned with improved performance and with the formation of CIDA, its work both facilitating and encouraging productivity improvement, reinforces the argument for attention to CTP. The argument is also supported by the potential for significant improvement which has been demonstrated by Stoekel and Quirke (1992, p41). Their analysis indicates a 10% construction industry productivity improvement will lead to a 2.5% increase in Gross Domestic Product.

### 1.3 THE RESEARCH MODEL

At the outset of this research a casual model of CTP was developed from a review of the literature. Others such as Bromilow *et al* (1980) and Ireland (1983) have sought to predict construction time in terms of project scope using the relationship:

$$\text{TIME} = \text{CONSTANT} * (\text{SCOPE to the power CONSTANT}).$$

This approach, however, omits project complexity or project team effectiveness other than by factoring them into the constants. While this work is limited to an investigation of management effectiveness with respect to time, it is not intended to imply that cost and quality effectiveness are not important or worthy of consideration.

A different approach was adopted for this work. The model illustrated in figure 1.1 indicates that project scope and complexity pose a challenge to the project management team which responds at varying levels of management effectiveness. It is postulated that a low level of management effectiveness results in a longer construction time and that a high level of management effectiveness results in a shorter construction time for the quantum of project challenge. Scope and complexity appears to form a function shaping risk and this is applied to a function of project team effectiveness which results in CTP.

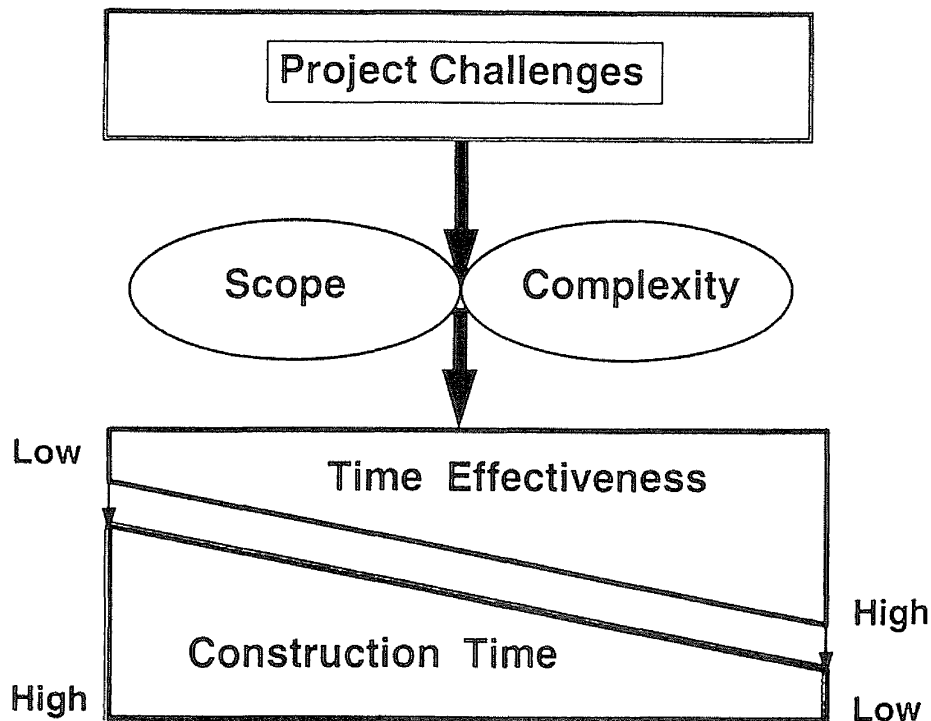
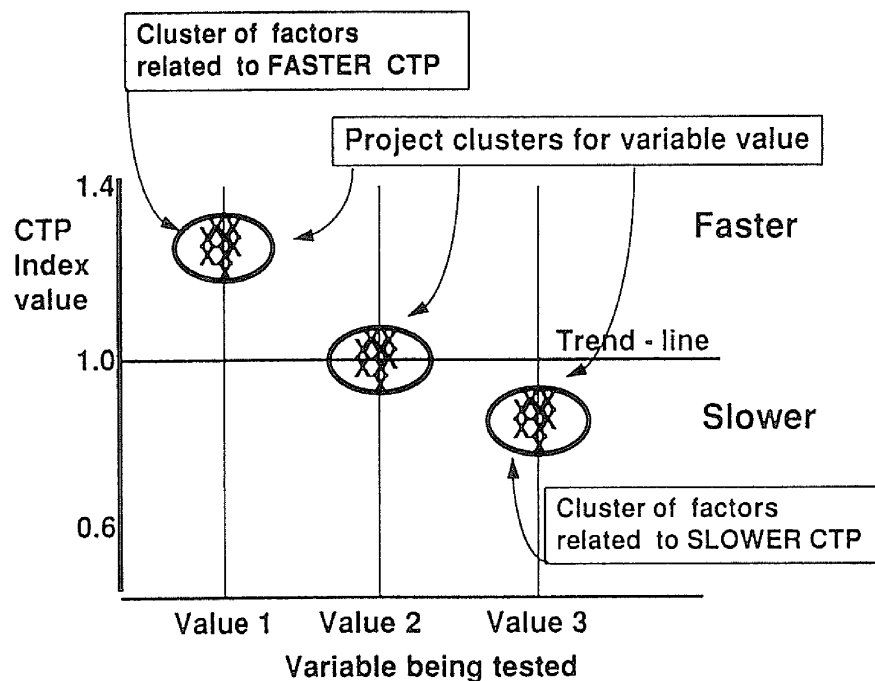


Fig 1.1 - Model of Factors Influencing Construction Time



This model of the process determining CTP is useful in explaining why some projects are constructed more quickly than others. It is postulated that a trend-line of construction time can be calculated for any given sample of projects and that an index of CTP can be constructed for any project in the sample by dividing the trend-line construction time by its actual construction time.

Some projects will perform above trend within the sample and others will perform below trend. The nature of the distribution of the CTP index value for sub-sets of the sample group can then be used to investigate the impact of data variables collected as part of this research.



**Fig 1.2 - Model for Testing Hypotheses**

Hypotheses relating to a factor's influence upon CTP can be tested on the basis of the expected clustering of the CTP index for projects for the value of each variable. Figure 1.2 illustrates a hypothetical case where clusters of projects with a CTP index value for the variable's value 1 indicates significant variance in CTP index from the cluster of projects for that variable's values 2 and 3. Such evidence, supported by analysis of variance testing would support the argument that the variable in question does or does not affect CTP.

### 1.3.1 PROJECT CHALLENGES

Challenges to the project team are derived from scope and complexity. Gross floor area (GFA) and construction cost were considered as measures of project scope and it was concluded, after investigation of the literature and undertaking statistical analysis of both GFA and cost data, that construction cost provides the best measure of scope. Complexity in this study is viewed as an aggregate measure derived from three qualitative data sources: client and client representative (CR) characteristics; project characteristics; and environmental characteristics.

Client and CR characteristics are explained in terms of: the nature of the client and (CR); nature of their objectives; CR sophistication, the nature of their relationship to other project team members; and both their capacity to interact and nature of their interaction with other team members.

Project characteristics are explained in terms of: inherent conditions prevailing at the site; buildability of a design solution; quality of design coordination and design detailing; quality management procedures; and access to site and within site.

Environmental characteristics are explained in terms of: the physical environment encountered on site; the prevailing economic conditions; the socio-political environment which includes the institutional environment; and the industrial relations (IR) environment.

Challenges presented by both scope and complexity have direct impact upon the performance of the project team. It was unclear at the start of the study the strength and impact of the relationship between scope and complexity. A project of large scope, a \$45 million dollar project for example, may have very little complexity associated with it and represent limited challenges to the project team. On the other hand a project of much smaller scope, perhaps a \$4.5 million dollar project, may present extensive challenges with a difficult site, highly complex socio-political environment and being subject to considerable complexity in the industrial relations environment. The latter project may also be subject to the whims of a very difficult client or CR. In this way the notion of project

*challenges* rather than project *scope* is an advance in understanding of the likely impact that these conditions present to those responsible for managing a project. The BCA (1993a, 1993b) reports stress the importance of the client ensuring that the design brief and the contractual arrangements adopted by the client should fully address the holistic nature of challenges to projects rather than be concerned with particular matters of contractual or procedural detail; flexibility in management approach in response to challenges presented has been shown to be of significant value (BCA 1993a, 1993b).

### **1.3.2 PROJECT TEAM EFFECTIVENESS**

Management effectiveness factors represent the effectiveness of management policies and procedures to respond to challenges posed by the client, nature of the project and environment prevailing at the time of construction to ensure acceptable CTP.

It is postulated that the construction management (CM) team, as the group charged with responsibility for the physical delivery of the project, must overcome challenges to achieve good CTP. Effective CM or CR team performance can obviate some problems associated with poor design team performance. It is less clear how an effective design team can overcome management problems associated with poor CM or CR team effectiveness.

Typically, cross-team assistance is applied in the form of additional resources, for example the CM team taking on board design expertise for checking and suggesting improvements and amendments to design documentation to improve design buildability while maintaining client objectives of quality and cost. Alternatively the CR may obviate such problems by facilitating assistance to CM or design teams to help overcome ineffectiveness.

Whatever the form of management action is taken it includes but is not limited to: analysing client characteristics and effectively coping with the impact of client demands; analysing project complexity and establishing effective action through management procedures - planning, coordination and control; analysing the environment external to the project and developing appropriate organisational structures for managing identified risks or sharing risk with other project stakeholders in a manner that devolves responsibility and

accountability to those parties that can best directly manage risk; effectively managing human resources to optimise inter and intra-group synergism and creatively manage group conflict; and effectively manage communications to facilitate appropriate speed and responsible decision making of the construction team.

#### 1.4 RESEARCH HYPOTHESES

The thesis tested by this research was that *'variance between actual performance and trend line performance can be substantially explained by managerial effectiveness of the project team in response to challenges posed by factors outside the control of the construction management team.'*

More specifically, four principal hypotheses are tested by this work:

##### **CR team's management effectiveness -**

$P_1-H_0$  that CTP IS NOT significantly affected by the management effectiveness of the client's representative;

$P_1-H_1$  that CTP IS significantly affected by the management effectiveness of the client's representative;

##### **CM team's effectiveness -**

$P_2-H_0$  that CTP IS NOT significantly affected by the management effectiveness of construction management teams;

$P_2-H_1$  that CTP IS significantly affected by the management effectiveness of construction management teams;

##### **Design teams' effectiveness -**

$P_3-H_0$  that CTP IS NOT significantly affected by design team management effectiveness;

$P_3-H_1$  that CTP IS significantly affected by design team management effectiveness;

##### **Project challenges -**

$P_4-H_0$  that CTP IS NOT significantly affected by a small number of challenges posed by factors outside the control of the construction management team;

$P_4-H_1$  that CTP IS significantly affected by a small number of challenges posed by factors outside the control of the construction management team.

Investigation of evidence to support or reject the principal hypotheses involved testing 102 sub-hypotheses because the principal aim of this work is to investigate the reason why some projects are built more quickly than others by establishing a 'league table' of factors for the sample group to also indicate the strength of each factor tested. Data was collected from 172 questions for each of the 33 projects though only 102 variables provided useful data, thus one sub-hypothesis was tested for each variable with useful data.

## **1.5 THE RESEARCH APPROACH**

The research approach began with development of a pilot study to test the initial model's conceptual effectiveness. A preliminary questionnaire (see appendix 4) was developed from the literature and used to canvass widespread reaction to possible factors affecting CTP. Site management staff from 100 projects were interviewed using a structured questionnaire. The insights and knowledge gained from the pilot study led to the development of a more detailed research instrument which, after further review of the literature including working papers from the Royal Commission into Productivity in the building industry in New South Wales, was used to compile data from 33 Melbourne metropolitan projects. These projects were selected as a pool of case studies because they spanned both private enterprise and government clients, traditional and non-traditional forms of contract, and projects constructed throughout the boom-bust cycle of the 1987 to 1993 period. The construction market in Melbourne is typical of many middle-order metropolitan areas in developed countries.

The structured questionnaire was answered by the construction team manager and was used to gather data from 172 questions. Each face-to-face interview took, on average, 2.5 hours to complete. Canvassing the views of other project team leaders - the client's representative, design team and key-subcontractors was considered, however, the scope of the work, in view of the breadth and depth of questioning employed by the research instrument, precluded seeking the views of 33 sets of team leaders - CR, design and key sub-contractors. A trade off between breadth and depth had to be accommodated to enable an appropriate sample size to be investigated. Discussion with industry leaders during the pilot study indicated that the construction team leader was considered to possess unique and representative insight into what actually occurs on-site and to be well placed to judge the effect of actions and circumstances that affect CTP.

## **1.6 OUTLINE OF THE THESIS**

In chapter 2 the methodology is discussed and the research approach justified from the initiation of the pilot study based on the literature to the development of the empirical research instrument. The concept of trend-line construction duration is explained in detail

as it underpins the approach to interpretation of information gathered. In chapter 3 the research instrument is explained and justified with reference to the literature. This chapter combines a literature review with an in-depth discussion of each question asked in the research instrument because separate chapters of a literature review and detailed justification of questions asked would result in considerable overlap and duplication of points discussed. In chapter 4 the results of the study are presented and discussed and chapter 5 provides conclusions.

A series of appendices provides supporting material for this work. Appendix 1 contains the questionnaire blank. Appendix 2 contains detailed results from the hypothesis testing in graphical form, with analysis of variance (ANOVA) test results and supporting evidence of significant correlation between the variable factor tested and all other variable factors tested. The correlation analysis segregates a list of correlated factors into those shown to affect CTP and those which do not. Appendix 3 contains the data used in the analysis and appendix 4 contains the questionnaire blank used in the pilot study.

## 1.7 GENERAL CONCLUSIONS AND VALUE OF THE RESEARCH

The general results of this work, while changing the order of significance initially expected, support the hypothesis that CTP is influenced by:

- 1 *managerial effectiveness and ability of the construction management team;*
- 2 *managerial effectiveness of the client's representative and sophistication of the both the client and client's representative;*
- 3 *a limited number of project characteristics, principally inherent site conditions, economic environmental complexity, project scope and whether the type of work is 'fit-out' or not;*
- 4 *design team effectiveness in communicating with the client's representative and construction management teams.*

The results of this work can be used by building clients, project management consultants and construction management teams to establish benchmark measures of CTP. The methodology developed can also be used to undertake project post mortem examinations

so that CTP measures can be studied for any non-civil engineering, non-residential construction project. Benchmarking has been recognised as an important step in achieving continuous improvement (Spendolini 1992). This research helps identify factors affecting CTP which can be used to establish benchmark measures. Further discussion of future research opened up by this work appears in chapter 5, general conclusions.

## **1.8 SUMMARY**

This introduction has provided a brief description of the work addressed in the thesis and justification for the field study. The research has extended previous endeavour and provides new data which challenges results based upon past circumstances. The research approach was described and hypotheses tested in this work were presented and an outline of the thesis provided. A summary of general conclusions to the thesis was given together with comments about the perceived value of this work and how it may be used to further extend the body of knowledge related to this line of inquiry.

## **2.0 INTRODUCTION**

The philosophical basis of the methodology adopted for the research work, its validity and how this work has built upon others' work is explained and justified in this chapter.

The study sample is discussed in terms of sample size and characteristics to justify the sample used for the survey of 33 projects. Variables tested are described and the source of interview data is justified. The use of a trend-line index of CTP and how the index may be used to determine causal links between the CTP and variables is examined and explained. Finally the method adopted for explaining why such causal links may be present is explored.

## **2.1 METHODOLOGY ADOPTED FOR THE RESEARCH STUDY**

Doctorial theses generally contribute to knowledge through empirical research supported by a body of knowledge. Gaps in knowledge in the area addressed by this work were identified in chapter one. Literature pertaining to the research approach is referred to in this chapter and in chapter two. It was considered more helpful to adopt this approach as a chapter devoted to a review of the literature would have required duplication of references to the literature in this chapter and chapter three.

The research approach adopted for this thesis followed six steps:

- 1 an appropriate data gathering and analysis approach was decided upon after reviewing the literature and consulting research methodology advisers;
- 2 a pilot questionnaire was developed as an aid to test the validity of data sought for the purposes of testing the research hypothesis;
- 3 the pilot study using face-to-face interviews was tested on 100 senior construction managers who provided comments on issues addressed by the research;
- 4 the responses given by pilot survey participants and their valued comments were reviewed in light of additional material from studies undertaken during the late 1980's and early 1990's together with other available sources of reference to develop the empirical research questionnaire for the 33 case study research;
- 5 data were collected using the research questionnaire in face-to-face interviews;



- 6 data were analysed using appropriate statistical tools and preliminary conclusions discussed with senior industry practitioners involved in the study to help understand the relevance of findings in context with changing circumstances prevailing over the period studied.

## **2.2 JUSTIFICATION OF THE RESEARCH APPROACH**

Observations require explanation but equally explanation must be tested against facts. De Vaus (1991, p11) believes that good explanation requires the related processes of theory construction and theory testing. He maintains that the basic question asked in theory construction when having made a particular observation is '*is this observation a particular case of some more general factor?*'. In establishing meaning from observations he recommends a common sense approach including: locating common factors; relating to existing theories and concepts as a source of ideas; working within the context of the subject area observed; asking survey respondents for insights into their answers to questions; and introspection, reflecting on why the observed has happened by trying to put yourself into the rôle of the respondent. In testing a theory one moves from the general to the particular to evaluate the variance between expected and observed responses and then try to explain why there may be a significant variance. De Vaus (1991, p20) also states that the key to empirical testing of theory is to look for evidence that disproves the theory as supporting examples can usually be found but are a weak form of evidence. He and many other authorities on research methodologies maintain that empirical research provides strong evidence for explaining phenomena whereas the use of logical deduction, anecdotal evidence, providing examples, and personal 'gut-feeling' provide only supporting evidence.

The approach adopted in this thesis is the investigation of a sufficiently large sample size of projects to enable statistical analysis of data groups to be undertaken. Adequate sample size should allow reliability of results so that the investigation can be repeated with consistent results. This means that the investigation should be constructed with methods of measurement of variables that are consistent between case studies and can be repeated using the same measurement technique. Tests must also be valid, that is they must test the

appropriateness of variables used. Examination of links between government clients and poor productivity, for example, may reveal many instances of government client and poor CTP association but the causal link may lie in team relationships and accountability constraints imposed upon public sector clients rather than the client being from the government or private enterprise sector. This example highlights the need for a research approach that investigates causal links rather than merely testing for associations.

The empirical work reported in this thesis involved the use of a survey. Marsh (1982, p6) understands a survey to be an investigation where systematic measurements are made over a series of cases yielding a rectangle of data, variables in the matrix are then analysed to see if they reveal patterns of meaning. This approach can be contrasted to an experiment where a situation is established, an intervention is introduced and the researcher investigates what the effect of the intervention has on the result. Experiments involving human behaviour in investigating productivity are very complex as the number of possible variables is usually extensive and difficult to effectively model and test. It for this reason that the survey method was adopted.

A structured survey was used to gather data in both the pilot study and 33 case study investigations. The format of questions followed a logical structure in gathering data about the projects from hypothesised factors affecting CTP. The structure ensures consistency of approach as questions were asked in the same order and the questions asked were identical. The questionnaire was completed face-to-face with the interviewer so that respondents could, if necessary, fully probe the meaning of questions and to reflect upon the nature of answers they gave. This approach also allows general discussion and peripheral comments to be noted to add supporting contextual evidence. This approach was adopted by Ireland (1983) and Sidwell (1982).

### **2.3 DEVELOPMENT OF THE RESEARCH MODEL**

The research model was developed from concepts based on ideas reported in the literature during the late 1970's and 1980's. Bromilow's seminal work (1970), (Bromilow and Henderson 1976) and (Bromilow *et al.* 1980) provided much of the basis for an

understanding of the impact of project scope upon CTP. Bromilow's research team provided little evidence, other than the possible impact of contract variations, which assists in understanding how complexity may affect CTP.

Client related complexity challenges were investigated by Sidwell (1982) in his investigation of the nature of project teams and how they might affect project success. Sidwell (1983) and (1984) identified factors influencing project time performance and concluded that client experience, form of building procurement, and project organisational structure are elements of a complex causal model of project time performance. The general hypothesis implicit in his research model (Sidwell 1982, p88) was that *'when the building team and project procedures are appropriate to client and project procedures, higher levels of success will be attained.'* He also identified managerial control, which he classes as project procedure, as a key element of achieving project success linking this to project complexity. Sidwell (1982, p93) states *'One team might be able to handle a complex project with relative ease because of the level of experience and ability of the team whereas another, less experienced, team may do less well. The measure of build rate seemed to be a reasonable indication of the technical complexity of the project. It might be appropriate to consider the experience of the team in addition to this'.*

The work of Bromilow, Ireland and Sidwell represents a broadening of understanding of causal factors that affect CTP. Sidwell identifies project characteristics as posing risk factors though he refers to building types in differentiating projects of varying complexity e.g. university library, airport buildings etc (Sidwell 1982, p52). Ireland (1983, p62) refers to complexity of form of construction which he defines as *'that which is unfamiliar to normal operatives or that which requires an unusually numerous set of steps ... Because of these reasons such projects take an unusually long time'.*

Other researchers investigating project complexity report useful findings. Chauhan and Chiang (1989) undertook a survey of 100 building and civil engineering projects in Hong Kong, India, Korea, Singapore, Taiwan and Thailand. Their survey results led them to believe that the performance of a construction management team is influenced by internal and external factors which they classify as: project, environment and management related. Their definition of project related factors includes:

- ☐ *design defects which indicate the influence of changes in design during actual construction and also the prescription of ambiguous specifications;*
- ☐ *overall job planning which takes care of proper selection of construction method and corresponding equipment, their operation and maintenance, sequencing of activities and layout of utilities;*
- ☐ *site problems which take into account the effect of accessibility, availability of utility services, supply of essential materials and commodities, space for material storage and weather;*
- ☐ *project duration which indicates if the owner has fixed a very tight completion schedule;*
- ☐ *contract conditions that reflect the existence of annoying and ambiguous clauses, complicated inspection procedures, lack of provision for arbitration and arguable suspension and termination clauses.*

Their environment related complexity factors include:

- ☐ *the economic-commerce factor which is considered to be influenced by the interests rates, currency exchange rates, availability and productivity of personnel, plant and equipment.*
- ☐ *the socio-cultural factor which influences productivity due to religious beliefs, union practices, customs and cultural background;*
- ☐ *legal-political issues such as protectionist laws favouring use of local resources, regulations pertaining to taxes, patents and procedures.*

Their management related complexity factors include:

- ☐ *Human issues like motivation, communication and leadership style;*
- ☐ *Organisational flexibility to cater for uniqueness of each project;*
- ☐ *Personnel influenced by inefficient and inconsiderate administrative systems which do not follow consistent policies and procedures for worker recruitment, training, appraisal, advancement, compensation and insurance;*
- ☐ *Control systems that identify bottlenecks and allow for timely action to be taken without being adversely affected by multiplicity of agencies causing problems in exercising managerial control;*
- ☐ *Financial factors covering the influences of limited equity capital, high risk, high cost of debt and adverse cashflow situations.*

Ireland's early work (1983) provides a more useful segregation of management factors from complexity factors. Using a case history approach on 25 high-rise construction projects, Ireland investigated two propositions:

*'The use of managerial actions can reduce the time taken, reduce the cost incurred and improve the quality produced of high-rise buildings.'*

*and*

*'The particular managerial actions have the effects on time, cost and quality performance*

*that are shown in Table 6.1 (Ireland 1983, p71).'*

The following construction time related managerial actions were tested and proved to be significant in reducing construction time:

- ☐ *selective tendering;*
- ☐ *increased use of a fixed fee on cost plus;*
- ☐ *increased use of time incentives or penalties;*
- ☐ *use of a construction manager;*
- ☐ *use of a project manager;*
- ☐ *use of a single coordinator for the whole process;*
- ☐ *responsibility for the whole process allocated to contractor;*
- ☐ *increased degree of coordination at the design-construction interface and during construction;*
- ☐ *increased construction planning during design;*
- ☐ *increased use of time control;*
- ☐ *increased use of cost monitoring during design;*
- ☐ *increased generation of alternative designs;*
- ☐ *number of site managerial personnel;*
- ☐ *increased use of competent and experienced design team;*
- ☐ *increased use of competent and experienced construction personnel.*

Ireland's work has made a valuable contribution to the understanding of management related factors affecting CTP. His conclusions relate to how management reacts to environmental factors, though environmental factors are not identified and discussed as independent variables.

Development of an empirical research instrument for the 33 case study project was achieved in three stages. In the first stage a model, based on the work of other researchers was developed. This was followed by the development of the pilot study questionnaire from the conceptual model. This instrument was then tested for robustness. The empirical research instrument was then developed and used for the 33 case study work reported in this thesis.

The option of mailing out the pilot study was considered, however, it was considered that

more value could be gained in developing a comprehensive instrument by interviewing practicing professionals, face-to-face, who manage construction projects. The value of the pilot study became clear when discussing key issues relating to CTP with industry experts. In discussing project characteristics for example, it became clear that issues of project complexity directly relate to the CM team's performance in addressing the impact of the extent to which project design or physical properties of the site assisted or inhibited a builder to conduct the work in a smooth, well coordinated manner.

Undertaking the pilot study also highlighted the need to further refine measures of client influence upon CTP including the nature of and commitment to objectives. It became evident that client sophistication needed to be measured in terms of performance (rather than designation of being from the public or private sector or experienced in terms of having being involved in few or many projects). Questions of CM team performance were also discovered to require further refinement. The effectiveness of all forms of communication within and between teams was not directly measured in the pilot study and management style and culture was also not explored. The process of interviewing CM team leaders in the pilot study revealed the need for the above concerns to be addressed in the full scale 33 project study.

The pilot study provided a useful tool for teasing out core issues affecting CTP requiring detailed investigation. Contact with senior management of construction projects, most with several decades of field experience, proved useful in allowing their expertise related to CTP to be absorbed and reflected upon. This technology transfer allowed development of the research instrument from its original pilot study stage to a more incisive document.

Building a model that could be used to develop the empirical research instrument followed four years of reflection and further review of the literature, particularly results from studies undertaken in the UK (NEDO 1988), the Royal Commission into Productivity in the building industry in New South Wales and the work of other researchers. Chapter 3 provides detailed discussion of the questionnaire with reference to the literature.

## **2.4 SAMPLE SIZE AND CHARACTERISTICS**

The scale of detail required to complete the questionnaire and the average time required to complete each interview imposed limits on the number of projects that could be included in the study. Limitations have to be considered with any research project and with the benefit of experience gained from the pilot study it was decided to limit the sample to commercial, light industrial and institutional projects undertaken in a metropolitan area. Experience with the pilot study also revealed that a sample size of 30 to 35 projects could be obtained in the \$4 million to \$45 million value range, forming a well defined sample pool of projects. Residential and heavy engineering projects were excluded from the study sample because there were few projects of the scope included in the sample scope range for the time span studied.

Metropolitan Melbourne which includes inner and outer suburbs is a major population centre and the capital of the State of Victoria. It comprises a population base in excess of three million people. The economy is generally regarded as advanced with the construction sector deploying modern materials handling equipment and construction techniques. Construction management procedures of a representative sample of the pilot study in 1987 revealed widespread application by Melbourne builders of a range of management techniques to control time and resources (Walker 1988, 1989/90, 1993a) (Hollands and Wilson, 1988/9).

It was decided, therefore, that case study projects should be drawn from, and represent, a pool of sophisticated construction management and building companies as the issue to be resolved was not whether builders employed sound management techniques but how well they applied such techniques to respond to project scope and complexity challenges.

The sample comprised projects within metropolitan Melbourne that commenced between 1987 to 1992 and were completed by the end of 1993. A minimum sample size was decided upon after consulting a number of statisticians. The minimum sample size that allows normal distribution assumptions to be used rather than using a *t* distribution, is thirty cases (Hinkle *et al.* 1988). A normal distribution forms a more reliable sample than

heavily skewed distributions for the type of study proposed (Levin 1987, p394).

The study used a sample size of 33 projects varying in contract value from approximately \$4 million to \$45 million. A sample size of greater than 30 was advised as the nature of the question asked was '*is the within sample mean significantly different from the among sample mean, e.g. does the CTP index value vary for a low, medium, high or very high rating of a studied variable*'. This kind of question can be answered using the analysis of variance (ANOVA) statistical test which requires a sample size (population) of greater than 30 cases (Levin 1987).

The Australian Bureau of Statistics provided statistics for the sample group in the sample target area and reports that 235 projects in this cost range were commenced in the metropolitan area during the study period. The study's sample of projects represents 14% of all projects constructed during the study period. This represents a stratified representative sample of the population and projects were selected in an unbiased manner to avoid selection of either a biased sample of weakly or strongly performing group of projects. Representation of the sample as part of all projects constructed during the study period is demonstrated by the following:

- 15 public sector and 18 private sector clients;
- 20 projects newly constructed, 5 refurbishment projects, 5 mixed new work and refurbishment and 3 office fit-out projects;
- 21 traditionally contracted projects, 7 construction management projects, 2 project and construction projects by the same client representative and 3 design and construct projects;
- 4 projects were designed to less than 25% at construction commencement, 1 designed to between 25% and 50%, 4 designed to between 50% and 75%, 22 designed to between 75% and 100% and 2 projects redesigned after commencement of construction work.
- There were 12 office buildings, 5 industrial buildings, 9 education related projects, 1 hospital, 2 hotels, 1 transport facility and 1 entertainment facility (these are classified as the most substantive end-use as frequently several end-use elements were present).

## 2.5 VARIABLES TESTED

The dependent variable tested was construction time measured in working days and the



primary independent variable was construction scope measured as cost in \$000's indexed to January 1990 using the Australian Institute of Quantity Surveyors' cost index. The construction mid-point in time between on-site commencement to practical completion was used as the date from which construction costs were indexed. Construction time is analysed in terms of working days as used by the Australian Construction Services (ACS) working days calendar which excludes public holidays and scheduled rostered days off as agreed between the Master Builders of Victoria (MBAV) and Construction Industry union representatives. All projects worked some overtime, however, the extent varied as part of this work was due to material movement, clean-up, work only safely conducted when the site was generally closed. Working days expended on productive output, that is time devoted to direct construction production outcomes, is usefully measured in this way. Other measures, such as equivalent working days, present problems in reconciling exactly what constitutes an off-site fabricated element and how off-site fabrication time can be accounted for in a time prediction model.

Other variables were tested using the questionnaire. Appendix 1 indicates all questions asked and methods of measurement of 172 variables derived from answers to the questionnaire. Appendix 2 presents the results of hypothesis testing for the 102 variables where useable data was obtained.

The form of questioning varied from factual data (e.g. question 1.9 actual start date on-site) to subjective responses (e.g. question 2.4.3 based on an assessment of the strength of the client's high quality of construction objective). The main objective in question design is to make questions asked clear, concise and unambiguous. A number of research methods and systems analysis texts were used to develop the questionnaire design. Extensive use was made of ordinal scale measures for eliciting data on respondents' perceptions. Ordinal scales can result in problems of leniency, central tendency and 'halo effect' (Kendall and Kendall 1988, p167-9). A seven point scale was adopted to obviate these problems and questions were constructed so that the 'good' answer did not always lie in the 6 and 7 value of the range (e.g. questions 15.2.1 to 15.2.6). The potential 'halo effect' was also addressed by varying the order of questions asked.

Interviewing all key members from the client's representative (CR), design, and key-subcontractor's teams was considered, however, this approach would present problems. The period 1991 to date has been characterised by a significant downturn in the construction industry resulting in mobility of staff engaged in key leadership positions associated with those companies participating in the survey. Difficulty was experienced in tracking down sufficient key project team leaders to interview for a survey sample of greater than 30 projects. Added to this were problems of convincing those with the information required to share that knowledge. While a great deal of goodwill and cooperation was experienced in gathering data from those interviewed, the time burden in agreeing to an interview was considerable and had to be respected. From experience gained during the pilot study and discussion with a range of industry experts it became clear that the CM team leader was the person with most knowledge of the impact of a range of project, environment and CR or design team management decisions, upon CTP. This can be explained from the nature of responsibility undertaken by the CM team, whatever the cause and nature of a challenge, it is the CM team that most confront the challenge.

## 2.6 MODELLING CONSTRUCTION TIME - THE LITERATURE

Several existing models are to be found in the literature that attempt to predict construction duration using project scope as the variable used to predict project duration.

Project scope is considered in this research to be a measure of project size that imparts a sense of magnitude and can be described in terms of construction cost per unit of time, area or volume. Project scope is usually measured in terms of time-related currency. Non-cost measures of scope include; gross floor area, functional units, capacity units etc. Describing a project's scope in terms of non-construction cost may be useful for specific types of project, e.g schools in terms of student places.

### 2.6.1 COST MEASURES

The Bromilow model (Bromilow *et al.* 1980, p79) (Bromilow and Henderson 1976, p4) predicts construction time using the formula:

$$T = K * C^B$$

- where:
- T = duration of construction period from date of site possession to practical completion in working days.
  - C = final cost of building in millions of dollars adjusted to constant labour and material prices
  - K = a constant describing the general level of time performance for a \$1 million project. Its value was 312 working days when C was measured on the 1972 price basis (Bromilow and Henderson 1976, p4), and this is equivalent to 248 working days when C is measured on the June 1979 price basis.
  - B = a constant describing how the time performance is affected by project size as measured by cost. Its value was 0.30 for both a 1972 and 1979 prices basis.

The model derived was from a survey of 419 construction projects and indicates that one factor (scope of the project as measured by construction costs in 1972 Australian dollars) partially determines construction time, however, it fails to identify and evaluate factors other than cost. Constants K and B are used in the model as a curve smoothing device but no successful attempt has been made to develop a fuller understanding of other factors determining CTP. This research also indicates that the best 25% of projects studied took less than 80% of the average time and that the worst 25% took more than 130% of the average time of the sample.

Ireland (1983, p136) concluded from an analysis of 25 cases that the best predictor of construction time based on cost (in millions indexed to June 1979) could be expressed by the formula:

$$\text{TIME} = 219 * \text{Cost in \$millions}^{0.47}$$

This result gave an  $R^2$  value of 0.576 and significance level of 0.001.

The term  $R^2$ , the coefficient of determination, is defined as the indicator of '*the proportion of the variance in one variable that can be associated with the variance in the other variable*' (Hinkle *et al.*

1988, p120). The Significance level 'p' measures the confidence that a researcher has in results reported. *'The most frequently used levels of significance is 0.05 or 0.01..... In deciding to reject the hypothesis at one of these levels, the researcher knows that the decision to reject the hypothesis may be incorrect 5% or 1% of the time'* (Hinkle *et al.*, 1988, p185).

The pilot study of 100 construction projects in Adelaide, Geelong, Melbourne, Canberra and Sydney was undertaken in 1987 and completed in early 1988. A relationship between construction cost and construction duration was evident, though, like Bromilow's model, great variation was observed between projects of similar construction cost thus the impact of complexity and management response to perceived risk was not explained.

From these three surveys, it is evident that a simplistic two variable relationship between construction cost and time paints only part of the picture predicting likely CTP. The wide disparity between cost as a measure of scope for contract time, indicates that either project cost is a poor measure of scope, or that other factors significantly influence CTP.

#### 2.6.2 AREA MEASURES

Ireland (1983, p145) offers building area as another measure of scope. In his study of 25 projects he concludes that *'large buildings can be expected to be constructed more quickly, per unit of area, than small buildings'*. He also concludes that *'buildings of a particular area will be more quickly constructed if they are of fewer storeys'*. The unit of area used by Ireland (1983, p84) in his study was the gross floor area (GFA) of the building as defined by the Australian Institute of Quantity Surveyors (NPWC, 1982); the number of storeys was defined as the number of full levels in the building, from lowest basement to, but not including, the roof. He attempts to describe scope in terms of magnitude which infers economies of scale in production but both the pilot study respondents' comments indicated that this aspect is more likely concerned with buildability and planning and coordinating resource movement.

Others have used GFA as a measure of project scope. Nahapiet and Nahapiet (1985, p38) undertook a study of ten projects - six U.K. and four U.S.A. projects - results of their study included a table of project performance details of GFA and area computed per week

of construction time. MacPherson (1991, p36) expressed construction performance of the Broadgate project in the U.K. as 627 m<sup>2</sup>/week comparing it with the fastest known U.S. building performance of 473 m<sup>2</sup>/week. The comparison did not document the scope of the fastest known US project to make a realistic comparison of CTP.

GFA is used as an input rather than anticipated construction cost in the PREDICTE<sup>1</sup> expert system (Stretton and Stevens 1990), but the system only deals with specific types of projects and is not designed for use on a wide range of construction project types.

Ireland (1986, p14) used GFA as a measure of scope in another study comparing construction cost and time performance of 15 USA office and 7 hotel buildings with 10 Australian office and 4 hotel buildings. His work indicates that GFA provides a better indicator of project scope than construction cost. The following model developed from his data indicates a sample industry average speed of construction (measured in square metres GFA per equivalent 8 hour working day) from two variables, gross floor area and number of levels excluding the roof. US Offices - base building with no fit-out works:

$$\text{SPEED OF CONSTRUCTION} = 0.042 \text{ AREA}^{0.724}$$

$$p = 0.0001; r^2 = 0.81 \text{ (sample size} = 15\text{)}$$

US Hotels - completed:

$$\text{SPEED OF CONSTRUCTION} = 24 + 0.0013 \text{ AREA}$$

$$p = 0.006; r^2 = 0.93 \text{ (sample size} = 7\text{)}$$

Australian offices and hotels fully completed, excluding extensions of time for industrial disputes and inclement weather in working days:

$$\text{Log}_{10} \text{ SPEED OF CONSTRUCTION}$$

$$= -5.72956 + 2.96889 (\text{Log}_{10} \text{ AREA})^{0.6124} + (2.93390/\text{NOSTOREY})$$

$$p = 0.001; r^2 = 0.92 \text{ (sample size} = 14\text{)}$$

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<sup>1</sup> The expert system was developed by the Australian construction company Civil and Civic P/L (a subsidiary of the Lend Lease group) using the expertise of Mr Geoff Stevens who is one of their management staff.

where AREA is gross floor area, NOSTOREY is number of levels excluding the roof.

While Ireland's (1986) results indicate that project scope (as measured by gross floor area) is a significant determinant, goodness-of-fit of his formulae is based on a small sample.

In a more recent survey GFA was used as the principal measure of building size instead of cost to describe gross CTP (RPD 1992, p21). The formulae derived from analysis of 277 case studies returned a significant correlation factor between GFA and gross construction time ( $R^2 = 0.73$ ). Using data from 340 case studies (RPD 1992, p14) also revealed a significant correlation between building cost (Australian million dollars at constant January 1988 prices) and gross construction time ( $R^2 = 0.74$ ). Gross construction time was defined as the number of calendar days from commencement to practical completion less weekends, public holidays and rostered days off, and adjusted to standard 7.6 hours per day (RPD 1992, p13).

### 2.6.3 DISCUSSION OF SCOPE AND COMPLEXITY MEASURES

It is clear that no perfect units of scope measurement can be identified. The problem with measuring construction performance in terms of GFA is that this unit of measurement also disguises the degree of complexity of work undertaken. Notes included in the results of the paper by Nahapiet and Nahapiet (1985, p38-39) illustrate the difficulty in using GFA per week as a measure of construction time performance. One U.K. project in their case histories comprised a 400 car parking garage beneath offices and they also commented that many office buildings in North America are constructed as a building shell with very few services or finishes in place. They also note that measurement of project performance in terms of square metres per time period can be misleading as car parking or office shells are usually easier and quicker to construct than a laboratory or a hospital operating theatre. Describing production performance indicators of output in terms of functional or production capacity units per period of time, results can also be misleading.

The principal advantage of using construction cost per time period as a measure of project

scope is that all elements of a building can be expressed in a single unit of scope measure. This is particularly true when considering mixed-use projects. Construction cost can also be seen as a reflection of complexity as perceived by a project's successful tenderer. The Melbourne World Congress Centre (WCC) project, one of the case histories in the pilot study, illustrates this point. It comprised a 400 bed hotel, 690 place car park and 2,500 delegate conference centre. It is more meaningful to describe CTP in terms of construction cost than to attempt segregating component parts, particularly where difficulty arises in determining the completion of components with shared spaces e.g. between the hotel and the conference centre (the hotel was completed four months before the conference centre).

The determination of project completion and project handover can also be complicated by projects having extensive external works as staged or partial completion can be achieved. Thus work may be substantially complete on a building but contract completion may be extended while external works are finished. The definition of practical completion of a project may in such cases appear to be longer than is sensibly the case. Construction which includes a significant external works component, may present two definitional difficulties in measuring construction scope per unit of construction time; using GFA as a measure of scope and the measurement of construction completion time.

Ireland's (1986) use of area and number of storeys for measuring speed of construction includes both scope and complexity aspects. The capacity for repetition of work on a project and its general implications for workflow is demonstrated in this work as being part of separate factors affecting CTP - project complexity and construction planning.

It is concluded, from the literature and feedback from experienced industry experts, that project scope should be measured in constant dollars. While this measure is offered as the most appropriate, issues of client influences, project and environmental complexity together with the construction management team's response to scope and complexity challenges must be incorporated into a model that explains variations in CTP between similar projects.

## 2.7 INVESTIGATION OF OPTIONS FOR DEVELOPING A CTP INDEX MODEL

Five approaches were investigated in developing a trend-line CTP index from the 33 projects survey data. The first used GFA and number of floors as a basis for measuring project scope. The second used the Ireland cost-scope measure. The third used Bromilow construction cost model as a basis for measuring scope. The fourth investigated a cost-based approach using the pilot study data, and the final model investigated results of all data collected from the survey of 33 projects to build a multi-dimensional model that also takes into account non-cost factors.

### 2.7.1 A GROSS FLOOR AREA (GFA) MODEL APPROACH

A multiple regression procedure was instigated using STATGRAPHICS<sup>™</sup> to test construction time in actual workdays against GFA and number of floors. The results of successive computer runs are summarised in Table 2.1. The first column contains the computer run number. The second column contains the  $R^2$  value. The third column contains the variable name used in the regression analysis and the fourth column includes the coefficient derived from the statistical procedure. The fifth column contains the significance value obtained from the computer run. Levels of 0.05 or less were considered significant as this represents the likelihood of the result being obtained by chance.

Run Number	$R^2$ Value	Variable	Coefficient	Significance Level
1	0.0000	Constant	5.470367	0.0000
		log GFA	0.024344	0.7401
2	0.9871	log GFA	0.627561	0.0000
3	0.9894	log GFA	0.652631	0.0000
		floor_bsmt	0.099884	0.4504
		floor_max	-0.049276	0.0194
4	0.9893	log GFA	0.655338	0.0000
		floor_max	-0.039977	0.0153

**Table 2.1 - GFA Multiple Regression Computer Run Results**

A constant was included in the first computer run. This represents a situation for a zero square metres GFA building. A building of zero GFA makes little sense and indeed the significance level of 0.7401 for GFA and the very low  $R^2$  of 0.0000 bears out the



conclusion that inclusion of a constant in the model is inadvisable.

The second computer run indicates that the model provides a good fit as predicted by Ireland (1982 p84), it shows a high  $R^2$  value and the low significance level implies that this is a reliable result.

In the third computer run numbers of basement floors (floor\_bsmt) and maximum number of floors (floor\_max) was added to the model. The number of basement floors proved to be a poor factor to introduce as indicated by the significance level which is greater than 0.05. The software package STATGRAPHICS reference manual instructs users that factors with high significance levels (over 0.05) may be dropped from the model.

The fourth computer run produced another high  $R^2$  value indicating a robust model with acceptable significance levels for the two remaining variables, gross floor area (GFA) and maximum numbers of floor levels. The derived model can be stated thus:

$$\log \text{Workdays} = 0.655338 * \log \text{GFA} - 0.039977 * \text{floor\_max}$$

the formula can be transformed to:

$$\text{Workdays} = (\text{GFA}^{0.655338}) * \exp (-0.039977 * \text{floor\_max})$$

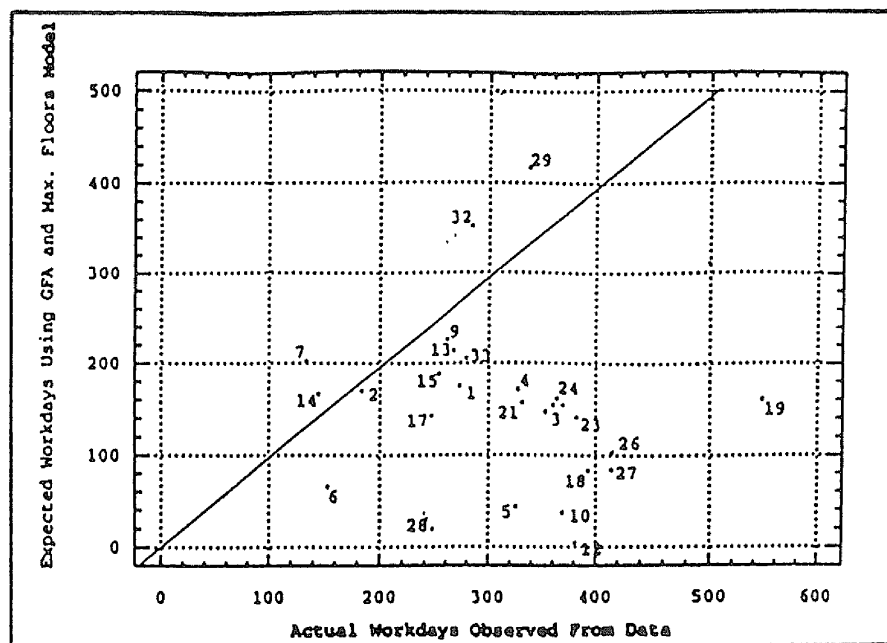


Figure 2.1 - Construction Time Using GFA & Maximum Floors Model

This formula was applied to observed GFA data in the survey data set and predicted construction build times produced. These were then graphed against observed construction build times in work days. Figure 2.1 illustrates the result. While the  $R^2$  value for this model indicates a good explanation of the data the graph illustrated indicates a poor fit.

### 2.7.2 IRELAND'S COST-BASED MODEL APPROACH

The second approach was investigated using Ireland cost-based model (Ireland 1983, p136) where  $TIME = 219 * Cost^{0.47}$  indexed from June 1979 to January 1990 dollars. The results were graphed as indicated in figure 2.2.

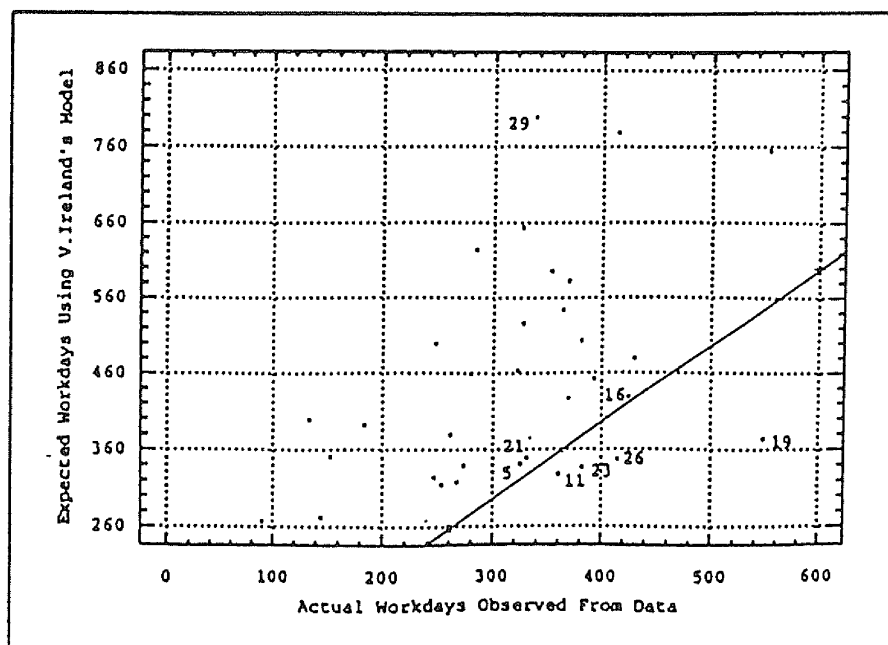


Figure 2.2 - Construction Time Using Ireland's Cost Based Model

The result did not look promising as many of the actual values were far greater than predicted (Ireland's cost formula) values. This may be interpreted in several ways. One interpretation is that the constants (219 and 0.47) used in Ireland's model are no longer valid when used with recent data, a second is that CTP has significantly increased during past years which is not reflected in his model, and the third is that cost index formulae used to convert June 1979 dollar values to January 1990 dollars is no longer sufficiently robust to be useful.

### 2.7.3 BROMILOW'S COST-BASED MODEL APPROACH

The third approach was to test Bromilow's model against observed data. In this case the construction costs were indexed from June 1979 to January 1990 dollars and the results used to predict construction time in working days. Figure 2.3 graphs expected (using the Bromilow prediction values) against observed values. This model again does not appear to adequately explain the data (probably for the same reasons as Ireland's), though it does appear more reliable than Ireland's model.

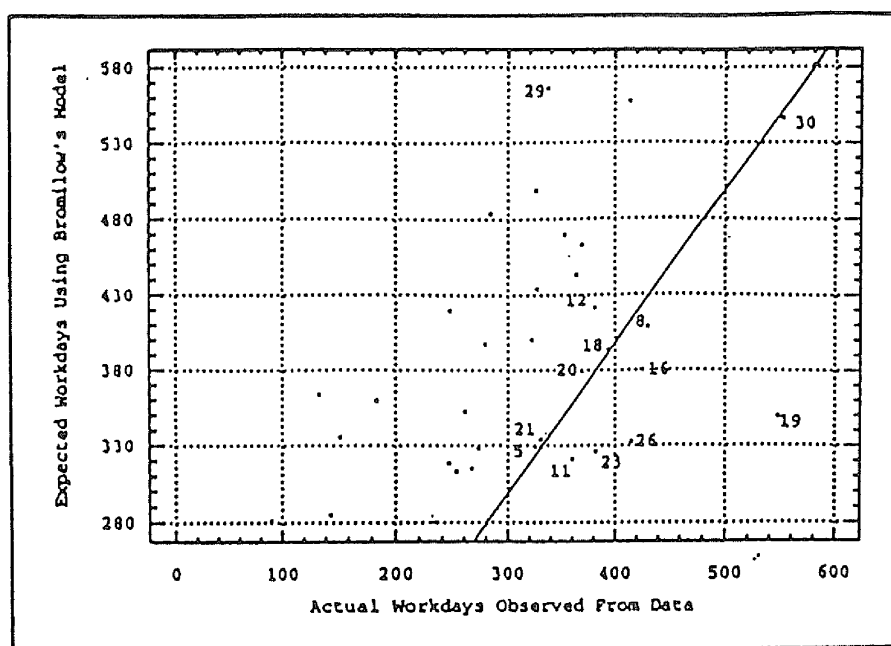


Figure 2.3 - Construction Time Using Bromilow's Cost Based Model

### 2.7.4 THE PILOT STUDY (WALKER 1987) COST-BASED MODEL APPROACH

The fourth approach was to test results of the 1987 pilot survey. The first step was to derive a multiple regression model from data gathered from that survey. The cost data was then indexed to January 1990 values using the AIQS index. The multiple regression results revealed a  $R^2$  value of 0.9938 for the following model:

$$\log \text{Workdays} = 0.592163 * \log \text{Cost in \$000's}$$

which can be transformed to :

$$\text{Workdays} = \text{Construction Cost in \$000's}^{0.592163}$$

The pilot survey used contracted construction duration plus approved extensions of time

plus expected acceleration or delay to completion as the construction time value (rather than actual construction time) for the 100 projects. Caution should be exercised, therefore, when judging the accuracy of the construction time data based on that model.

Figure 2.4 illustrates a graph using the above model of predicted workdays against actual workdays from the 33 case study data. While the model displays a reasonable fit with a high  $R^2$  value, it lacks the tightness-of-fit of actual to predicted values compared to the model derived from the 33 case study (described in the next approach).

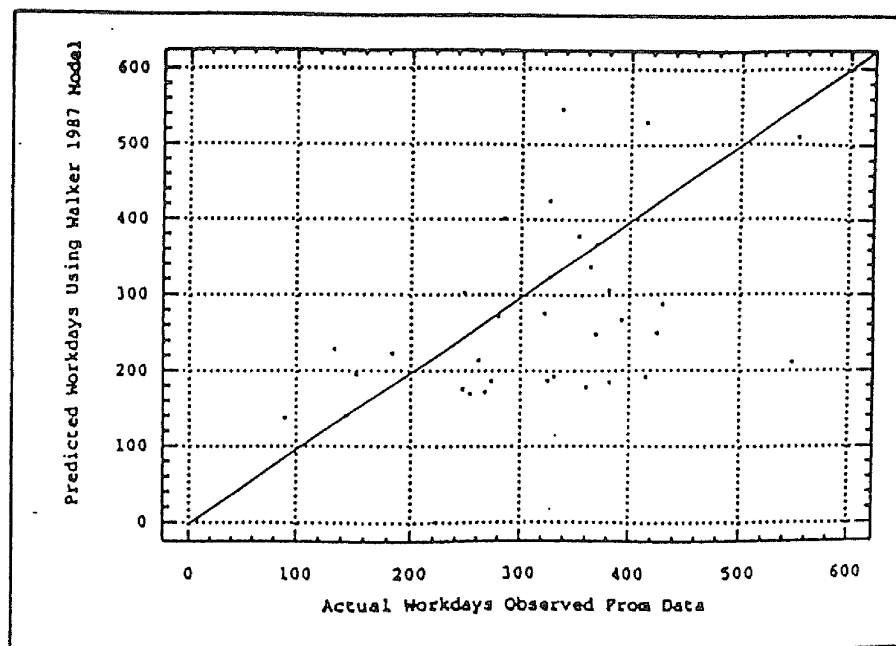


Figure 2.4 - Construction Time Using The Pilot Study Cost Based Model

#### 2.7.5 THE 33 CASE STUDY COST-BASED MODEL (DHT WALKER) APPROACH

The fifth approach uses a model derived from the 33 case study data set. A multiple regression model was first established with log workdays against log construction costs (indexed to January 1990 dollars and expressed in \$000's). A multiple regression model was established starting with log wd\_act (actual workdays) to log endval (indexed to January 1990 construction end cost). The first run used a constant and the  $R^2$  value was only 0.2215 which indicates a poor fit. This is not surprising as it assumes that a cost of zero dollars will result in a duration of X days which does not appear logical. The constant was dropped and the  $R^2$  value rose to 0.9954 which indicates a good fit. The

formula that could be derived from this reads:

$$\log \text{ Workdays} = 0.608048 * \log \text{ Cost in \$000's}$$

While the  $R^2$  value was robust at 0.9954 and the significance level of the variable 'cost' was 0.0000 i.e. well within the 5% (0.05) range acceptable, the model infers that construction time can be adequately explained by construction cost. This appears a shallow explanation given the literature and collective experience of study survey participants.

In refining the model each data variable was added incrementally and the multiple regression model re-run noting, at each step, changes in the  $R^2$  value and more importantly the significance level of variables. Those with a value greater than 0.05 could be discarded. At several points during this process models were produced that provided a good fit to the model. A case in point is the model:

$$\begin{aligned} \log \text{ Workdays} = & 0.584489 * \log \text{ Cost in \$000's} \\ & + (0.281799 \text{ if the CR is government}) \\ & - (0.479837 \text{ if the project was a fit-out}) \\ & + (0.930145 * \text{ the extension of time to actual time ratio}) \end{aligned}$$

This formula gave an  $R^2$  value of 0.9975 which is very high and indicates a robust model. Again this seemed a superficial explanation as other variables can be expected to better explain the reason why 'CR type' might affect CTP rather than the fact that the CR was a government employee.

The analysis required 172 variables to be tested one after another. At each point the significance levels were reviewed to test if they were less than 0.05 and if so those variable were retained. The result of this level of analysis was that a model was derived that explains CTP in greater depth than other models considered.

The ANOVA results from the best-fit run gave all variables a 'p' value less than 0.05 and a plot of residuals indicated that they were random and normally distributed. The result for log Workdays with a 0.9987  $R^2$  value is as follows:

Variable	coefficient	significance level
log end.val \$000's	0.481294	0.0000
eot_act	1.187976	0.0002
work_type = 'fit'	-0.488867	0.0011
obj_qual	0.105097	0.0126
cr_people	-0.125269	0.0011
cm_des_com	0.079837	0.0278
cm_IT_use	0.104343	0.0204

The model describes predicted construction time in workdays in terms of end\_val (construction cost in \$000's indexed to January 1990 taken at the mid-point of construction), eot\_act (the ratio of extensions of time granted to actual construction period e.g. 0% = 0 and 22% = 0.22), work\_type = 'fit' (applicable if the project is a fit-out), obj\_qual (the case study's data for the CR's objective for high quality of workmanship scaled measured on a 1 to 7 point scale where 1 = very low and 7 = very high), cr\_people (the case study's data for the CR's people-orientated management style measured on a 1 to 7 point scale where 1 = very low and 7 = very high), cm\_des\_com (the case study's data for the communications management for decision making between the construction and design team measured on a 1 to 7 point scale where 1 = very low and 7 = very high), and cm\_IT\_use (the case study's data for the effective use of information technologies by the construction management team measured on a 1 to 7 point scale where 1 = very low and 7 = very high).

The formula can be transformed from log form as follows:

$$\begin{aligned} \text{WORKDAYS} = & \text{Construction Cost in \$000's}^{0.481294} \\ & * \exp [(1.187976 * \text{eot\_act}) - (0.488867 \text{ if it is a fit-out project}) + \\ & (0.105097 * \text{obj\_qual}) - (0.125269 * \text{cr\_people}) + (0.079837 * \\ & \text{cm\_des\_com}) + (0.104343 * \text{cm\_IT\_use})] \end{aligned}$$

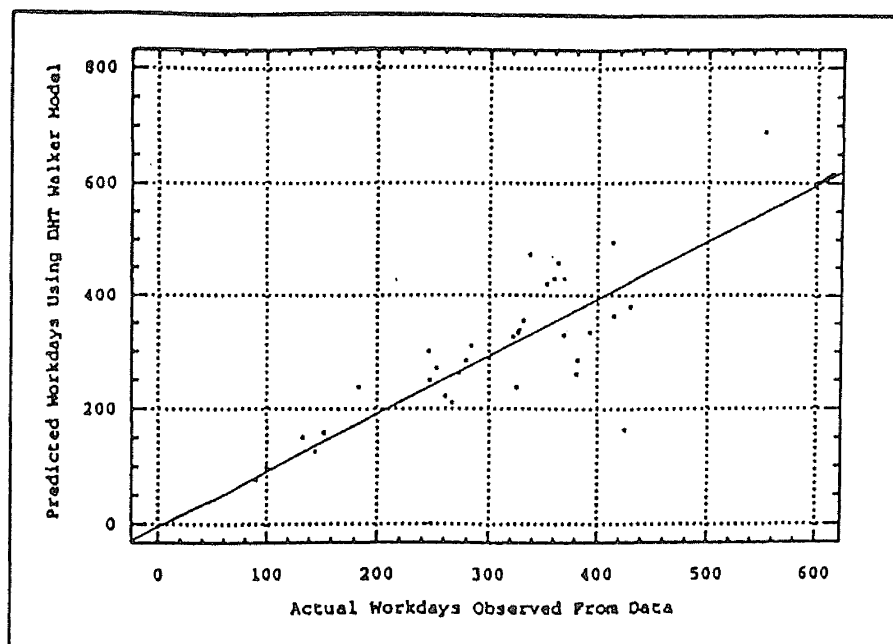
Coefficients provide some indication of impact of each variable. This model appears to indicate that the principal factors affecting construction time performance, apart from scope measured as construction cost and fit-out projects which appear to be quicker to construct than non-fit-out projects, are management and client related. The CR, however, contributes to the granting of extension of time from scope changes.

The CR's quality expectations are significant, as they increase so does construction time and the degree of CR's people-orientated management style has an inverse impact

indicating that a high people-orientation reduces the factor and therefore the time. The CM team also has a strong influence upon construction time with one important factor being its ability to effectively work with the design team to get decisions made and acted upon, and another being its effective use of information technologies (IT).

It is surprising that the model indicates that good CM/design team communication tends to increase construction time. This may have resulted from too much time being spent on talking rather than acting or team relationships being in a transition phase, a similar study in the future may yield a negative coefficient. Alternatively, respondents may have misunderstood the question asked. One would also expect a decrease in construction time with an improvement in effective use of IT by the CM. This expectation may be explained by a learning curve being experienced; increased use of IT initially decreases productivity. Alternatively, respondents may have been confused between degree of IT use and effectiveness of IT use.

The DHT Walker model was used to derive predicted construction time in workdays for each case study project. Figure 2.5 graphs the expected versus actual workdays.



**Figure 2.5 - Construction Time Using The DHT Walker Cost Based Model**

Inspection of the models presented in figures 2.1 to 2.5 indicate that the DHT Walker model indicates a better fit of a trend line for construction build time in workdays. The model appears sound, as it provides a good approximation of a normal distribution for the residuals which are randomly distributed as illustrated by figures 2.6 and 2.7.

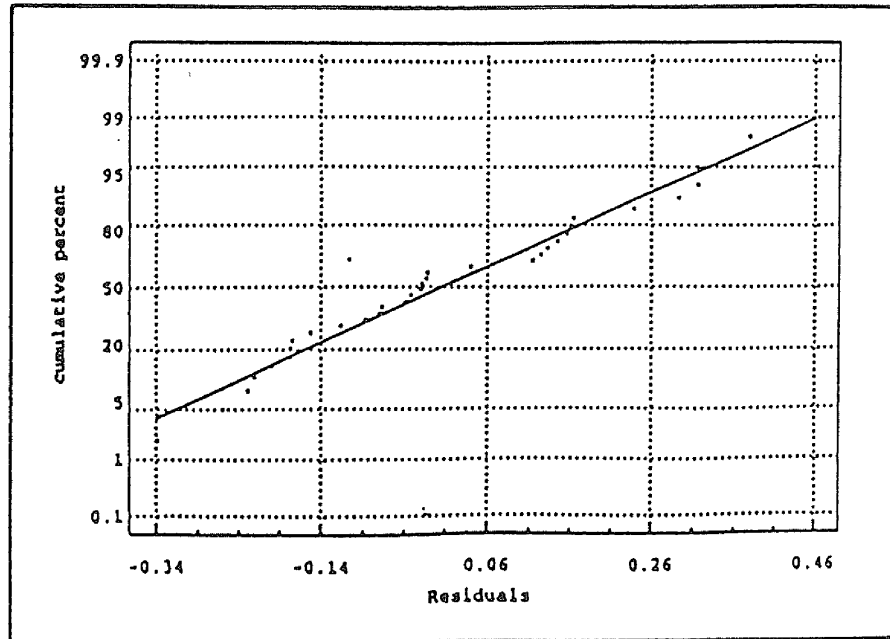


Figure 2.6 - Normal Probability Plot Of Residuals For DHT Walker Cost Based Model

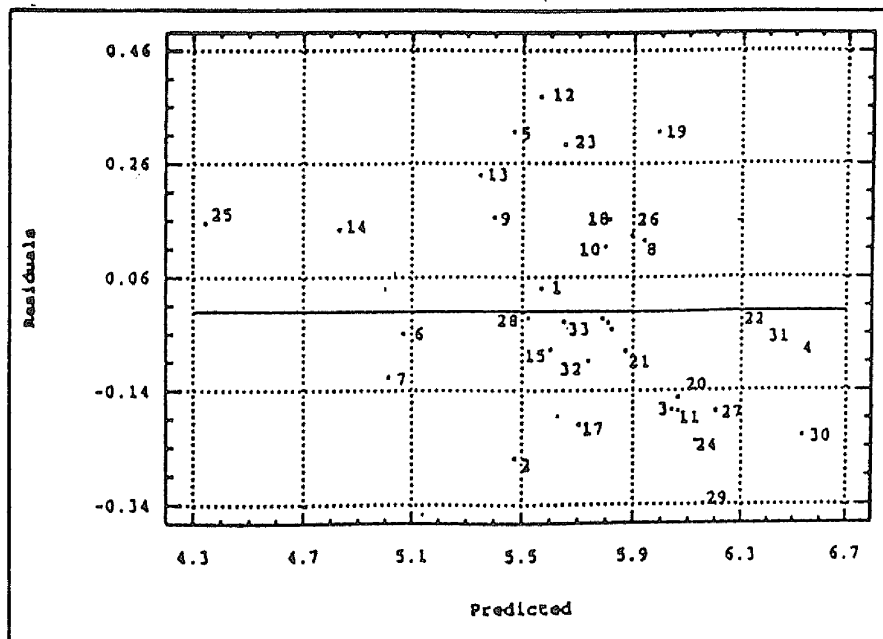


Figure 2.7 - Residual Plot For DHT Walker Cost Based Model



## 2.8 DISCUSSION OF WHICH MODEL TO USE

An important aim of this research was to construct a model that better describes CTP than anything currently available. Perusal of figures 2.1 to 2.5 indicates that the DHT Walker model derived from the 33 case studies better describes predicted construction time duration than either Ireland's or Bromilow's model. One way to substantiate this assertion is to investigate how closely these models correlate to actual construction time.

A simple pairwise Pearson's Product-Moment correlation was undertaken using STATGRAPHICS to investigate the correlation between expected construction times predicted by: the GFA with maximum floors model (pred\_area); the Ireland model (verntime); the Bromilow model (bromtime), the pilot survey results (surv87pred) and the DHT Walker model (pred\_time). The actual observed data values (wdact) was also compared.

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Sample Correlations

	wdact	pred_time	pred_area	surv87pred	verntime	bromtime
wdact	1.0000 ( 33) .0000	.7599 ( 33) .0000	-.1559 ( 27) .4374	.4380 ( 33) .0108	.4451 ( 33) .0094	.4550 ( 33) .0078
pred_time		1.0000 ( 33) .0000	.1499 ( 27) .4554	.6717 ( 33) .0000	.6702 ( 33) .0000	.6671 ( 33) .0000
pred_area			1.0000 ( 27) .0000	.2491 ( 27) .2103	.2364 ( 27) .2352	.2183 ( 27) .2741
surv87pred				1.0000 ( 33) .0000	.9992 ( 33) .0000	.9956 ( 33) .0000
verntime					1.0000 ( 33) .0000	.9985 ( 33) .0000
bromtime						1.0000 ( 33) .0000

-----  
Coefficient (sample size) significance level  
-----

Figure 2.8 - Pearson's Product Moment Correlation Of Model Comparisons

Figure 2.8 illustrates the results. Strong correlation (0.7599) exists between actual duration (wdact) and the DHT Walker model's predicted duration (pred\_time). The GFA area and maximum numbers of floors model (pred\_area), though appearing to have a good fit from the  $R^2$  value of 0.9893 in its derivation (see table 2.1) has a weak negative correlation

(-.1559) with actual duration (wdact). Both the Ireland model (correlation 0.4451) and the Bromilow (0.4550) experience only marginally moderate correlation with the actual duration (wdact). The pilot survey results provide a marginally moderate correlation (0.4380) with actual duration (wdact). Hinkle *et al.* (1988, p118) recommend as a rule of thumb that a correlation of 0.70 to 0.90 be considered a high correlation and 0.50 to 0.70 as moderate.

Evidence presented in the correlation analysis clearly indicates that the model based on multiple regression analysis from the 33 case studies has the strongest correlation of those presented. In addition to this evidence, the  $R^2$  value of 0.9987 also supports this view. Furthermore, weaker evidence from visual inspection of figures 2.1 to 2.5 suggests that the DHT Walker model fits the data better and also has a closer association of predicted to actual workdays for each case study.

## 2.9 DEVELOPING A CONSTRUCTION TIME PERFORMANCE INDEX

Part of this study's objectives were achieved by deriving an improved model to predict construction duration from work commencing on-site to practical contract completion. This model by itself cannot be effectively used to explain why some buildings are built more quickly than others. The trend-line predicted construction duration can, however, be used as a benchmark for expected duration ignoring the residuals unaccounted for between modelled times and actual times.

Each case study project was given a CTP index value based on the ratio of predicted to actual time. Thus project one has a predicted duration of 262.183 workdays but an actual observed duration of 273 workdays. The CTP index for project one is, therefore, 0.960376. This statistic indicates that project one's CTP is 96.04% of trend, i.e. below trend. Project two with a predicted construction duration of 238.488 workdays and an observed duration of 184 workdays performs above trend at a CTP index of 1.29613 or 129.61% of trend. In this way a picture emerges of the relative CTP of projects so that inferences can be made and statistical analysis and hypothesis testing can be undertaken based on comparing CTP of projects.

Table 2.2 summarises the CTP index for all projects. The ranking scale used corresponds to the following CTP index values: rank = 1 for an index of less than 0.600; rank = 2 for an index of 0.600 to less than 0.850; rank = 3 for an index greater than 0.850 and less than 0.950; rank = 4 for an index greater than 0.950 and less than 1.050; rank = 5 for an index greater than 1.050 and less than 1.150; rank = 6 for an index greater than 1.150 and less than 1.400; and rank = 7 for an index of greater than 1.400.

Results show that 14 of the 33 projects performed below trend and 19 of the 33 performed above trend with 4 of these within 3% of trend-line index.

Above Trend-Line			Below Trend-Line		
Case Number	Index Value	Ranking	Case Number	Index Value	Ranking
2	1.29613	6	1	0.960376	4
3	1.18991	6	5	0.729272	2
4	1.03236	4	8	0.883467	3
6	1.03981	4	9	0.848685	2
7	1.12362	6	10	0.892417	3
11	1.19313	6	12	0.685092	2
15	1.07003	5	13	0.787748	2
17	1.22111	6	14	0.865790	3
20	1.16438	6	16	0.386367	1
21	1.07243	5	18	0.851494	3
22	1.01269	4	19	0.729267	2
24	1.25704	6	23	0.746024	2
27	1.19369	6	25	0.855910	3
28	1.01166	4	26	0.875988	3
29	1.40281	7			
30	1.24718	6	Average	0.992618	
31	1.02055	4	Median	1.01845	
32	1.09153	5	Std. Devn.	0.213402	
33	1.01845	4			
Number Above	%age Above		Number Below	%age Below	
19	57.58%		14	42.42%	

**Table 2.2 - Construction Time Performance Index By Case Number**

## 2.10 TESTING CAUSAL LINKS AND BETWEEN-VARIABLE RELATIONSHIPS

The second part of this work commenced once a comparative measure for projects was developed. The CTP Index provides a sound basis for comparing the performance of projects for any data variable having sufficient data to permit comparison. The problem presented, investigating how the mean value of clusters of data values compare to the general population mean, is addressed by several well known statistical techniques. Two such techniques considered were chi-squared and analysis of variance (ANOVA). *'The chi-squared test is used to examine the differences among more than two sample proportions and to make inferences whether such samples are drawn from populations each having the same proportion. The ANOVA is used to test for significant differences among more than two sample means'* (Levin 1987, p463).

Initially chi-squared was considered for testing hypotheses, however, this test assumes that the data approximates the normal distribution which is only likely when the expected frequency for a classification is greater than or equal to five (Levin 1987, p453). The chi-squared test is appropriate when testing data against an assumed norm for large samples of multiple category data. In many cases in this research work, an expected value of less than five was being tested within a classification (in this case data categories e.g. 1 to 7 for a 7 scale classification of data values).

The ANOVA technique was adopted as the preferred statistical technique for testing hypotheses of causal links between CTP and each of the 102 variables tested. This technique addresses the analysis required. Each variable has data values for each case study. Most of the variables were measured using an ordinal scale of 1 to 7 and much of the remaining data was grouped into classifications. The variable describing the ratio of extension of time (EOT) to actual construction time, for example, was grouped into 5 classifications. In testing hypotheses, the shape of the test was 'is there a significant difference among the means of the variable classification value?'. If there is a significant difference, for example, in the mean value of the CTP index for different project procurement methods (i.e. those using a traditional procurement method, those using a CM procurement method, those using design and construction procurement method, and those

projects using a project and CM procurement method) then it can be concluded, at the accepted level of significance, that procurement method significantly affects CTP.

This statistical treatment of the study's data yields interesting results. While this technique reveals likely causal links between the variable tested and CTP it still does not explain how those links may have been formed. Demonstrating a causal link between CTP and a variable begs the question 'why does this link occur?'. That kind of problem is one of data association. In order that the relationship between variables can be better understood there needs to be a measure of correlation between variables. Levin (1987, p535) describes correlation analysis as '*the statistical tool that we use to describe the degree to which one variable is linearly related to another*'.

Pearson Product Moment Correlation is used to investigate the linear relationship between two continuous data sets. Spearman Rank Correlation is used to investigate the linear relationship between two ordinal data sets. Useable data was collected on 102 variables in this study and so a matrix of 102 by 102 of cross-data correlation was undertaken so that the relationship between each variable and all others could be examined. This led to interesting associations which assist in explaining why certain variables were found to significantly affect CTP and others do not.

A PC based software package, STATGRAPHICS developed by Manugistics in the USA, was used for data analysis. Choice of this package was determined by its appropriateness for the task.

## **2.11 SUMMARY**

The methodology adopted for the research has been shown to be founded on a sound philosophical basis. The survey approach was justified. Proof of this was presented by demonstrating that of the five models considered for predicting CTP, the adopted model was state-of-the-art. Choice of the data sample used also justified.

Using the CTP index as a basis for comparing the value of variables to establish or refute

causal links represents an advance in the application of research methodologies for this area of inquiry. Finally, the statistical tools chosen to help explain causal links represents a deep approach to understanding and exploring the research problem.

### **3.0 INTRODUCTION**

The research model discussed in chapter one identifies project challenges in terms of scope and complexity which impact upon project team effectiveness. The outcome of this research leads to an explanation of construction time performance. It was concluded in the methodology approach for the research study discussed in chapter two that a face-to-face survey provided the best means to gather empirical research data in this particular case.

The rationale behind the design of the research instrument is discussed in this chapter drawing upon the literature to justify and support the content and form of questions asked in the research instrument. Chapter sub-headings follow the sequence of the questionnaire blank presented in appendix one and a discussion of the literature is followed by an explanation justifying each of the case study questions in turn. This chapter should be read in conjunction with appendix one. Each question asked provided data, much of which was useable data for testing 102 hypotheses. Appendix two provides results of statistical analysis for each question which yielded useable data. Appendix three contains data recorded from the survey.

### **3.1 PROJECT SURVEY IDENTIFICATION INFORMATION - QUESTIONS ASKED**

The questionnaire begins with a panel of general case history questions used for identifying the project and providing a useful contact point for clarifying queries about answers given in the questionnaire.

The case history number identifies the case number and the date interviewed is requested. Project and contact person name, position, address and both phone and fax numbers are requested to provide reference material for later contact. The contact person's experience with the project is requested, however, only management personnel with close personal involvement with the project case study at a level sufficient to form a view of working relationships within team groups and between teams were interviewed.

### **3.2 PROJECT SCOPE DETAILS**

The questionnaire includes varied questions under the section 'project scope details'. These

include: project scope; construction materials and building systems used in the project; project end-use; contractual arrangement; degree of design and construction overlap; description of external works; and construction time. These questions provide information to enable scale of work undertaken for projects to be better understood.

### 3.2.1 PROJECT SCOPE - THE LITERATURE

Two measures of project scope are recorded in the questionnaire for use in the data analysis stage of the work, construction cost and gross floor area (GFA). Scope measures were discussed with reference to the literature in chapter two.

Discussion with pilot study participants indicated that choice of construction materials and building systems may impact upon construction time. One group favoured off-site prefabrication over cast-in-place concrete framing systems. Others with particular expertise with in-situ concrete systems countered this argument. They reasoned that fabrication and building system are irrelevant to speed of construction and that continuous workflow and design buildability are the core issues affecting CTP. Both schools of thought linked CM planning performance with a design that readily allows workflow on a number of work-faces as more important than construction materials or building system used for projects.

Both Sidwell (1982, p52) and Naoum (1991, p31) link building type with the concept of project complexity. They generalise about project complexity being linked to building type, such as university libraries, airport buildings, office buildings, etc., The National Economic Development Office (NEDO) report (1988, p65) also pin-points speculative office buildings and supermarkets as building types potentially built more quickly. Bresnen *et al.* (1988, p32) and (Sidwell 1982, p58) support the view that building type is a project characteristic rather than causal factor.

Conflicting evidence appears in the literature to support a preference for a particular contractual arrangement over others as affecting CTP. Ireland (1983) maintains that contractual arrangement and overlap of design and construction may influence CTP but the degree of contribution is open to question and may be better explained by other



management factors. Other researchers (Mohsini and Botros 1990) and (Brandon 1990, p330-333) have built knowledge based expert systems based on the assumption that appropriate contractual arrangements influence CTP. The effectiveness and nature of management contracting has been widely researched (Sidwell 1983; Elton 1985; Franks 1984; Naoum and Langford 1984; Barnett 1988/89; Sidwell and Ireland 1987). Ward *et al.* (1991, p199) developed a model of possible management contracting pathways to meet cost, time and quality objectives which illustrate complexity of decision making that the client faces in prioritising objectives and deciding upon appropriate contractual arrangements. Others (Barnes and Partners 1984) and (Sidwell 1987, p90) have concluded that contractual arrangements does NOT significantly determine speed of construction.

Those supporting non-traditional contractual arrangements stress the advantages of widening possibilities for the builder to provide informed advice on the design to be adopted, construction methods to be proposed and organisational structures to be developed to manage the project. This school of thought also believes that alternative modes of contractual arrangement have highlighted shortcomings in the traditional approach and that the client can, if aware of advantages and disadvantages of these, make a positive contribution to decisions regarding appropriate contractual forms.

Degree of design and construction overlap affects the opportunity for contribution that the builder can make to the design process. The main advantage of involving the builder early in the design process is that advice can be given on buildability and a more practical design can be achieved which enhances CTP and reduces unnecessary costs (Ward *et al.* 1991, p202). The challenge of a builder taking on a construction consultant rôle has, however, been documented as having a patchy success record. The principal problem identified is the difficulty that some builders face in responding to the demands of being a constructive critic of the design concept and detail (Naoum and Langford 1987).

Ireland (1983, p71) indicates that overlapped or fast-track construction can shorten the overall project delivery time but may increase the construction period. While overlap of design and construction can shorten the overall project duration it may cause delays during

the construction phase from problems associated with design detailing and coordination. Problems occurring from use of fast-tracked design include: lack of coordination due to design detail instability; unclear or missing information due to unavailable finalised documentation; and design details that will not work because of hasty design production betraying a lack of proper consideration (Fazio *et al.* 1988).

The NEDO report (1987, p18 & 19) also illustrates general design quality problems that may be shared by a fast-track approach. Moselhi and Hout (1990, pI.3.3) expressed reservations with the fast-track approach citing research of cost overruns on fast-track projects. They demonstrated a simulation model to test the effect of fast-tracking with contract variations which indicates a dramatic increase associated with intensity of design/construction acceleration. Bromilow (1970) and Ireland (1983) has confirmed a link between contract variations and poor CTP. Since contract variations can affect workflow and will change project scope, they must have some impact upon CTP. Sidwell and Ireland (1987, p9) reported a representative of the USA General Services Administration (GSA) as stating that under the fast-track system of design and construction, coordination problems increase dramatically and that construction time in the USA also increases by approximately 5-10%, although they maintain that no evidence has emerged that public clients in Australia experience this to the same extent. In Revay's (1988) study of 150 projects in Alberta Canada, it was found that on many fast-track projects the start of construction could have been delayed by up to six months on projects which would still have finished ahead of the date actually completed.

Data on extensions of time (EOT) granted was gathered in the survey. The ratio of EOT to actual construction time as a measure of project risk encountered can be misleading when used to infer CTP. Ireland (1988, p23) cites a poor record of CTP for Australian builders with widespread delays caused by inclement weather and industrial relations (IR) disputes. His argument holds that IR disputes and inclement weather claims for EOT are substantially under the control of management and that many weather EOT claims are in fact generated from occupational health and safety issues as interpreted by union representatives on-site. His arguments have been vindicated by workplace reform which

has recently dramatically reduced lost time due to IR disputes through negotiations between union and management representatives (DOL 1988, p33).

### **3.2.2 PROJECT SCOPE - QUESTIONS ASKED**

Construction cost, recorded under **question 1.1**, is defined as the final project construction cost excluding fees, land, interest and holding charges.

A number of possible reference points could have been adopted for indexing construction costs. Accurate cost adjustment could be obtained if the actual cash flow, including adjustments for contract variations and other claims, could be discounted to a single point in time. Gathering this data, however, was not practical for several reasons. Each survey interview took between two and three hours to complete and respondents needed to seek further information from archival sources in addition to this time commitment which took varying amounts of time to obtain. Many respondents reported difficulty with obtaining data on the full cash flow actually expended. They also indicated that they would be unprepared to assist with the work on the basis of providing information at that level of detail. Furthermore, this kind of data was generally considered commercially sensitive. A common approach for comparison of each project's cost, however, was achieved through discounting construction cost at completion. Construction cost was indexed to the common benchmark *datum* of January 1990 using the AIQS standard index for the average of index values for the month corresponding to the actual start on-site and practical completion for each case study.

Data was also collected on the cost of external works and prefabricated construction components. Data pertaining to the value of external works helps indicate the relationship between direct building works and external works. Further information on the nature of external works was gathered from respondents in question 1.8 and recorded under description of external works.

**Question 1.2** is used to record GFA area data. The AIQS definition of GFA was adopted.

**Questions 1.3 and 1.4** pertain to data on additional project scope measures, namely maximum number of floors above and below ground. Several of the projects studied comprised a multi-building complex while others had stepped roof profiles. This data was gathered as scope variables to help determine predicted construction time. Projects studied in this work vary considerably in type, composition, end-use and design. Project 17, for example, was a single storey building of 20 metres in height. Project 18 also had elements of floor height greater than that usual for standard office buildings or hotels.

**Question 1.5** is used to gather data on building construction materials and construction methods including information on construction technologies used to build the structural frame, floor, roof and building cladding. This data helps better paint a picture of the nature of the building constructed.

**Question 1.6** is used to determine the project's end-use.

**Question 1.7** gathers data on the form of contract used and degree of design completed prior to commencement of construction.

**Question 1.8** allows respondents to give a brief description of the nature of external works so that a better picture of project scope can be envisaged.

Construction time data was gathered from answers to questions 1.9 to 1.13. **Question 1.9** is used to record actual construction start date records the date that work began on-site including any demolition or preparatory works included in the contract. **Question 1.10** is asked to obtain the practical completion data.

**Question 1.11** is used to record the estimated construction time in working days as submitted as part of the tender for the project.

**Question 1.12** is used to gather data on agreed extension of time (EOT) claimed segregated into scope changes, inclement weather, industrial relations and other causes.

This gave a useful insight into the ratio of expected to actual time of construction. It can be argued that the EOT reasonably reflects the impact of work finally undertaken over and above that known at the time of tender. EOT claims are negotiated to allow for the effect of risk to be accepted by the builder at the time of tender. In theory, when EOT is added to the tendered completion time, a measure of construction time-related risk which was encountered can be derived. In practice, however, EOT claims may be negotiated as part of a trade-off for compensation claims for a host of unrelated claims too difficult to resolve individually, especially when liquidated damages (LD) may be applied.

**Question 1.13** is used to gather data on the number of days worked excluding rostered days off (RDOs) and public holidays. This was calculated using the industry standard working day calendar, based on a 38 hour week by agreement between the Master Builders Association of Victoria (MBAV) and Australian Construction Services (ACS).

**Question 1.14** is used to record estimated average days and hours worked. This data is used to supplement the understanding of the on-site working culture i.e. whether the workforce allowed overtime to be worked when required. Sites work longer than normal hours or days for a variety of reasons. These include catching up on lost production, undertaking material movement, progressive cleaning the site, and undertaking special work such as lift installation and commissioning.

### **3.3 PROJECT COMPLEXITY DETAILS - RÔLE OF THE CLIENT**

The client is the entity that identifies the need for a building and is the genesis of the construction process. Project objectives are defined by the client independently or in conjunction with advisers. Shaping a project's scope and complexity, therefore, lies very much in the hands of the client and project inception team. As Sidwell (1984, p90) observes '*Clients who get the quickest results are those who provide the building team with well defined specialised needs and are able to become closely involved with the building process*'.

#### **3.3.1 RÔLE OF THE CLIENT - THE LITERATURE**

The client also commissions principal consultants and has input into the approval of sub-

consultants. The melding of a project team into a cohesive entity that can achieve shared objectives was identified as having an important influence on project success in a report of 5 case study projects commissioned by the Construction Industry Institute (CII) in the USA (Rowings *et al.* 1987).

The importance of clear goal definition to management success has also been identified by others (McGregor 1960) and (Hersey and Blanchard 1982, p117-118). If the client has clear, well enunciated goals which are effectively communicated in the briefing and team selection process, then it can be expected that a better climate exists for goal congruence. A better chance of project success as a consequence of this. The client also needs to have a clear idea of expected performance and reputation of key project team members to effectively build a project team that has a promising chance of success.

Clients can perform a useful rôle in ensuring that a brief is properly and clearly given, that appropriate consultants are commissioned and an appropriate management structure for the management of the project and the construction process is established. Sidwell (1982) demonstrated that sophisticated clients (those having built projects before) and specialised clients (who repeat similar buildings) had a better chance of success with their projects than novices. Ferry (1978, p8) lists delusions suffered by uniformed clients:

- ☐ *'that designing and erecting a building is a process that has been going on for so long that all major technological problems have been ironed out by now;*
- ☐ *the architect's objectives will be the same as his own;*
- ☐ *the membership of the relevant professional institution is a guarantee of high competence;*
- ☐ *that large building contractors are well-organised firms of substance able to guarantee price, quality and time performance;*
- ☐ *that experienced professionals and businessmen will use their experience on each new project and will not be absurdly optimistic about time and money.'*

NEDO (1988, p53) also demonstrate the key influence of the client on the outcome of building projects which is mirrored by the client's skill in:

- ☐ *'clearly expressing project objectives in terms of building requirements, cost and time budgets;*
- ☐ *defining the procurement strategy and the input that the client can make to the project;*

- ☐ *bringing together a - possibly unique - configuration of specialists to work as a team;*
- ☐ *determining the level of service expected from each member of the project team.'*

Clients express their brief in a variety of ways ranging from highly developed requirements such as extension or expansion plans for manufacturing plants to vague impressions of shortcomings in an existing facility.

NEDO (1988, p63) suggests that it is not essential that a brief be detailed so long as instructions were defined, stating the client's priorities in terms that could be responded to by the consultants involved in the development of the brief. It is important that clients be clear-cut about the nature and degree of help required to develop a brief, as distinct from design development where a brief evolves from dialogue between client and consultant. This is because a number of specialists may be required to contribute their expertise such as space use consultants, marketing consultants interior designers or other specialists familiar with specific technologies such as materials movement, security, computer installations etc.

NEDO (1988, p64) has also demonstrated the central importance of a well-managed connection between design and construction for project success. In a recent analysis of 20 major Australian projects (BCA 1993a, p3) the following conclusions were drawn which pertain to client generated delays. The report states highlights:

- ☐ *'a need for a greater assumption of the responsibility by the client for a firm brief, a realistic timing of commitment and a comprehensive analysis of project delivery needs and methods;*
- ☐ *and the creation of a climate in which the parties can operate efficiently and the supply of clear decision making'.*

In a second BCA report (1993b, p3), further requirements for success are specified including the need for definition of project rôles, detailed expression of client needs and ensuring accountability and responsibility by assigning sufficient power to individuals or units that have the capacity to bring needed results. Both BCA (1993a, 1993b) and NEDO (1988, p64) stress the importance of the client dealing with the design brief and design development in a unified and coherent manner. The latter report indicates confusion and

delay occurring in cases where diffused briefing from inside a client's organisation had occurred. Drucker's work (1974, p436) on management by objectives concludes that clear objects have a strong affect upon management performance. Clear objectives form the basis for a clear brief. This may, in part, explain why publicly funded clients have attracted a poor reputation for their projects achieving good CTP. If a hospital board, for example, comprises disparate interests of doctors, specialists, medical research and teaching interests and the board bureaucratically constrains its project representative, then appropriately quick approval for many low level decisions may be inhibited. More generally, if a disparate group control the decision-making process in any project, then a strong likelihood of confusion, decision reversal and untimely decision making may ensue with its attendant problems of generating temporary 'holds' on construction work and contract variations (which have been shown to inhibit good CTP (Bromilow 1970) and (Ireland 1983)).

NEDO (1988) illustrates examples of actions taken by 'very professional' clients and their approach to the development of the brief, design and construction process. These customers, typically supermarket and chainstore developers, have standard briefs which succinctly define their requirements. Instructions include distribution of responsibilities between the project team members, lists of preferred suppliers and specialist contractors and even proposed design concepts and construction techniques. The brief also commits principal consultants to produce a plan of key decisions required of the customer and a timetable of decisions required of specialist consultants, subcontractors and suppliers as well as planning the design development phase (including detailed design and shop drawing production). NEDO (1988, p65) states: *'In the study, this extent of initial effort was vindicated by the success of the projects and the confident spirit in which it was achieved. It demonstrated the usefulness of defining at the outset a comprehensive strategy for the project and a firm context for the responsibilities and contributions of participants.'*

Sidwell (1982) established that public clients, who may well as an organisation have much experience of commissioning buildings and may also have commissioned many similar buildings, can experience higher cost and time over run compared to privately funded



clients. He explains this in part by drawing attention to bureaucratic procedures that publicly funded and some privately funded clients are subject to. Kaka and Price (1991, p398) in a study of 801 UK projects conclude that public buildings take longer to build than private ones of similar construction cost. Many case study respondents in my study formed a view, they claim is widely shared in industry, that 'government' projects are likely to take longer to construct than similar private sector client projects. This view may be missing the point in that the real issue may be accountability and rigid adherence to procedures for decision making, approval and control mechanisms that inhibit innovative approaches which places a brake upon the pace of the decision making process.

Client organisations may be highly experienced but individuals acting in the rôle of project sponsor/client may be inexperienced or overloaded with work and relying on delegated persons of lesser experience. Many researchers maintain that clients should participate actively and supportively throughout the project life cycle (Sidwell 1982; Ireland 1983; NEDO 1988, p12-13; Bresnen *et al.* 1988, p33; Bresnen and Haslam 1991, p339).

A client who is experienced and sophisticated in terms of project management may choose to take the initiative and lead the process. In many instances the client is a corporation, government department or syndicate of joint-venturers. In these circumstances it is usual to appoint a project manager as client representative (CR), this can be accomplished in ways outlined by Barnett (1988/89) and Ireland (1987). The client or CR often chooses to allow other team members to take much of the initiative, e.g. the architect or a construction management consultant for reasons that may include a lack of desire, resources or experience. The characteristic of experience may be individual and not organisational. If an organisation has built up experience then knowledge and expertise is available to an individual, however, individuals may not access or be aware of this resource.

### **3.3.2 RÔLE OF THE CLIENT - QUESTIONS ASKED**

A considerable amount of information about the client and CR in response for a need for a clear picture of the rôle of the client and CR. The notion that a client's influence may be

established through the client organisation's past experience with similar projects or the CR's experience of similar projects was considered worthy of examination. Questions needed to be asked to gain an appreciation of client and CR impact upon CTP.

Feedback from pilot study participants exposed issues of client confidence in the CR which may affect CTP. The client may or may not have confidence in the CR, whether an internal or external person to the client organisation has been appointed. Furthermore, a CR may be hamstrung by client policy and procedures which may affect the CM team's confidence in the CR. It was speculated that this may affect CTP.

Issues of the project teams' confidence in the client or CR raises interesting questions about level of experience, the nature of the client's objectives, client or CR influence, client or CR sophistication and client or CR relationships with the design and construction team members. Pilot study respondents seldom had access to 'the client' as this entity may be an individual or a group of individuals acting in concert, sometimes out of tune with each other. In the 33 case study work the CR was assumed to represent the client's views and objectives.

**Question 2.1** provides an identification of the client and **questions 2.2.1 to 2.2.2** establish whether the client is in the public or private sector of the economy.

**Questions 2.2.3 to 2.2.5** establish a measure of the size of the client's organisation. These questions contribute information which may help explain client characteristics, actions and motivations but the questions do not indicate the autonomy or effectiveness of the CR.

**Question 2.3.1** measures the client organisation's experience with the building procurement process.

**Question 2.3.1** helps determine if the client organisation is capable of judging the quality of the CR. **Question 2.3.2** helps measure the CR's relevant experience of the building procurement process and **question 2.3.3** establishes CR performance as perceived by

client.

**Questions 2.4.1 to 2.4.3** helps measure the strength and ranking of the client's project objectives for low construction cost, quick construction time and high quality of construction.

**Question 2.4.4 and 2.4.5** help determine how well these objectives were established by measuring the stability of objectives and clarity of the client's communication of project objectives.

**Question 2.4.6** helps establish how reasonable these objectives appeared to the manager of the construction team. These questions help establish whether the CR has assisted in gaining commitment to shared common goals for the project.

The CR may or may not have exercised a significant impact upon CTP and any influence exerted may have added to, or detracted from, risk associated with the management of the project. **Questions 2.5.1 and 2.5.2** elicit this information.

**Question 2.6** gathers data which helps to establish the degree of CR sophistication. A sophisticated CR should have high performance measures associated with **questions 2.6.1 to 2.6.6**. These questions measure the CR's understanding of the project's constraints, ability to quickly make authoritative decisions, ability to effectively brief the design team, stability of decisions, and the CR's ability to contribute ideas to both the design process and construction process.

Ability of the CR may not, however, be sufficient to facilitate a convergence of management effort directed towards achievement of stated project goals. The need for team confidence is explored in questions 2.7.1 to 2.7.8. **Question 2.7.2 and 2.7.4** relate to CR confidence in the project design and construction team groups and **questions 2.7.1. and 2.7.3** measure confidence of these key team groups in the CR. **Question 2.7.5** is related to CR leadership abilities to mould shared project objectives. **Question 2.7.6 and**

2.7.7 relate to the CR's ability to accept and contribute positive ideas. **Question 2.7.8** measures the overall contribution of the CR to project harmony.

Questions 2.1 to 2.7, and their associated sub-questions, provide an aid to establishing a clear picture of the competence and conduct of the CR. Further questions (discussed later in this chapter) elicit information which provides measures of CR management style and performance as perceived by the manager of the construction team.

### **3.4 PROJECT COMPLEXITY DETAILS - INHERENT SITE CONDITIONS**

Problems arising out of inherent on-site conditions pose potential risks. Strategies for dealing with these risks, if identified, can be formulated and appropriate management action can result in adequate provision for the risk and management of the risk impact. An estimation of ground conditions, known and anticipated, measures the impact of this category upon CTP for new work. A similar assessment must be made for sites where demolition or renovation work is to be undertaken.

The nature of inherent site conditions affects perceived complexity. This question is asked to provide some measure of risks facing a builder. Some respondents found difficulty in separating the identification of inherent site conditions risk factors and site access factors for constrained sites, or other problems relating movement of materials and manpower resources around site, presents complexity. Respondents were asked to direct their comments and assessment of 'degree of complexity associated with access' to question 7.1 which deal specifically with this factor.

#### **3.4.1 INHERENT SITE CONDITIONS - THE LITERATURE**

NEDO (1988, p75) cites unexpected conditions and obstacles under the ground as a significant factor in preventing fast construction times in the U.K. The report was based on a detailed sample of 60 projects built between 1984 and 1986 from a range of project types and values (£250,000 to £30 million) deliberately slanted towards complex medium and large scales projects. Information was supplemented on a questionnaire to customers and promoters of 260 projects and statistical analysis of non-detailed data was considered

on a further 8,000 commercial projects. Problems reported include: ground water and natural springs; presence of underground services including underground railways; underpinning adjacent buildings; the need for foundation re-design after encountering a range of problems; ground contamination; and archaeological finds.

The Melbourne experience is similar. Pilot study projects and other case studies reveal instances of soil chemical contamination delaying construction or hindering progress. The Bayside project in Port Melbourne (Walker 1993c), is one instance. In another example, Degenhardt<sup>1</sup> cites the construction of the Melbourne Concert Hall as an example of a project substantially delayed due to unexpected ground conditions which necessitated demolition of the majority of an existing and extensive foundation system.

Demolition works associated with site clearance or preparing for refurbishment work provides another example of this the type of risk. Whellan<sup>2</sup> (1990) detailed the difficult nature of problems facing wreckers in undertaking demolition work, particularly partial demolition in preparation for renovation works.

#### **3.4.2 INHERENT SITE CONDITIONS - QUESTIONS ASKED**

**Question 3.1** elicits information about the complexity surrounding latent conditions pertaining to the site. Site conditions may appear complex for a number of reasons. **Questions 3.2.1 to 3.2.8** served as a checklist which helped the respondents form a view of the complexity of site conditions.

This checklist comprised questions about the contribution to project complexity from: **question 3.2.1** the nature of demolition work; **question 3.2.2** nature of restoration work; **question 3.2.3** structural stability of the ground; **question 3.2.4** extent of ground

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<sup>1</sup> Mr Bill Degenhardt is principal of a Melbourne based planning and scheduling consultancy, he addressed RMIT final year students at a lecture in late 1992 on planning for risk.

<sup>2</sup> Myles Whellan was managing director of Whellan the Wrecker, an established demolition company in Melbourne until the company's insolvency in late 1990. He addressed the Building Science Forum in Melbourne on 26 March 1991 on risk associated with demolition works.

contamination; **question 3.2.5** extent of archaeological finds; **question 3.2.6** impact of water table; **question 3.2.7** impact of underground services; and **question 3.2.8** the impact of underpinning existing structures. Respondents base their rating of the complexity measure (question 3.1) on an overall impression of site conditions complexity.

### **3.5 PROJECT COMPLEXITY DETAILS - BUILDABILITY**

Designers can contribute to construction productivity in a number of ways without detracting from the quality of design. Intricate design details may not necessarily lead to low CTP, and design details that may appear simple and straight forward may prove to be both complex and time consuming to build.

Stretton and Stevens (1990, vol 2/590,594) maintain that well planned resource movement and a capacity for uninterrupted flow of work are major contributors to achieving acceptable building contract time performance. They developed the knowledge based expert system PREDICTE for estimating construction duration of high-rise commercial buildings and comparing alternative designs for construction time consequences. The system focuses on buildability issues and prompts users to answer a number of questions relating to the building's size, shape, repetition of floor configurations and the nature of finishes to the building.

Respondents from both the pilot and the 33 case history studies commented that good CTP is exemplified by a smooth workflow on a narrow range of activities and/or a flexibility to perform simultaneously work on a large number of activities. Disruption to workflow on building sites usually occurs because workers and not products have to be moved. In some cases, factory conditions can be established, where workers remain relatively static and materials and/or components are brought to them. Work on building sites tend to lack the level of output achievable under factory conditions because the design of components, space and access constraints may not facilitate a production-line approach.

#### **3.5.1 BUILDABILITY - THE LITERATURE**

Gray (1983, p4-5) explains the importance of buildability as follows *'... if operations which*

*interrupt the flow of work by one skill could be removed, then that skill could continue more productively ... by amending the design the sequence can be changed to produce a simpler sequence of work packages, which can then be examined to achieve simplification within themselves. In this way the increase in productivity will be lead by the design but in practice will only take place if the implications can be analysed and evaluated.'* NEDO (1988, p69) supports Gray's view stating that *'many projects were wanting in their concern for the practical aspects of construction: 'fiddly' details, awkward positioning, impractical material combinations, difficult junctions - particularly between the roof and the frame - complicated and slowed the work on site.'* In a comprehensive review of the literature pertaining to buildability Hon *et al.* (1988/89) links buildability with early involvement with the builder and the builder's quality of project planning, quality of design detailing and efficient project organisation and management. Complexity of form of construction in the view of the above sources appears to revolve around 'design buildability' and the ease with which builders translate the design into the constructed form.

The issue of ensuring that designs are practical and buildable will be considered later under a discussion of management factors. Scrutiny of the literature reveals that risk is not so much associated with the form and complexity of design, but with how the builder can devise standard or novel technologies to construct the building to overcome difficulties associated with a complex design.

One factor that influences buildability is the degree to which the design inhibits the ability of the builder to adopt a production-line approach to building (Walker 1989, p199-200). This applies to achievable levels of repetition as well as ease of re-deploying work crews to other work faces in the event work on one set of tasks being disrupted. Greater degrees of repetition of tasks increases productivity through operatives gaining proficiency through the learning or experience curve effect (Chase and Aquilano 1981, p605). Bennett and Ormerod (1984, p231) qualify the impact of the learning curve effect, cautioning that there will be variability of production output due to individual and group motivation, other behavioural factors, general disruptions, and fatigue.

While it is difficult to accurately model the learning curve effect, facilitating continuous workflow and/or maximising flexibility in use of the on-site labour, can have a significant

effect upon production output for those activities on or close to critical path. A complex looking design may be considered simple if the design team bear in mind that builders can achieve high productivity when a steady workflow is maintained. It is possible, therefore, for well thought through design to meet aesthetical high standards and be of a buildable design with the potential for high rates of productivity.

Two Melbourne projects in the pilot study exhibiting fast construction rate, as measured in cost per month constructed, were the Shell Building and Coles-Myer Headquarters. Both projects were very different in design, the Shell Building is a high rise structure with a sweeping curved facade and stepped roof profile, and the Coles-Myer Headquarters is low rise comprising a series of inter-connected nodes. In both cases design was modular allowing for task repetition and smooth activity sequencing.

Ireland's (1983, p106-107) conclusions that production performance is related to project scale, with greater performance for larger floor area buildings can be explained in the light of a builder's capacity to adopt a production line approach and/or opening up of multiple workfaces. This may be due to large areas of low-rise construction being available for work to proceed. Typically large shopping centres, factory or warehouse, and medium to low rise office projects offer opportunities for flexibility of work rescheduling to overcome bottlenecks in production or materials delivery/supply problems. It follows from this interpretation that buildability may not be intrinsically a factor, rather due to construction management planning and control performance which may be enhanced or simplified by a design that promotes good workflow.

### **3.5.2 BUILDABILITY - QUESTIONS ASKED**

**Question 4.1** requests information on the impression of the extent to which general buildability affected project complexity. This impression is based upon the impact upon the smooth flow of construction work of the design and is helpful in assessing the contribution to CTP of the design team as well as being a measure of effective design briefing.



**Questions 4.2.1 to 4.2.4** are asked to identify responses to a number of conditions which may affect design buildability including: **question 4.2.1** for scope for off-site fabrication (which may help or hinder CTP); **question 4.2.2** for complexity of off-site fabrication components; **question 4.2.3** for appropriateness of design tolerances; **question 4.2.4** for appropriateness of working space; **question 4.2.5** for implication of design upon trade coordination; **question 4.2.6** for the impact of materials storage and movement; and **question 4.2.7** for the impact of design upon activity workflow and sequencing.

The questions do not imply that design solutions that allow for pre-fabrication of components necessarily achieve good buildability. Indeed such a design solution may impose complexity due to tight or inappropriate fixing tolerances, working space, or complexity of fixing details.

Design buildability issues also include the impact of the design solution upon access within site. Questions 4.2.5, 4.2.6 and 4.2.7 help measure the impact of the design on the builder's capacity to achieve a smooth flow of work that optimises the resources used, their sequence of use and their coordination of availability.

A project may have design buildability characteristics which simplify the problems facing the builder, for example, designing a floor slab system that minimises the requirement for back-propping or minimising the time that support systems or falsework is required. Similarly, a seemingly straight forward design solution for a cladding system may require the coordination of several trades adding complexity to the management of the project.

### **3.6 PROJECT COMPLEXITY DETAILS - QUALITY OF DESIGN COORDINATION**

Interviewees in the pilot survey commented that design coordination contributes to a perception of design complexity. Many of the projects in the study had a significant services component and typical comments about quality of design complexity related to design details being missed or appearing differently on various drawings. Typically, pipe runs on hydraulic or fire services drawings were not fully coordinated with structural drawings so that the location and manner of some penetrations through structural elements

had to be resolved during construction. This often caused inconvenience and delay to the flow of work which in many cases negated the benefits of a design that was otherwise 'buildable'. Other lack of coordination examples relate to incorrect issue of revisions of drawings or other critical contract information. If work proceeds based on superseded information then there may be a critical changes which may lead to delays or demolition and/or re-working being required.

### 3.6.1 DESIGN COORDINATION - THE LITERATURE

(NEDO 1987, p3) states that *'the design process is difficult enough to control when there are several disciplines to bring together, each of which can affect the performance of others. If information is incomplete or erroneous at time of tender, tenderers have little chance to assess the resources required and price accordingly. The customer's principal adviser should coordinate the contributions from all the design specialists'*. NEDO (1987, p31) also concluded that:

- ☐ *'Time constraints did not necessarily lead to poor quality; unrealistic constraints led to problems.'*
- ☐ *'Late and incomplete project information was a frustration on many sites. It lead site managers to spend an undue amount of their time on chasing information rather than on managing their job and on quality control.'*

Poor design coordination may result from inadequate attention being given to detailed design or it may follow from a general atmosphere of haste surrounding fast-tracked projects. While overlap of design and construction can save time for the client, it may cause delays during the construction phase from problems associated with design coordination and design detailing. Problems occurring from fast-tracking design include: lack of coordination due to design instability; unclear or missing information due to unavailable finalised documentation; and design details that will not work because of hasty design production betraying a lack of proper consideration. NEDO (1987, p18 & 19) illustrates general design quality problems shared by a fast-track approach.

Quality of design skills also comes under scrutiny. Burbridge (1987, p16) lists five main faults identified as causing failure in design quality:

- ☐ *'faulty lines of communication between participants in the design process;*

- ☐ *inadequate information available, or failure to check necessary information;*
- ☐ *inadequate reviews, checks and corrective control;*
- ☐ *lack of technical expertise;*
- ☐ *failure to obtain feedback and learn from mistakes.*

Remedy of these faults lies in management of the design process, however, the potential existence of these design faults must be recognised when predicting how long a project will take to construct. An unwelcomed result of faults described above is a plethora of design variations which has been argued as one cause of poor building contract time performance (Ireland 1985, p85). Recent work provides provide interesting results from a study into causes of design variations based on 32 Australian projects and 6,266 contract variations. The study indicates that the two most significant categories of variations generated are design documentation, 51% of the total number of variations, and client sources variations, 16% of all variations (Choy and Sidwell 1991, p29).

NEDO (1987) also draws attention to the extent of poor design detailing that can render a building design complex to work with. Valuable construction time may be lost with temporary 'holds' being placed on parts of a project while design detail inconsistencies, errors or confusions are resolved. This type of delay can break continuity in construction activity and disrupt workflow. NEDO (1987, p18-19) presents evidence to support strong association between poor design detailing and construction delays.

### **3.6.2 DESIGN COORDINATION - QUESTIONS ASKED**

**Question 5.1** requests information on the impression of the extent to which general design coordination affected project complexity. This question allows respondents to rate the impact of the performance of the design team and CR in moulding the design documents as useful working documents.

Principal influencing factors have been identified and **questions 5.2.1 to 5.2.6** allow measurement of the overall quality of design coordination. Questions pertaining to conflicting design information (**question 5.2.1**), missing information (**question 5.2.3**),

dimensional inaccuracies (**question 5.2.4**), and thoughtful location and provision of penetrations (**question 5.2.5**) provide a picture of design quality performance from a practical rather than aesthetic point of view. This picture is further textured with information about the ability of the design team to maintain current information available and issued to those at the coal-face. **Questions 5.2.2 and 5.2.6** measure the design team's responsiveness to the exigencies of maintaining the currency of design information which helps to minimise re-working and/or mis-use of resources.

Linkage between aspects of design coordination and to management issues are addressed later in questions relating to design team management performance.

### **3.7 PROJECT COMPLEXITY DETAILS - QUALITY MANAGEMENT (QM) PROCEDURES**

A key factor in achieving good CTP appears to be designing the building and drafting contract conditions to facilitate the builder's capacity to minimise interruptions and increase work package flexibility. Quality management related contract conditions include formal and informal arrangements for assuring that work produced is in accordance with that stated in the contract documents.

Useful and effective QM procedures are not necessarily formal or recognised though there has been a greater focus on QM in recent years. It is postulated that a useful QM system will assist CTP by ensuring that re-working is minimised, i.e. that the work is correct first time. This may affect CTP by facilitating better planning of the works and coordination of productive resources.

#### **3.7.1 QM - THE LITERATURE**

Chauhan and Chiang (1989, p138) believe that contract conditions containing ambiguous clauses, complicated inspection procedures and poor dispute resolution mechanisms increase project complexity. Quality performance is one potential area of dispute where the client's representative may require that work deemed sub-standard be rectified; this may impose time burdens upon builders and sub-contractors.

Numerous industry experts interviewed in the pilot study maintain that contract conditions were rarely invoked in the initial stages of dispute resolution. It was felt that contract conditions were useful in arguing points in a court of law or when using an arbitrator, however, good faith and common sense usually prevailed. Disputes between builder and sub-contractor are generally settled quickly as it is in the interest of both parties to resolve disputes quickly so that good workflow can be maintained. This is as important to a sub-contractor who has, no doubt, priced the job on the basis of continuous workflow; likewise the builder or construction manager. For serious disruption to occur, sub-contractors or the builder/construction manager would have to place stop-work bans on critical activities.

Inappropriate quality management systems may impose complicated quality checks of work requiring breaks in continuity. This may result in disruptions to construction workflow due to a need for checking the accuracy of set-out or other disruptive detailed checks. Lack of consideration by designers to requirements for working space and specification of quality standards that impose unrealistically tight tolerances also contribute to a design that inhibits smooth workflow.

Standards Association of Australia (1985) as 'fitness for purpose' this means that the design specification should reflect the client's needs/requirement and not be simply viewed as 'the best'. Feigenbaum (1961) discussed the theme of management of quality in terms of getting products right the first time with emphasis on defect prevention to minimise the need for routine inspection. He saw the burden of quality proof '*.. resting not with inspection but with the makers of the part: machinist, assembly foremen, vendor, as the case may be*'. This has lead to a trend towards quality assurance (QA) rather than quality control (QC) where the provider of a good or service assures the quality through adherence to a system of quality management (QM).

It is useful at this stage to review the Australian Quality Standard so that an appreciation can be gained of the scope of effort required to manage the quality process and possible impact this may have upon CTP. Australian standard (AS) 2990, Quality Systems for Engineering and Construction Projects, defines the minimum requirements of three

different categories of quality systems. The categories are designated A, B and C.

Category A is the most comprehensive with a progressive reduction in requirements for B and C. Requirements not only reduce in number but are less comprehensive.

Category C (the lowest level) aims to provide objective evidence that the contractor requirements are met. It requires the contractor to plan and establish an inspection system for identifying non-conformance. It also requires a documentation inspection and test plan, but otherwise does not require the system to be documented unless specified in the contract.

Category B also primarily requires identifying non-conformance but in accordance with the inspection and test plan submitted to the customer. In addition, it requires a Quality Manual and documented description of elements/activities affecting quality. Category A introduces more sophisticated planning and control to prevent deficiencies occurring in the first place rather than merely correcting them when they are encountered. Feedback control is included to correct the cause of defective products or services or deficiencies in the system when they are encountered. Documented system procedures are required.

Martin (1988) notes that it is essential when using AS 2990, that the customer selects the most appropriate category for the specific contract to be let because specifying too high a category may result in excessive costs without improvement in quality. Choosing an inappropriate category may also affect time performance as inspection requirements may lead to breaks in workflow, particularly if quality inspection personnel are not available when required.

NEDO (1987, p17) citing Building Research Establishment (BRE) studies of communication and control of quality on a wide variety of non-housing projects, stated that: '*.. Projects with quality problems were often those which were behind with their program ... Tight contract times did not necessarily militate against quality ..*'

Rounds and Chi (1985, p121) believe that a growing interest has developed in the need for a shift in emphasis from 'controlling quality' to 'controlling management for quality'. This process encourages policies to be defined to address quality, for the control of quality and for management of a quality control system. Furthermore, groups of team members facing day-to-day problems where improved work methods, processes and feedback of information are formally established to identify problems suggest feasible action plans and implement approved changes to work methods to minimise waste and achieve improved quality. These groups have been described as quality circles (QCs).

Gilly *et al* (1987, p431) document the rise of QCs in the Japanese construction industry with the 'oil shock' of 1973 as being the principal stimulus to increase productivity and a disastrous failure of a sheet piling system by the Takenaka Kometan Company raising critical safety/quality issues. The result of those stimuli, compounded by a growing awareness of the benefits derived from QC in the manufacturing sector, spurred the use of QCs in the construction industry and as Gilly *et al* observe (1987, p432) '*there are many indications that QC programs are effective in improving labour motivation and morale*'. In their paper they cite three from numerous case studies that document success of QCs including 15% cost reductions in cost on a nuclear power plant, 11.4% reduction in rejection rates of a concrete mixing plant, and a 10% increase in productivity on reinforced concrete work.

Effective management of quality does not mean that time is traded for quality. Szafraniec (1989) and Rosenfeld *et al.* (1992, p32) maintain that quality, cost and productivity are interrelated so that when quality is raised, costs are lowered and productivity is enhanced through lower rejection rates, fewer instances of re-working completed products and improved flow of work. Clearly there is a significant growing interest in quality management and the benefits that can be derived.

The key QM issue affecting CTP is the impact of the quality management procedures on workflow and resolution of disputes that relate to contract documents. In part this may be determined by the design team's response to requests for information or resolving quality issue disputes. Contract documents should determine the extent and degree of inspection,

approval and quality management procedures. Contract documents should also provide an indication of mechanisms available to resolve disputes over quality and other matters.

Expert opinion of those managing the construction process from the pilot study indicates that an appropriately designed and implemented quality management system may assist, and not hinder, good CTP. This may be because QM systems encourage better specification of acceptable standards, approval of prototypes, and planning so that work is completed properly first time and not after re-working or demolition and re-building)

It became evident from some of the case studies undertaken in this work that the use of prototypes built to an agreed quality assisted in both decision making and planning of the work. Prototyping also allows designers and constructors to experience difficulties with the practicalities of a design so that a more buildable product can be agreed upon.

Specification of a QM system must, however, take into account inspection requirements, adequacy of inspection resources available, the timing of inspections with relation to activity sequencing and how this may affect CTP.

### **3.7.2 QM - QUESTIONS ASKED**

Many respondents had initial difficulty in responding to **question 6.1** which measures the outcome of the QM procedures upon perceived complexity of the project. Few projects involved a requirement for a QM system to be enforced. Respondents not operating a QM system either had an internal inspection and approval of work operating as work progressed, or had little or no formalised system of managing quality.

**Questions 6.2.1** measuring timely QM inspection procedures and **question 6.2.2** adequate QM inspection resources, focus on the requirements of the contract form or normal QM procedures adopted by the builder to adequately inspect quality of work. **Question 6.2.3** relates to the use of QM documentation and its impact upon CTP. **Question 6.2.4** relates to rejection rates for work which was linked to quality of design specification as well as quality of work produced. **Question 6.2.5** relates to clean/dry working environment



requirements. Only high-tech production facilities projects appeared to require clean or dry working areas, though on some refurbishment projects there were client constraints for cleanliness of work areas.

### **3.8 PROJECT COMPLEXITY DETAILS - SITE ACCESS CONSIDERATIONS**

This issue emerged as a focal point during discussions in the pilot study (Walker 1988) in determining which factors affecting CTP appeared to be prominent. Two issues are bound up in this category. Access to site and access within site. Access to site was not generally an issue as the sample of case studies were restricted to the Melbourne Metropolitan area.

Remote sites pose many potential access problems: access to workers; access to materials; access for equipment; and access to transport and other infrastructure facilities. Although these problems may be overcome by taking appropriate managerial action, there is still a potential for poor CTP due to the inherent risk associated with working on remote sites. Shmall and Aronov (1990) discuss particular problems associated with undertaking construction work in Siberia and the far north regions of the USSR where transport communication is completely absent. Their discussion also includes strategies to minimise the effect of these problems including using helicopter and river transport and more importantly using off-site fabrication of components in locations where there is greater access to resources. Difficulties encountered in the former Soviet union are encountered elsewhere in remote locations, notably in Canada (Walker 1978). Australia has examples of construction undertaken in remote areas, notably in developing outback mining infrastructure, however, this case studies were restricted the Melbourne area.

#### **3.8.1 SITE ACCESS - THE LITERATURE**

While access poses problems of complexity, sound management through good advanced planning can obviate many of these problems. Gray and Little (1985, p133) discuss an expert system that helps planners rapidly select appropriate craneage for construction projects and they stress the importance of access both within site and to site in the selection of appropriate materials movement equipment and how this influences floor cycle times. Redden (1989, p13) in a discussion of a number of case histories taken from

projects undertaken by the Baulderstone-Hornibrook group, outlines access problems for the Sydney Convention Centre project at Darling Harbour. The builder sought solutions to counter this constraint by extensive off-site fabrication and by influencing the design team to consider structural system design changes to mitigate access problems inherent in the site location. Redden (1989, p17) concludes that '*.. more and more the responsibility for managing the design/construction and commissioning process of a development will be assumed by the builder*'. When interviewing case study respondents from both the pilot study and 33 case study, many cited access problems as being a principal element of project complexity that can be overcome with good management expertise.

Access to and within site sets parameters within which possible combinations of resource movement options are selected in view of load capacity of equipment and estimated weight and size demands of materials to be moved around the site to determine critical lifting requirements (Furusaka and Gray 1984, p171). Gray (1986, p143) believes that the pace is set by key resources and that crane resources required to lift large components in the building are based on design features and access to the site and parts of the site.

It is reasonable to envisage that a highly congested site, or one with little or no easy access to adjacent roads or other material delivery facilities, would suffer some disruption to workflow. Burch (1985, p75) gave an example of problems associated with site access on a town centre redevelopment in the Midlands of the UK where material deliveries were allowed only outside the periods of 10:00 and 15:00 hours, Mondays to Saturdays inclusive. He also observed that on smaller confined sites, access on to the site may be impossible for large delivery vehicles.

Many of the respondents of the pilot study (Walker 1988) regarded appropriate resource movement strategies as holding the key to determine floor cycle times. This conviction has been confirmed by others (Falloon 1990; Stretton and Stevens 1990; Oxley and Poskitt 1986; Hinkley 1989; Halpin and Woodhead 1976). Access within site can be inhibited in many ways.

Client or community demands due to concerns over dust or noise may result in access to particular areas being restricted, this can be particularly evident in refurbishment works when tenants are still occupying parts of a building. Existing tenant security concerns can also impose access problems with no-go areas: prisons, banks and medical laboratories are examples that illustrate this condition. Concern about construction noise may also result in the imposition of constrained access times for work near educational institutions, hospitals or factories where worker's exposure to noise may be an issue.

### **3.8.2 SITE ACCESS - QUESTIONS ASKED**

**Question 7.1** measures the perceived complexity associated with access to or within site. This question was developed from experience gained in testing the pilot study. It became evident that this may be a strong factor in determining CTP as it influences the ability of the builder to maintain workflow.

**Question 7.2.1**, proximity to required resources was asked to test whether any of the conditions experienced at remote sites were present in metropolitan sites. This question could not be ignored even though it is believed to be more significant for remote location projects or for projects where significant and critical components are not readily available.

**Questions 7.2.2**, access to site entry/exit points, and **question 7.2.3**, congestion at site entry/exit points, relate to peculiarities associated with the site layout and position. One may, for example, have a large open site but it may be bordered on all sides by difficult obstacles so that limited access is featured. Alternatively, a city business district location may appear to present a cramped site, however, there maybe good access at each face of the site border.

**Questions 7.2.4**, building footprint to site area, **question 7.2.5** storage space at or near ground level, and **question 7.2.6** storage space at upper levels, reflect the capacity of construction teams to provide temporary storage space for the builder to store materials and establish site accommodation.

Issues of access within site due to the design solution were tackled under the category of design buildability. Issues pertaining to access considerations dominated by a need to maintain the working environment of existing tenants is dealt with in **question 7.2.7**.

### **3.9 OVERALL PROJECT COMPLEXITY**

A summarised measure of project complexity was developed to test if this measure may be as useful as detailed measures of complexity as discussed above.

**Question 7.3** provides an overall assessment of the survey respondent's opinion that those characteristics over which the CM team has little control, had an influence upon CTP.

### **3.10 PROJECT ENVIRONMENT DETAILS - PHYSICAL ENVIRONMENT CONSIDERATIONS**

A number of environment complexity aspects are investigated using the research instrument. The pilot study questionnaire briefly touched on these issues but only addressed the industrial relations climate. Greater depth of investigation is sought in this research instrument, however, with detailed questions being asked on the physical, economic, socio-political and industrial relations environments operating during the construction phase of projects under scrutiny.

CTP may be affected by the nature of the physical environment at the location where production is taking place. Two specific aspects of the physical environment will be discussed in this section: geographical and climatic/weather factors.

Climatic or weather conditions impose a potential for adversely or favourably affecting productivity; managerial action will be influenced by this potential and determine how this potential is translated into actual influences on the production process.

Geographical or topographical factors may also influence CTP; the influence of location, and specifically problems associated with remote sites or distance from transport infrastructure facilities has been previously discussed at length (Walker 1990a, p17). The effect of these influences must be considered and appropriate managerial action taken with

due consideration of the degree of risk involved.

### **3.10.1 PHYSICAL ENVIRONMENT - THE LITERATURE**

Weather conditions and the general climate may significantly affect CTP despite the best endeavours of site management staff. The planning and development of strategies for dealing with the influence of climate is under the control of management and can, therefore, be viewed as a management related factor influencing CTP. Climate and weather conditions have a potential impact upon CTP which may, or may not be realised. One can infer the impact of inclement weather from site management records of lost time due to inclement weather. It is less easy to infer the impact of good weather upon the construction process.

Ireland (1988, p23) reports on time lost due to inclement weather as a percentage of days worked on 25 projects in Brisbane, Melbourne and Sydney in Australia. His findings indicate wild fluctuations in time lost with a 11.03% sample average. The minimum result, however, was 0% and the maximum 63.6% with a 12.15% standard deviation. Two projects appeared to be well outside expected delay figures, one being 25.6% and the other 63.6% delay as a percentage of days worked. There was no further information on specific causes of delay, though Ireland's report (1988, p23) states that there appeared to be a correlation between inclement weather and a high level of industrial disputes. One project, for example, with a 63.6% inclement weather delay also suffered a 143.3% time loss due to industrial disputes.

In 1988, safety issues comprised the largest single issue dealt with by the Victorian Building Industry Agreement Disputes Board (DOL 1988, p31). In the period 14th August 1987 to 12th August 1988, it was reported that safety issues accounted for 41.5% of the claims heard by the Disputes Board. Bill Wallace<sup>3</sup>, one of the Board members at that

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<sup>3</sup> Mr Bill Wallace who was also a member of the negotiating team representing the Master Builders of Victoria in the establishment of the Victorian Building Industry Agreement 1987 to 1989 and its successor agreement 1989 to 1992.

time, commented that a number of claims for work stoppages based on inclement weather were a myth as the real issue determining a stoppage is safety in specific areas of a site as a result of inclement weather such as high winds stopping cranes, wet weather making specific work surfaces slippery or hot weather making metal surfaces unsafe to touch. Clearly any statistical evidence gathered, regardless of the sample size, and analysed in published reports and research studies can only provide an approximate guide to the effect of weather or climate upon delays to projects.

The 1987 to 1989 and 1989 to 1992 Victorian Building Industry Agreements included a clause providing for employees to continue working on a site affected by inclement weather (but only in areas not affected by the weather). This clause addresses one of the recommendation in Ireland's report (1988, p5) that '*no direct payment be made to employees for days on which inclement weather occurs.*' This provision stops the prior propensity for the entire workforce on sites to cease work and go home citing inclement weather as grounds for these actions. Attachment B in the VBIA (1987) and Clause 17 in the VBIA (1989) agreements provides for workers to be transferred to other sites or work on a part of the site unaffected by the weather.

CIOB (1985, p81) state that the effect of weather upon the construction process depends upon the location of the site; the nature of the construction assembly processes; and the time of the year or day during which these might occur. Site location may, or may not, however, provide an indication of likely problems that may be encountered with inclement weather. It can be argued that general climatic conditions can be anticipated for a general geographical location, however, considerable variation in climate can occur within any general area. Topographical features can affect construction operations by producing weather patterns non-typical of surrounding areas (CIOB 1985, p84). In Melbourne, for example, cranes can be halted on one side of a site due to localised effects of wind direction and wind force while other cranes are working safely and effectively on another side of the same site. Influence of the physical climate is a separate issue to that of inherent site conditions

**3.10.2 PHYSICAL ENVIRONMENT - QUESTIONS ASKED**

**Question 8.1** is aimed at gaining a general impression of the impact of physical environmental conditions upon CTP.

**Question 8.2.2** seeks information on the impact of natural hazards and **question 8.2.3** seeks information about the general and local physical environment. Several projects were commenced during some of the wettest weather in recent history. Several of the sites were also located in Melbourne's eastern suburbs within the rain-shadow of the Dandenong Ranges. This imposed special environmental conditions upon projects relative to others in different locations in the general region. This influence may make its impact evident during critical periods of construction when exposure to the elements inhibits CTP.

Risk from natural hazards posed in **question 8.2.4** ambient noise conditions, and **question 8.2.5** ambient light conditions were generally regarded a rarity. One project located close to a sewage pumping station, however, was deemed to have had minor impact upon CTP through the environmental influence of smell.

**3.11 PROJECT ENVIRONMENT DETAILS - ECONOMIC ENVIRONMENT CONSIDERATIONS**

The economies of all countries in the world experience periodic surges in investment in the built environment, frequently described as boom and bust cycles. The economic environment can affect CTP by influencing the construction management team's ability to effectively utilise resources. The macro-economy influences the general economy and availability of resources for firms to use. It also influences money supply, export and import trading policy, credit policy and other measures that affect the whole economy - and thus the firm.

The micro-economy indirectly influences the firm through its competitors, customers and suppliers which in turn influence the firm's ability to utilise available resources. Recent micro-economic reform in the transport system, the docks system and other industries workplace reform affects the trading relationship of individual firms in the way they

conduct their business. The economy is in a permanent state of flux and this means that firms are required to adjust to changed circumstances, review how they are affected and act accordingly.

#### **3.11.1 ECONOMIC ENVIRONMENT - THE LITERATURE**

Non-residential construction expenditure decreased during 1990-91 following six years of growth, primarily in office construction (according to the Australian Bureau of Statistics (ABS) records of construction activity). At the peak of the boom, output was almost 50% higher than the 1985-6 period.

The capacity for builders to attract adequate resources is partially determined by the business cycle. Suppliers of resource inputs (materials, labour, equipment and services) enter or leave the industry at a rate governed by perceived profit potential. Once suppliers perceive that it is in their interests to expand their activities and do so, a stabilisation point at higher construction activity (that is at the boom) is established. The boom may maintain its surge with a balance of supply and demand as innovations are introduced to effectively increase productivity. This has been evidenced in the most recent construction boom by changed work-practices accepted by the union movement.

In the last phase of the boom and bust cycle (the bust) demand stalls (often quite dramatically) leaving high levels of supply, high levels of competition and excess resources available for use. Many companies may hold excess resources in reserve hoping to 'win' projects. This may result in widespread insolvencies of firms and unemployment. As the bust part of the cycle firmly grips the industry, many resource providers remove themselves from the industry. Companies with low cost barriers to entry e.g. labour-only sub-contractors, will drop out more quickly because as their cost of carrying labour becomes unattractive they will shed labour and attempt to re-hire when contracts are won. Companies with high barriers to entry e.g. those with specialised skilled labour or expensive or difficult to obtain plant or equipment, would tend to remain in business as long as they can sustain their cashflow.



During the onset of boom times, suppliers of resources may lack confidence in demand for their inputs resulting in their slow entry into the market or, if they are already in the market, expansion of their activities. This will lead to demand exceeding supply and resultant shortages of resources may translate to lower CTP and resource bottle-necks. This may manifest itself in shortages for specific materials e.g. steel, concrete, specialised equipment e.g. cranes or shortages of labour e.g. management staff, or specific trades e.g. steel fixers or plasterers.

Firms may be offering uncompetitive terms and conditions to their staff, suppliers or sub-contractors, so resource shortages may occur during the early stages of the boom and bust cycle. Shortages of equipment may result in inappropriate use of equipment resulting in lower levels of productivity than would otherwise be the case. Shortages of skilled professional management may result in sites being staffed by a management team that is less experienced than normally available, or one that tends to make errors of judgement leading to poor CTP.

Micro-economic reform has attracted the attention of all significant political parties in Australia. In New South Wales a commission into productivity in the construction industry has completed its hearings. In Victoria a review of work practices is being undertaken through the auspices of the Construction Industry Development Agency (CIDA). The outcome of these research efforts will be policy proposals which, if implemented, will alter the industrial relations climate and system which operated in the past. The impact that micro-economic reform will have upon individual firms or the industry in general remains to be evaluated.

Many inefficient work practices stemming from unreasonable interpretation of occupational health and safety (OHS) regulations were reduced by negotiations which resulted in the Victorian Building Industry Agreements (VBIA 1987, p15) and (VBIA 1989, p33-37). Substitution of labour in short supply with technology takes place, for example, widespread use of nail guns in lieu of hammer and nails, and precast concrete slab systems in lieu of in-situ concrete such as Transform<sup>™</sup> and innovations in gypsum

pre-formed products such as preformed plasterboard bulkhead sections, lift shaft and duct shaft walls, and column casings. Multiplex Constructions used these innovations in plasterboard technology in 1991 and 1992 on the Hotel Australia project in Melbourne. Substitution of prefabricated materials and equipment for on-site labour helps to make construction activities more productive but it is unclear whether this directly leads to productivity increases as technological advances are not necessarily tied to management productivity advances.

Construction projects may be halted by company insolvency affecting builders originally engaged upon a project or builders taking over a project that has been affected by company insolvency. Frequently a result of this consequential insolvency is a breakdown in coordination between builder and subcontractor, between sub-contractors and between sub-contractors and suppliers. This may lead to progressive paralysis of construction work with an eventual stoppage of all building activity on and off site.

Problems may also arise in getting rectification work completed when sub-contractors or suppliers become insolvent after practical completion. If a sub-contractor or supplier becomes insolvent, the builder must either take over the works directly or replace the bankrupt party. Work can continue on the project except on the areas affected by the insolvent sub-contractor or supplier.

Plant and Wilson (1989/90) investigated the problem of trade contractors defaulting on five construction projects in Melbourne. Their paper concentrated on contractual relationships and actions taken by site managers in damage management resulting from these insolvencies. Their findings indicate that site management minimised adverse affects to CTP through pursuing a constructive approach to getting work done rather than pursuing litigation as a remedy. This approach includes assisting the trade contractors by quickly processing and making progress payments to allow the companies to continue trading, re-tendering or negotiating with other trade contractors to replace the defaulting trade contractor, employing the trade contractor's work-force directly themselves on a daywork basis and negotiating with non-performing trade contractors to reduce the scope

of their works and re-assign that work to others.

Whatever the basis for the insolvency, all legal issues related to asset ownership of the project, on-site and off-site, have to be resolved before construction work can re-commence. This may contribute to extending the completion of a project.

Five case histories of builders taking over projects from insolvent predecessors was investigated (Walker 1993a, p47). The results of the research indicates that a number of risks caused by the insolvency of a builder or developer can be identified and avoided through taking appropriate managerial action. The following risks were identified from that study.

- ☐ *There is a risk associated with under-estimating the cost and time required to complete the project. An adequate audit of work remaining and work requiring rectification or demolition needs to be undertaken to quantify this risk.*
- ☐ *There is a risk of having to demolish and rectify poor quality work. Builder insolvency is probably preceded by poor supervision with trades being built-out.*
- ☐ *There is a risk of contractual disputes stemming from previous site management action being raised which may influence supply of materials or the installation of components on-site once work resumes.*
- ☐ *There is a risk that previous industrial relations disputes may be inherited by a new on-site management team.*
- ☐ *There may be a risk in locating documentation required to obtain necessary permits for project hand-over.*

The major thread that weaves through this section is that the economic environment directly affects individual projects through access to, and quality of, available resources. NEDO (1988, p75) highlighted 'labour shortages, low and erratic resourcing by subcontractors' as one characteristic of slow projects.

### **3.11.2 ECONOMIC ENVIRONMENT - QUESTIONS ASKED**

Case study projects were selected to straddle the boom and bust cycle of the late 1980's to early 1990's. **Question 9.1** is asked to gauge the impact of economic conditions upon CTP.

**Question 9.2.1** materials availability, **question 9.2.2** equipment availability, **question 9.2.3** trades/operative availability, and **question 9.2.4** supervision staff availability, relates to the impact of critical resource shortages or surpluses resulting from the phase of the economic boom-bust cycle. **Question 9.2.5** indirect impact of interest rates or inflation rates is posed to find out if there was a perception that the interest rate and inflation environment affected CTP.

**Question 9.2.6** is asked to assess the impact of sub-contractor and/or supplier insolvency upon CTP.

### **3.12 PROJECT ENVIRONMENT DETAILS - SOCIO-POLITICAL ENVIRONMENT CONSIDERATIONS**

The socio-political environment can affect CTP by influencing the construction management team's ability to effectively utilise resources. The socio-political environment is defined in this thesis as: those matters of policy and political activity that establish a framework within which laws and regulations are administered and the environment in which they are administered. Public sector utilities such as providers of electric power, telephone and fax communications, water and sewerage may also affect CTP as there is often a regulatory requirement for inspection of utility connections.

Projects of national or strategic importance may be affected by special acts of parliament but such cases are rare. Planning legislation can affect the start of a project but cannot directly delay or stop projects once they have commenced. Direct state government legislation may be passed to permit projects to proceed, the Rialto project in Melbourne's central business district is one example of this.

Local action and protest groups can exert political pressure that may result in delays to construction, particularly if building unions or union members are persuaded to convert a political issue into an industrial dispute. The 'green bans' of the early to mid 1970's (Mundey 1981) provide a potent example of this, attempts to delay the landing of tropical hardwoods at the docks is another.

Lobby groups may also influence Local Government to pass by-laws affecting construction activities e.g. restricting construction activities under noise or traffic control legislation. Zoning legislation may also affect construction activities, particularly when planning the use of property outside the site's boundaries for temporary storage or off-site fabrication.

Australia is fortunate to have escaped much of the turmoil experienced by many countries though several much publicised but isolated incidents have occurred with protesters slowing down or stopping resource-based construction projects e.g. mining (Nookambah), forestry projects (South Gippsland), and civil engineering (The Franklin Dam and Daintree Highway).

Many countries have been engaged in civil war and a breakdown in basic law and order for decades, e.g. The Lebanon, and the former countries of Yugoslavia and the USSR. The principal difficulty, which inhibits CTP under these circumstances, lies with diversion or un-availability of resources required for undertaking construction work. Resources may include on-site operative or supervisory manpower, equipment, or materials. Serious breakdown in communications may also occur. The key issue is not the existence of political unrest but to what extent a breakdown in the supply of resources has occurred and the priority that construction work is given in resource allocation and delivery.

Potential disruption to CTP may be anticipated, however, some protest actions may be spontaneous. The following risks are considered in this work:

- ☐ the general thrust towards a 'green' political lobby group and consequential action against uses of rainforest timbers;
- ☐ protests and demonstrations affecting development of wetlands areas;
- ☐ protests and demonstrations affecting development of environmentally 'sensitive' areas - habitats containing rare species of flora or fauna;
- ☐ protests and demonstrations affecting development areas of cultural significance - aboriginal sacred sites, or popularly accepted places such as theatres, hotels, temporary parks or recreational facilities;
- ☐ protests and demonstrations regarding the use of chemical agents generally accepted as environmentally unfriendly.

### 3.12.1 SOCIO-POLITICAL ENVIRONMENT - THE LITERATURE

Two recent key aspects of environmental legislation that may affect CTP are requirements specified for disposal of toxic substances and administration of the Occupational Health and Safety Act (OHSA) of 1985.

Prior to the introduction of the Labour and Industry (Asbestos) Regulations of 1978, asbestos could be removed by hand, placed in rubbish skips and carted to a disposal tip in the same way as scrap timber, metal or plaster is removed. A complex and time consuming process is now required involving isolation of affected areas, complete dust and air control monitored by special equipment and staff, and removal procedures that add considerable time to methods previously adopted. The MBAV (1990, p22.6) recommends that '*... In the event of asbestos or any material containing asbestos being discovered on site, it shall be immediately reported to the foreman. The site foreman will immediately stop work in the area concerned and isolate that area.... The Safety Manager will arrange for removal of the asbestos by an approved specialist*'.

Section 4 of The Health (Harmful Gases, Vapours, Fumes, Mists and Dusts) Regulations of 1984 prescribe stringent regulations to apply to safe allowable limits of concentration of harmful substances to be present in the air or inhaled by persons in any way (MBAV 1990, p22.2). Employers or workplace occupiers also have a duty of care and must ensure that waste material is disposed of in a safe manner.

Myles Whellan highlights asbestos removal, dust control legislation and limitations of the use of explosives as being significant factors affecting the CTP of demolition work. The application of chemical agents to clean existing facades is another example of legislative changes affecting building construction methods. Disposal of toxic substances, resulting from washing or sand-blasting facades, into drains is presently an illegal materials disposal method.

Legislation requiring stringent cleaning of contaminated soils during the excavation phase of construction is another example affecting CTP. The clean-up of contaminated soils on the Bayside project in Port Melbourne was completed in a significantly longer time frame

than originally planned (Walker 1993c). Such stringent requirements would not have been deemed necessary before the 1980's.

Federal or State government legislation affecting projects under construction includes: occupational health and safety legislation; imported materials controls; State and Federal building regulations inconsistencies; legislation or case law precedence defining legal liability affecting construction methods, processes or construction team legal relationships; zoning by-laws or legislation.

Governments exercise the right to limit materials or construction processes to protect the general public and those in the workplace. The Occupational Health and Safety Act (OHSA) Section 21(1) states that *'An employer shall provide and maintain so far as is practicable for employees a working environment that is safe and without risks to health.'* An employee is considered, subject to Section 21(2) and (3), to include independent contractors and the employees of independent contractors at the workplace. This act has wide ranging implications to employers as it leaves the problem of definition of safety open to interpretation. OHS issues often migrate to become IR issues where a dispute arises between management and union representatives over interpretation of the terms 'a safe workplace' or 'hazardous materials' (Ireland 1988).

Creighton (1986, p55-56) notes *'that the commonsense interpretation of working environment would include: the workplace itself; the machinery of the workplace; the work process, including what is done and how; work arrangements, including shift work and overtime arrangements; the physical environment, including temperature, humidity, lighting, ventilation, space and general atmospheric conditions; and the intellectual environment, including the presence of stress factors such as cramped and overcrowded conditions, availability of recreational facilities, inadequate staffing levels, speed of process and so on.'*

The Master Builders Association of Victoria (MBAV 1990, p9.2) define hazardous materials as *'.. a material which may cause injury to persons or damage to property or plant or which may react with other materials to cause injury or damage, or in the course of normal operations, may produce dusts, gases, fumes, vapours, mists or smokes which cause injury or damage, unless appropriate safeguards are provided' .*

The process from design to construction may involve considerable lags, so construction may have started and alternative materials or processes may have to be found during the construction phase. In some cases this may pose no problem to CTP provided that alternatives are readily available and affected activities can be re-scheduled without affecting critical path activities. On other occasions, however, critical activities may be placed on hold until the problem is resolved.

Disruption to construction of projects may occur if imported material or equipment affecting critical path activities is prevented from being delivered to site due to sudden political action (e.g. imported components manufactured in Iraq during the Gulf War of 1990). Other examples of this occurring could be a ban on tropical hardwoods or quarried stone for facade treatments. In these cases work may have commenced and be at a critical stage when the political problem emerges.

Reform legislation such as the OHS Act may have a major impact upon construction methods and materials used, however, the political environment is generally predictable. Much of the legislative process involves consultation, preparation of discussion papers and debate before Acts of Parliament are passed, usually with review and some amendments in passing through the upper house. Acts then require royal assent and to be proclaimed, each stage generally takes sufficient time for managers of the design and construction process to adapt. Violent action by protest groups or terrorist cells may erupt spontaneously, however, non-violent demonstration and protest activity is generally predictable and can be anticipated with only marginal impact on CTP experienced.

Acts of Parliament generally establish broad policy or permit subordinate statutory bodies to generate policy statements which become law. There is usually sufficient time during the political process for management to accommodate changes to design and plans. These laws and regulations are usually administered by government agencies who interpret the law. Interpretation should be straight forward, building permits should be issued according to set predictable procedures, and inspections should be made promptly so that construction work can proceed expeditiously.



Unfortunately this is not always the case. On occasions, design compliance to the relevant acts is not clear and special application to a Building Referees Board may be required. The Board meets at set times and if an application is not considered it must wait until the next Board meeting. Disruptions affect CTP when delays to work on critical path activities or changes to the critical path eventuate.

In recent years, micro-economic reform has included a review of the way that government and government agencies affect the productivity of firms. One of the more important initiatives taken by governments has been the review into the building control system. Two important documents, the NEDO (1978) report and the Building Regulation Review (BRR) Task force review (1991), will be used as a basis for discussion and comparison of the experiences of the administrative environment in the U.K. and Australia.

Recent reform initiatives have begun with the establishment of the BRR Task Force by the 1989 Special Premiers Conference to undertake a review of the technical regulations and other requirements affecting the construction of buildings in Australia. In March 1991 the report was presented at public forums convened in State capital cities to form the background for debate which resulted in the Task Force's recommendations to State and Territory Governments and the Federal Government.

The report documents responsibility for regulation of land, planning and building is distributed amongst all three levels of Government.

- *'the Federal Government coordinates Commonwealth-State agreements (such as Australian Uniform Building Regulations Coordinating Council) and supports and funds national approaches to regulation including research activities;*
- *State and Territory Governments are responsible for land and building regulation (including enabling legislation) and approvals systems. They delegate some responsibilities, particularly implementation, to Local Government;*
- *Local Government implement much of the land and building regulations'.*

The current Australian building control environment does not have a consistent system of development control, but a multi-tiered, often an *ad hoc* uncoordinated approach, each

level controlling different aspects, often applying different criteria to approval of the same development. Each is dominated by different professional and technical groups.

The BRR Task Force (1991, p7) states *'....system of regulation in Australia is too complex, it serves relatively narrow interests, it does not respond to change or innovation, it is not readily accessible to the public, it creates unnecessary levels of cost and it provides only a narrow range of benefits.'*

The system is not very effective in delivering the benefits used to justify its existence and there is evidence (1991, p14) that it is also inefficient. A principal deficiency and restraint inherent in the system identified by the BRR Task Force is the development of regulation and the regulatory systems that is neither transparent nor easily understood by users. This manifests itself through disputes over design compliance with the approval authorities which may cause temporary delays or holds on sections of work while problems become resolved. Local Government is primarily responsible for approving designs, checking that construction follows approved designs and approving final occupancy. Other bodies, with different legislative mandates, may also become involved in respect of matters such as fire safety, water supply, sewerage, heritage values, environmental considerations.

Concerns expressed in the BRR Task force document are not unique to Australia. The NEDO report raises similar concerns (1988, p25). The report states that the major causes for complaint about local authorities were: *'the necessity in most parts of the country to deal with two separate authorities (district and county); the lack of consistency in decisions by the different authorities dealing with one project (eg the fire officer refusing to accept building control officer's waiver on fire protection); inconsistency of interpretation of regulations by officials in different parts of the country, especially on building control and fire; lack of consistency from fire officers from the same authority on the same building'.*

The report (NEDO 1988, p25) noted that in some local authorities one official coordinated all their decisions on a particular project and this provided a solution to many of the problems identified. The report also observes that management action can overcome difficulties, however, these efforts required diversion of effort and attention from other management activities.

The impression given by NEDO (1988) and the BRR Task Force (1991), is that local authorities and those responsible for building control interpretation and administration can greatly contribute to a project's CTP either in a positive or negative way.

Local Governments are seen as an essential part of the administrative process of land and building because they are decentralised (BRR Task Force 1991, p23). Local governments at present cover the advisory, approval, inspection, maintenance of records and enforcement rôles, except where private certification exists in some States/Territories.

The BRR Task Force argues (1991, p23) that *'local government should concentrate on advisory and enforcement activities while allowing approvals and inspections to be handled increasingly by private certifiers. The regulation of health and safety would not be impaired, while approval times and costs would be within industry control. On this basis, local government's rôle in respect of building regulation would encompass: implementation of the building approval system; guidelines for procedures; approval, certification and inspection in parallel with the private sector; advisory and archival rôles; enforcement.'*

The aspect of this environmental factor that affects CTP is dispute resolution and enforcement of building control legislation. Many disputes have to be presented to a Building Referees Board for resolution. In many cases a design solution may have to be significantly amended which often means that a hold is placed on construction works in an affected area. Any delay caused by resolution by the Building Referees may well affect activities on the critical path and thus will affect CTP.

Recent changes to the Building Regulation system has been the use of self-certification. Self-certification, defined (BRR Task Force 1991, p26) as: *'certification by an accredited industry professional of his own work; and certification by an accredited applicant or accredited employee of the applicant where the applicant is the beneficiary of the application'*, has re-introduced issues of liability which may have the effect of making local governments and others involved in the building regulations and amendment approval process more cautious.

Public utilities have been identified in the NEDO (1988, p92) report as a problem on many construction projects. A postal return from the survey of 260 projects indicated that

15% of projects with higher than average rates of construction were disrupted by utilities providers and 6% of projects with lower than average rates of construction. Results from NEDO's 60 on-site case studies indicated that hold-ups and delays presented difficulties on one third of the projects. An interesting comment was made regarding delays and the type of project as follows (NEDO 1988, p92). *'In contrast with industrial projects, the majority of commercial customers built repeatedly and often had continuous building programs. They were supported by experienced professionals who, as a rule, made it a priority to approach the utilities in good time. Despite this, a feeling of frustration was prevalent: the effort required to succeed in what was needed was considered out of proportion to the order of the problem itself.'*

The impression given in the NEDO report is one of dynamic organisations being confronted with inflexible bureaucracies with inferences of gross ineptitude on the part of the utilities, however, later in the report (page 93) the other side of the argument is presented. The principal mitigating circumstances appears to be the utilities' resource constraints when faced with emergencies as they are legally obliged to deal with emergencies as a matter of highest priority. The highest incidence of delays appeared to be weather dependent, water utilities having to respond to burst mains due to frost in January and February (in the northern hemisphere winter).

An initiative instigated by the Victorian Labour Government (1982-1985), the creation of the Major Projects Unit (MPU), in its first term of office is used to illustrate potential benefits that can be derived from a cooperative approach between government and builder/developers (Walker 1993b, 1993c). The MPU was initially able to structure the project organisation of one Melbourne project investigated in the pilot study (Walker 1988) such that building approval and certification of plans was undertaken by a private consulting organisation rather than the Melbourne City Council (MCC) and this arrangement continued throughout the life of the construction period. The Building Control Act (1981) was amended in 1987 to allow authorised consulting groups to certify plans for all manner of projects to facilitate speeding up the building approvals procedure.

This case study illustrates the need for various government and quango groups to be

coordinated so that the developer could have one point of contact, in this case the MPU, which could act with authority. The advantage of this arrangement is that there is within the government camp, a single point of contact and focus for coordination and decision making. In this respect, the MPU can be seen to have effectively taken on the rôle of consultant project manager (Barnett 1988/89, p122), however, once the project was established, a project controller was appointed to take on that rôle.

### **3.12.1 SOCIO-POLITICAL ENVIRONMENT - QUESTIONS ASKED**

**Question 10.1** is asked to determine if any political or government related influence may be detected that influences CTP. This issue was segregated into two parts, political and government/public utilities.

**Question 10.2.1** is asked to investigate evidence of civil strife or riots affecting CTP. **Questions 10.2.2** 'influence of protest action groups'; **10.2.3** 'national or local political intimidation' and **10.2.4** 'disruption' due to environmental concerns' are asked to gauge any possibility of political problems emerging that may affect CTP.

The research indicated that local authorities may have some impact upon CTP with regard to building legislation interpretation, permit processing and the creation of a generally hostile, supportive or neutral environment with which to work with statutory authorities. **Questions 10.3.1** staged permit processing, **10.3.2** programmed building inspections, **10.3.3** interpretations of codes and standards and **10.3.4** non-building approvals such as fire authorities, liquor licensing etc. are asked to determine the impact of these authorities upon CTP. A delay to occupancy and construction hand-over may occur if local authorities refuse to grant a certificate of occupancy or pursue legal remedies to cause construction work to cease.

**Question 10.3.5** deals with connection of utilities and **question 10.3.6** deals with the impact upon CTP of the coordination of multi-government departments in facilitating project development.

### **3.13 PROJECT ENVIRONMENT DETAILS - INDUSTRIAL RELATIONS (IR) ENVIRONMENT CONSIDERATIONS**

In the pilot study, many industry experts interviewed believed that a hostile IR environment posed one of the most significant threats faced by management. Industrial dispute resolution mechanisms form an infrastructure for dealing with conflict. If this infrastructure provides for a speedy resolution of conflict where all parties can settle their differences without duress, then the IR environment can be seen to mitigate the problem. An unfavourable IR environment exists where parties are unsatisfied with conflict resolution procedures, either by intimidation or other forms of duress generated by any of the parties involved in a dispute.

Grievances are often re-directed into a total range of behaviours and attitudes. Kornhauser (1954, p12-13) lists amongst dispositive forms of behaviour: strikes and lock-outs, boycotts, work-to-rule situations, work bans, demarcation and other work limitations, political actions, sit-ins, absenteeism, alcoholism, poor health, low morale and productivity, material wastage, slackness and inefficiency, go-slows, sabotage and high labour turnover.

There is current evidence to suggest that the IR environment in the construction industry reflects a more positive and coordinated outlook on how work can be structured and managed to minimise industrial conflict. Lessons, appear to be learned from the conflict (much of it political in nature) of the past two decades in the Australian construction industry. The IR environment, however, is in a state of flux; it is necessary, therefore, to review the literature and investigate IR issues over the past two decades to gain a better understanding of the nature of this environment.

#### **3.13.1 IR ENVIRONMENT - THE LITERATURE**

The pilot study indicated that IR was a crucial factor affecting CTP. Comments made by participants in this thesis' research study suggest that there appears to be a fundamental break with past IR history. A brief discussion of IR history comparing recent experience with the turbulent past follows so that it becomes clearer why questions about the IR environment were asked and why answers received were quite surprising.

Deery and Plowman (1987) explain industrial conflict in terms of structural determinants identifying the structure of industry as being the major cause of industrial conflict. They maintain (1987, p29) that work characteristics give rise to economic, technological, organisational and institutional conflict. They make the important point, in terms of the general economy, that workers naturally attempt to protect themselves against inflation and that '*... the ability of income earners to maintain real disposable wages heightens wage discontent and has implications for industrial relations and economic policy.*' They also explain technological change in terms of power, generally displacing human labour, and reducing the quantity of labour required (1987, p32). Technology also alters skills required and merges sets of skills shared by different groups of workers, often belonging to separate unions. Inter-union conflict may develop from this with a rise in demarcation disputes.

Organisational and institutional conflict stems from the institutionalisation of control. Management considers that it is their prerogative to direct and supervise 'as a right' and often resents what is seen as 'interference' by unions, government or any other external organisation. Workers, however, tend to resent the manner and application of power over this part of their lives.

There is also a cultural dimension to IR. Some industries have tightly bounded work cultures. Kerr and Siegal (1954, p191-192) explain strike-proneness of industries based on their study of the strike record of 11 countries. They state '*The miners, the sailors, the longshoremen and, to a much lesser extent, the textile workers form isolated masses.... They live in their own communities .... These communities have their own codes, myths, heroes, and social standards .... All peoples have their grievances, but what is important is that the members of each of these groups have the same grievance.*' These workers form strong cohesive unions and, being enclosed in their own culture, are not subject to external pressures to moderate their stand. Workers in the construction industry, particularly those on large sites, see themselves as a distinct community and as Boyd (1991) observed the BLF took advantage of this to give the impression of their union as a version of the Robin Hood myth.

Rose (1987, p471) maintains that Australia's economic prosperity and decentralised

bargaining system was a major characteristic that changed the industrial relations environment in the 1960's and early 1970's. Deery and Plowman (1985, p33, p49) indicate that: the construction industry accounted for only 3% of strikes in industry between 1913 and 1930; from 1941 to 1950 the industry accounted for 1%; and from 1951 to 1960 the figure was 5%; there was a 12% increase in strikes from 1961 to 1965 rising to 16% from 1966 to 1970 then returning to 12% from 1971 to 1975 and remaining at 9% from 1976 to 1981. From 1975 to 1984, the period associated with building trades award and centralised negotiations, nation-wide strike activity declined substantially from the preceding decade with a decline of 13% in disputes, 36% in the number of workers involved in disputes, 32% in working days lost<sup>4</sup> and 17.5% in working days lost per 1,000 workers (Rose 1987, p481). This pattern appears to shadow the demand for construction - the boom times of the late 1960s and the crash of the mid 1970's. Technological change has been gathering pace during that time with the substitution of machinery for manpower. There was a 11% proportional increase in the industry's workforce at a time when there was 24% general workforce growth (Deery and Plowman 1985, p33). The number of strikes dropped at the end of the building boom of the early 1970's and from 1971 to 1974 the construction industry employed 8.3% of the workforce in NSW yet the average working days 'lost' was 26.8% relative to all industries (Frenkel and Coolican 1980, p24).

From 1975 to 1980, however, the figures are 7.8% and 8.1 % respectively. The 'lost' days breakdown is approximately 81% involving strike activity, 13% for bans and 6% due to un-authorised stop-work meetings. They report that 71% of strikes were concentrated in the Sydney metropolitan area and 14% in other high population centres. The commercial-industrial sector accounted for 69% of disputes and 24% of these were on civil engineering projects. It can be concluded from these statistics that strikes formed the most significant actions, that commercial and industrial sectors were most vulnerable to strikes and that the CBD was the most risky workplace for IR disputes. The breakdown of likely

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<sup>4</sup> is defined by the ABS as working days lost by employees directly and indirectly involved in a dispute and figures are generally reported by parties to the dispute. For some disputes working days lost are estimated on the basis of the number of employees involved and the duration of the dispute.



effects of industrial disputes is useful. Of the strike activity, 56% lasted three days and 37% continued for five days or more; 83% of bans persisted for 10 days or more. The nature of industrial disputes changed during the turbulent years of the mid 1970s and early 1980s. Thus bans, although superficially seeming less serious industrial action, may have more significant impact upon CTP because they usually affect targeted critical activities.

In the 1976-78 period in New South Wales almost half of all labour conflicts reflected site based issues (Frenkel and Coolican 1980, p33), however, as Boyd (1991, p16-17) reports at that time there was a particularly bitter power struggle being waged inside the Builders Labourers Federation (BLF) New South Wales branch which resulted in agitation on sites as one group tried to out-do others in undertaking militant action on 'behalf' of the workers. Norm Gallagher, the then BLF Federal Secretary, was involved in a particularly bitter campaign to establish his authority and to stave off legal proceedings against him on corruption charges. This insiders view of union politics is supported by (Huntley ?1980, p132-134) who interviewed a 'worker-cum-law-student' on-site who was able to provide a cogent inside view of IR issues and union politics operating on-site on the Qantas Centre project in Sydney which had a particularly bitter history of IR disputes.

Huntley (?1980, p119) indicates that specific sites were particularly bad for IR disputes. She interviewed company executives, union leaders and workers on the Qantas Centre project which took over a decade to build, and according to its project manager John Falkner, 50% of working days were '*lost on disputes*'.

According to Frenkel and Coolican (1980, p36) the BLF and Australian Workers Union (AWU) organise unskilled workers, however, the nature of their work has become semi-skilled with the introduction of more mechanisation on-site. They also conclude that the BLF generated disputes by a factor of more than five to one (1980, p33) of those reported.

The BLF had a strategic position by covering some crane work and through their dog-men, riggers scaffolders and hoist-drivers. These workers control critical aspects of construction work such as materials movement and providing access to the workplace.

Their left wing political position and antagonistic posture to other trade unions provided their own justification for taking militant action that often adversely affected other unions, particularly the Building Workers Industrial Union (BWIU). BLF leadership was firmly committed to a Marxist-Leninist stance and supported the interests of the Chinese Communist Party. Their rivals, the BWIU, though sharing many of the BLF political ideals, supported Soviet Russian interests. Given this history, and statements made by union officials that production on major construction projects could be stopped almost in an instant by the action of a few key members of the BLF (Socialist Party of Australia, 1977), it is quite clear that the IR environment was a highly sensitive environmental factor affecting CTP during this period.

Frenkel and Coolican (1980, p38) note that 52% of all bans in the 1976/77 period were instigated by the BLF and that 80% of these were single union actions. The strategy employed consistently by the BLF was, using their own term, 'to turn the screws' on particularly high profile projects to maximise increased pay and site allowances as part of a political campaign using specific sites and to pressure parties who could influence the dropping of charges faced by Norm Gallagher of corruptly accepting commissions (Boyd 1991). The BLF's choice of words illustrates the mind-set of the union at that time.

Frenkel and Coolican (1980, p60) conclude that there are forces both facilitating and containing collective action. They also saw the following as conducive for labour conflict:

- ☐ *keen market competition;*
- ☐ *a tendering system placing successful bidders in a highly vulnerable position due to low margins;*
- ☐ *persistent job insecurity for workers;*
- ☐ *de-skilling of work; and*
- ☐ *the growth of sub-contracting as conducive to labour conflict."*

According to Frenkel and Coolican (1980, p60) economic downturns restrain IR unrest in the short term, mainly from the threat to employment however attitudes and initiatives are starkly contrasted between the two periods discussed in this section. In the turbulent years there was an emphasis on confrontation and exercise of power in the workplace.

The mid 1980s arrived with increased construction activity and a Labour government in power, federally and in most states. An interesting political environment influenced the IR environment with greater collective action on securing worker participation in the national decision making process through the Australian Council of Trade Unions (ACTU) and Government connections, and reforms to the workplace. The Federal Labour Government, elected in 1983, voiced strong commitment to reform of the industrial relations environment and introduction of a more participative approach to business decision making. Benefits envisaged by the government (DEIR 1986, p3) included:

- ☐ *the need to produce more dynamic, productive and competitive industries;*
- ☐ *human resource development that changed the nature of work from a traditional job organisation, narrow vocational training and demarcation problems to a more broader skills-based focus with a more participative decision making approach;*
- ☐ *a move away from confrontationalist 'them and us' attitudes to a shared commitment;*
- ☐ *introduction of new technology to improve skills levels, continual learning and a flexible workforce;*
- ☐ *recognition that employees contribute to organisational performance.*

The ABS do not publish (but maintain) data on working days lost in the construction industry by state by year, however, data up to 1988 obtained by the Department of Labour for an internal report (DOL 1988, p25) indicates that working days lost in Victoria declined dramatically compared with that of Australia. From August 1980 to 1982 working days lost in Victoria, as a proportion of the Australian construction industry total, was 22.6%, 24% and 26.2% respectively. In 1983 this proportion had dropped to 14% rising to 14.6% in 1984. In 1985 the rate had risen to 17% and was 29.7% in 1986. Victoria only accounted for 6.3% working days lost in 1987 and from August 1987 to June 1988 a 3.3% figure was reported. This has been attributed (DOL 1988, p33) to two factors, the de-registration of the Building Labourers Federation (BLF) and the Victorian Building Industry Agreements (VBIA 1987, 1989).

The 1985 and 1986 period, however, was particularly turbulent in Victoria as well as other states, mainly as a result of the BLF's campaign to place pressure on State and Federal governments to have corruption charges dropped against the BLF secretary Norm Gallagher. Commissioners Ludeke, Alley and Maher at a full bench of the Arbitration

Commission commenting on the BLF's history of broken agreements and undertakings reported that *'By early July 1985 approximately 45 major building projects were affected. The majority of these were projects for the government of Victoria or for State instrumentalities'* (Boyd 1991, p295).

A radical change in the IR environment evolved from the end of the 1980s. This agenda for change was firmly established with the publication of *Australia Reconstructed* (ACTU/TDC 1987). In his foreword to the report (1987, page v) Bill Kelty<sup>5</sup> states *'Structural change and the promotion of a productive culture are necessary to enhance our international competitiveness, while employers need to accept that structural change and new work organisation are not simply opportunities to shed labour, and that workers need to be a party to any change. Similarly employers and unions need to recognise their obligation to tackle the problems of skills formation. ....We are about nothing less than the reconstruction of Australia'*. Much of this sentiment can be seen as the desire to achieve an improved IR environment where individuals can fulfil their potential and conflict is reduced. Where conflict occurs, effective mechanisms are intended to be established to resolve problems in a rational manner that minimises disruption and negative outcome.

Employment in the construction industry peaked in 1990 at a time when working days lost were at a low point over the past six years. There has been a shift in the late 1980's and early 1990's in Australia towards a cooperative approach and an attempt to restrain the exercise of power so that shared goals can be explored. The Australian Bureau of Statistics (ABS)<sup>6</sup> indicates a downward trend in working days lost per 1,000 employees with the construction industry recording figures for the twelve months ending: December 1987, 743; December 1988, 725; December 1989, 204; and December 1991, 415. While the mid 1980s to early 1990s have not been a time of complete harmony it has been a time of remarkable restraint. The trend indicates that a change in IR culture has been achieved, at least since the late 1988 period.

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<sup>5</sup> Secretary of the ACTU

<sup>6</sup> ABS (Catalogue number 6321.0, March 1992 table 4, page 4)

Deregistration of the BLF from the Conciliation and Arbitration Commission coincided with the fall from grace of its Secretary, being convicted and failing to win an appeal on charges of corruption. On 5 June 1991 the High Court rejected an appeal by the BLF against the Federal Government's 1990 legislation, extending the union's deregistration until 1996.

Three initiatives discussed in this section which have shaped the industrial relations environment in Victoria are: the Victorian Building Industry Agreements (VBIA); the Victorian Building Industry Disputes Board (VBIBD); and workplace reform.

It can also be argued that the decline in working days lost reflects acceptance of the views expressed by the union movement in *Australia Reconstructed* and the effects of implementation of parts of its recommendations. This policy was pursued through the 1980's into the early 1990's. The VBIA, 1987 and 1989, established a framework for shared commitment and better dispute resolution mechanisms.

The first agreement (VBIA 1987) was established between the Victorian Trades Hall Council (VTHC), the Master Builders Association of Victoria (MBAV) and nine major Victorian building unions. The agreement followed a more positive relationship being developed between employers and unions and the March 1987 National Wage Case decision which required productivity increases to offset additional labour costs. A number of restrictive work practices were addressed in this agreement including:

- ☐ *more sensible arrangements for rostered days off being scheduled to minimise disruption, particularly where public holidays fell on days other than Monday;*
- ☐ *greater flexibility in the Christmas close down period;*
- ☐ *defining inclement weather in a more realistic manner reflecting actual disruption to work on-site;*
- ☐ *the 'homers' agreement whereby a more reasonable dispute resolution agreement was agreed to be followed on action to be taken by unions over issues relating to union membership, contribution to long service leave schemes and other similar provision of worker benefits. Prior to the agreement (VBIA 1987), workers would refuse to work and go home until the disputed issue was resolved, even though the employer (builder) may not technically have been at fault. The agreement provided for builders to rectify an identified problem as soon as it came to their attention. Any stoppage of work*

*would then be confined to affected builders, unions or sub-contractor and not result in closure of the entire site.*

The changed IR climate resulted in workers gaining greater financial security through centralisation of redundancy, long service leave and superannuation schemes that are transportable across the industry.

The success of the 1987 VBIA can be demonstrated by reductions in the effect of industrial disputes upon the industry and the desire by all original parties to continue and expand the agreement (VBIA 1989). Comments by ten senior building industry union representatives and three senior employer group representatives reflect a positive response after the first full year of the 1987 agreement (DOL 1988, p33). The employer group expressed surprise that the agreement had been accepted so quickly and the union group commented that the agreement had led to a continual improvement in IR in the industry and that it had been accepted more readily than expected. It had been pointed out (DOL 1988, p33) that *'it was the first time in many years that there had been a total commitment to the substance of the Agreement from all parties'*. The agreements created a watershed which starkly contrasted the late 1980's and early 1990's with the bitterness and factional strife of preceding decades of IR in the industry in Victoria.

A second initiative established in 1987 was the VBIDB composed of a chairperson, one MBAV representative and one union representative. It has been a significant mechanism for adjudicating industrial disputes and its functioning has expanded since 1987 with the introduction of the VBIA. In the year ending August 1987 the number of disputes had risen from 198 to 400 (DOL 1988, p26). This may give the impression that the IR environment had deteriorated, however, it is more likely that disputes that previously were left to fester or resulted in prolonged stoppages were instead brought to the Board if they could not be resolved on-site (DOL 1988, p27).

In figures published by the ABS (1992)<sup>7</sup>, working days lost from disputes ending during

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<sup>7</sup> Catalogue No. 6322.0, table 15, page 12

1990 comprised the following method of settlement (working days lost are shown in brackets and percentage of total in {}):

- ☐ *negotiation, (7,800 {12.5%});*
- ☐ *State legislation, (18,000 {28.9%});*
- ☐ *Federal and joint Federal-State legislation, (4,900 {7.9%});*
- ☐ *resumption without negotiation, (31,000 {49.8%}); and*
- ☐ *other methods, (500 {0.8%}).*

The ABS defines '*negotiation as private negotiation between the parties involved, or their representatives, without the intervention or assistance of authorities constituted under State or Federal industry legislation. State legislation is defined as intervention or assistance of an industrial authority or authorities created by or constituted under State conciliation and arbitration or wages board legislation, or reference to such authorities or compulsory or voluntary conference. Intervention, assistance or advice of State government officials or inspectors. Federal and joint Federal-State legislation is taken to mean compulsory or voluntary conference or by intervention or assistance, of, or reference to, the industrial relation commissions created by or constituted under the Industrial Relations Act, Coal Industry Acts, Stevedoring Industry Act, and other acts such as the Navigation Act, Public Service Arbitration Act. Intervention, assistance or advice of Federal government officials or inspectors. The category resumption without negotiation may include some disputes which are settled subject to subsequent negotiation of a formal nature, such as industrial court hearings. Stop-work meetings are included, and this category may also include disputes settled by 'resumption' as stated, but about which no further information is available. Other methods include mediation; filling places of employees on strike or locked out; closing establishments permanently; dismissal or resignation of employees*'.

Data presented from the ABS <sup>8</sup> indicates that approximately 50% of disputes are resumed without negotiation. The ABS definition includes disputes settled in a forum such as the Victorian Building Industry Disputes Board.

The need for workplace reform in the Australian construction industry has been identified by many commentators, practitioners and academics. A report comparing Australia, the UK and USA (Ireland 1988, p4) identified 22 recommendations to make Australia's construction industry more competitive. The DOL (1988, p14) report reveals that '*the VBIA*

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<sup>8</sup> 1992 Catalogue number 6322.0 for 1990 page 12

has in theory at least addressed in part or in full some 12 of the 22 recommendations made in the Ireland Report'. Ireland's recommendations identified inadequate working practices and grievance and dispute resolution procedures, requirement for skills enhancement and multi-skilling and changes to union and employer behaviour and attitudes. The current climate of IR and workplace reform indicates that while Ireland's concerns should be addressed, many have yet to be addressed. The VBIA 1987 and 1989 is a demonstration of this climate of reform.

Workplace reform is taking place on several fronts. Evidence of union rationalisation is illustrated by recent union mergers. Other workplace reforms agreed to in the construction industry reform strategy include: *a single industry award to be applicable nationally; rationalisation of agreements; undertaking to agree on resolution of restrictive practices which are attached to the document (CIDA 1992, p10-13) and are consolidations of the VBIA with additional measures highlighted by Ireland (1986); award restructuring and training; workplace bargaining; and the establishment of model sites for the purposes of trialing innovative arrangements including single bargaining units, new work arrangements, productivity schemes and on-site skill centres.*

The entire IR environment has changed over the period of the late 1980s and early 1990s. Recent research into skills formation and workplace reform in the construction industry indicates that while the scope and direction of some of these reforms have a long way to go to achieve stated aims (CIDA 1992), one can remain optimistic that real positive reform is underway (McLachlin and Jarman 1992, p14). While reforms to workplace practices are occurring, there is a need to also scrutinise management practices.

In figures published by the ABS (Catalogue No. 6322.0, table 9, page 9), working days lost from disputes ending during 1990 comprised the following causes of dispute (working days lost and percentage of total are shown in brackets { } ):

- ☐ wages (12,400 {19.9%});
- ☐ hours of work (500 {0.8%});
- ☐ leave, pensions and compensation (3,400 {5.5%});
- ☐ managerial policy (24,700 {39.7%});
- ☐ physical working conditions (8,000 {12.9%});



- ☐ *trade unionism (5,400 (8.7%));*
- ☐ *other (7,800 (12.5%)).*

Management policy and wages appear to be the prime concerns followed by physical working conditions. Management policy is defined by the ABS as *'concerning the exercise of managerial control by employers (other than disputes specifically about wages and hours); new awards; award restructuring; work practices; principles of promotion or deployment of staff including roster complaints and retrenchments; disciplinary matters including alleged victimisation of union officials; employment of particular persons; disagreement with managerial decisions.'* Physical working conditions have improved in latter years with standards of facilities being provided on-site being set by leading contractors such as Civil and Civic, and Grocon. These benchmark standards have been formalised with the provisions of the VBIA. Occupational Health and Safety legislation, and its pre-eminent position in the VBIA has contributed to this issue being successfully addressed. Documents such as the VBIA have helped communicate a shared understanding of what constitutes reasonable working standards.

Callus *et al* (1991, p257) undertook a survey within Australia of 2,004 workplaces with a minimum of 20 employees involving face-to-face interviews with 4,500 managers and, where present, union delegates. Their report reveals that construction industry responses to the question relating to average percentage of IR decisions made by various types of managers (comprising 14 out of the 305 workplaces) can be summarised as follows: *13% by line managers; 7% by an IR manager; 44% by most senior manager; 16% by other manager; and 20% by a manager beyond the workplace.* It would appear from these data that line managers have exercised little power or influence to manage IR issues. This situation would be more critical on sites where the most senior manager is remote from the workplace, either in attitude or physical presence. The greater burden appears to fall on the most senior manager who deals with the workers representative, usually a union delegate. This model minimises the constructive input that can be injected by all workers and all managers.

A more participative model would bring more ideas, options, solutions and collective wisdom to the problem solving arena. This pre-supposes that all parties can contribute which is dependent upon each participant's knowledge, skills and ability to communicate

ideas. The need for greater skills formation and attitudinal change has been identified in Australia Reconstructed (ACTU/TDC 1987, p154) the report states '*The seminal rôle of industrial democracy in Australia as a force in production which is crucial to the maximisation of productivity can only be overlooked at our peril.*' The document also stresses the importance of skills formation as a pre-requisite for constructive input into decision making.

Joint decision making in IR still appears to elude the construction industry. The nature of the industry with its high level of sub-contracting and cyclical demand patterns makes it difficult for management to establish enduring relationships with worker representatives. Experienced managers, however, may develop such relationships over their career, having worked for many employers on many projects dealing with a relatively small group of worker representatives. Fragmentation has been cited (AFCC 1992, p9), (Ireland 1988, p71), and (ACTU/TDC 1987, p175) as part of a problematic IR environment which hinders workers participation in decision making. With high differentiation of work groups (sub-contractors), unions and employer associations, problems arise on ways in which these groups can be integrated into a management approach that can address IR problems and solve them at the lowest possible appropriate management level i.e. closest to the workplace. The Australian experience contrasts with the Japanese model which uses quality circles, informal or semi-formal groups of workers supported by management, which tackle quality and production problems in a bottom-up fashion (Imai 1986, ch4) and (Bennett 1993).

Calls for greater central union control may appear to run contrary to a democratic approach. The Scandinavian experience suggests otherwise. One of the principal recommendations made at the *Landsorganisationen i Sverige* (LO) congress in 1981 (ACTU/TDC 1987,p177) was to " .. Revitalise the political process in the (union) movement by delegation and encouraging effective decision-making at the local level (rather than calling on meetings to communicate information)". Another recommendation (6.4, page 191) stated "*The Australian trade union movement should plan to have no more than 20 union organisations within two years....*". It should be noted that as at 1994, recommendation 6.4 has not yet been achieved, however, there has been radical change in construction industry unions and a high level of amalgamation

is proceeding. One impact of this will be to swamp the influence of former BLF leaders and it is hoped by employers and industry commentators that a BLF spectre will not rise again.

What could a more participative construction industry look like? Would such an environment contribute to improved CTP? It is difficult to judge at this stage. It is anticipated that performance generally would rise with the introduction of a new quality management culture, where broader aspects of quality control through worker participation, skills enhancement, and making jobs more enriched in terms of challenge and job satisfaction. Callus *et al* (1981, p304) indicates that Australian quality circles and productivity improvement groups in the construction industry are used as a method of management communicating with employees for only 9% of all communication methods compared with 23% for the manufacturing industry.

We can look for inspiration to other industries and other countries known for their achievements in increased productivity, improvements in IR and quality. Ford (1984, p54) warned of '*...Australia becoming a comparatively underskilled and vulnerable nation, unable to meet the aspirations of many of its people, organisations and governments.*' Ford (1986, p125) interviewed the production manager of a Northern Japan plant which operated at 98.5% capacity and in comparing this to an identical plant in Australia reported that the production manager was emphatic that the difference in output could be attributed to the higher skills of the Japanese process worker. Skills formation is the bedrock of knowledge required to enable meaningful interaction between workers and management at all levels.

The evidence cited leads to the conclusion that a radical change has taken place in the recent past in the IR environment within the construction industry. Decades of turbulence has been replaced by commitment on both union and employer sides to a more productive culture. This does not mean that all problems have been solved or that construction firms are not facing IR problems. The general IR environment, however, is more predictable and more characterised by a shared vision of the way forward.

Background influences that have shaped the IR environment has been explored. It has been shown that the BLF in particular was responsible for much of the militancy that has affected CTP. Further reference to Boyd's account of the workings of the BLF (1991) paints a grim picture of an IR environment resembling a battlefield. However, the BLF were not responsible for all IR disputes.

Reports of results of a survey into construction industry worker attitudes (Frenkel and Coolican 1980, p40) indicated that 25% of workers believed that '*most employers treat their workers fairly*' and 72% believed that '*most employers try and get as much out of the workers as possible so you have to struggle for many of the things you want*'. In response to questions regarding the two most difficult problems faced by job delegates, over half referred to worker apathy and problems faced with collecting union dues and lack of unity on-site.

Huntley (?1980, p124) quotes Noel Olive BLF delegate on the Qantas House project in 1979 as saying '*When men are treated like cattle or sheep they react*'. This sentiment has been expressed many times before by workers and many managers. The basic issue is respect for the person doing a job and for that person's self respect, their self-esteem.

In reviewing the literature for this section it appeared that many of the IR issues that have been raised, training, better communication, worker participation in decision making, worker driven quality management systems, all revolve around the value that the worker places on his or her input into the task and process and the value that the worker perceives management to place upon their contribution. This view is not radical or unique to Australia but is already in place in Japan and understood by the term '*kaizen*' (Imai 1986).

### 3.13.2 IR ENVIRONMENT - QUESTIONS ASKED

**Question 11.1** elicits a response on the impact of the IR environment upon CTP. **Question 11.2.1** asks for a response on the impact of national IR campaigns upon CTP while **question 11.2.2** seeks a response on local IR issues. Responses to **question 11.2.3**, level of demarcation disputes, and **question 11.2.4**, occupational health and safety issues, provides data to assess the impact of site-based IR issues upon CTP. **Question 11.2.6**

requests information on the impact on CTP of the flow-on of IR problems associated with business insolvency which may be affected by highly localised issues (Walker 1993a).

The general atmosphere of a progressive attitude towards workplace reform was evident in the late 1980's and early 1990's in Melbourne. **Question 11.2.7** was asked to investigate the extent to which this may be reflected on-site.

#### **13.14 OVERALL ENVIRONMENTAL COMPLEXITY**

It was considered appropriate to gather information on a measure of overall environmental complexity. This was because it was unclear at the outset of the data gathering stage of the research whether an overall measure of environmental complexity might be useful.

**Question 11.3** provides an overall assessment of the survey respondent's opinion that the level of environmental complexity encountered affected CTP.

The question required respondents to judge the overall effect of environmental factors identified in **questions 8.1, 9.1, 10.1 and 11.1** as a summarised impression of the influencing environment encountered during the construction period.

#### **3.15 MANAGEMENT RESPONSE DETAILS - CLIENT MANAGEMENT CONSIDERATIONS**

An analogy often stated regarding team performance is that a chain is only as strong as its weakest link. Given the number of 'links' in a project's 'management chain' and the potential for weakness in those links, it is surprising that any projects are completed at all. If a chain is an apt analogy then it should be a braided or woven chain with the capacity for frayed and broken strands to be supported by stress being transferred through stronger components of the 'chain', however, only exceptional buildability advice being taken by a design team could salvage some measure of time success from a poorly designed project.

In managing a project, there is a client who may or may not be capable of enunciating the brief adequately, design consultants who may or may not be able to adequately extract and translate a brief into a workable project design, and a construction team that may or may

not be able to translate a good or bad design into a successful project. This scenario appears grim and one would expect almost all projects to fail.

If a 'braided-chain' analogy is a more reliable paradigm, then it would be expected that most projects to be completed at varying levels of success depending upon the strength of the 'braiding' of the management team, the coping mechanisms with external environmental factors and effective use of technologies to support the project management infrastructure.

#### 3.15.1 CLIENT MANAGEMENT - THE LITERATURE

Sidwell developed a complex model (1982, p104) in which the potential for a client's positive influence is recognised but not quantified. The complexity of his model is a direct reflection of the complexity of the construction process which makes it practically impossible to find sufficient projects which are identical, with the exception of level of client experience.

NEDO (1988) provides excellent case-history data for appreciating the effect that a client or client's representative can have upon CTP. The following observations from the report (NEDO 1988, p55-56) are summarised:

- ☐ *client representatives were usually members of the customer's own staff who coordinate and express customer requirements for buildings, act throughout the projects cycle as the point of contact for communications and decisions and participate in the management of projects;*
- ☐ *they also had the authority, time and knowledge to define and demand the level of service required;*
- ☐ *customers who built regularly usually had a staff of specialists with a thorough professional understanding of the construction process, typically their first concern was to set the project in motion taking great care to select and appoint design and construction teams;*
- ☐ *customer's project managers would move to the site as coordinators or effectively take over management of construction if called upon. Intervention by customer's project managers were decisive on a number of 'fast' projects. More often than not their involvement exceeded that normally expected of a purchaser;*
- ☐ *on over half of the 60 projects with detailed data collected, and two-thirds of shopping developments, customers played a direct part in the construction phase. It is enlightening to note that the average overrun of these was 1 week with client participation (through on-site*

- representation) and 10 weeks where control was in the hands of professionals and contractors;*
- *customer direct influence and participation was motivated by the need to effectively manage design changes stemming from tenant requirements to minimise the disruption of construction time performance;*
- *those clients who performed their rôle in this manner usually did so as a reflection of their greater stake in the success from their own perspective rather than success measures perceived by other project team members.*

These comments indicate a tendency towards success for pro-active clients who work with the project team assuming leadership and control when and where necessary. These clients forge unified goals and maintain focus upon the project's goals rather than goals of individuals or small groups. Their response is also consistent with a 'braided-chain' notion, the client underpinning shortcomings in the design or construction team.

Bromilow (1970) provided a focus on contract variations as a possible cause, if not symptom, of poor CTP. It has been argued previously that clients need to clearly formulate their requirements in the brief. Given this premise one might conclude that projects with many contract variations should indicate a propensity for poor CTP. Contract variations, however, vary in both scope and impact upon construction and some may be easily incorporated into the construction works with no impact upon the agreed construction hand-over date.

NEDO (1988, p76-77) notes that in one-third of the projects investigated, significant variations were initiated during construction. On several of the projects apparently superficial design changes caused '*inordinate upheaval and extension to programs*'. The report also notes that disorder can be contained if variations are administered effectively and decisions are made quickly in a climate of trust between all participants. Many variations are made by clients in response to a desire to incorporate the most current facilities or tennant's customised alterations in shops and hotels so that the building is a more attractive proposition to the market served. The most pernicious cases of lost time and cost resulted from amendments to design documents due to design errors and incompatibilities in design details with building regulations. Many of this class of variations, unwanted by any of the design team, unforeseen but not unavoidable, could throw site work into disarray.

The client must also avoid disunity in its interaction with the project team. To this end a single entity should represent the owner's interests and be given sufficient authority to communicate directives and make judgements on behalf of the client. This concept of a single point of contact has been stressed by many researchers in the field of project management including (Barnett 1988/9) and (Ireland 1987).

The client has a rôle to play in:

- ☐ *maintaining control over the design development even if it means periodically auditing design documentation to minimise design errors;*
- ☐ *ensuring that design resources are adequate to design to the detail required so that design in haste is not an outcome. This may result in the appointment of a document planning adviser to assist in the planning and monitoring of design development and permit processing;*
- ☐ *ensuring that construction time performance implications of design variations generated by the client are fully understood, appreciated and considered so that appropriate action may be taken to integrate them into the construction process, shelve them or to release contingency budgeted cost and time to accommodate them;*
- ☐ *ensuring that conflicting requirements and/or objectives are not given, this can be avoided by appointing a strong project manager with authority and sufficient credibility to interact with key client decision makers to present cases and discuss policy so that a unified response emerges from the client organisation on all decisions made.*

A sophisticated client can overcome design team inefficiencies by imposing a high level of design management over weak design consultants. A project or construction management consultant can likewise impose measures to counter construction team inefficiencies if required when empowered by the client.

### 3.15.2 CLIENT MANAGEMENT - QUESTIONS ASKED

Question 12 comprises two distinct parts addressing two distinct issues. The first issue is concerned with the CR/construction team manager working relationship and the second is concerned with the effectiveness of the construction team in managing the CR so that urgent decisions are made and communicated.

A client or CR's demeanour may range from aggressive to highly submissive, each



attitude being appropriate under a range of circumstances. The issue is not solely, therefore, one of the client or CR having a 'good' or 'bad' attitude which influences the relationship with the construction team. Effectiveness may be partially determined by the way in which the CM team manages its relationship with the CR.

**Question 12.1** seeks to define the effect of the working relationship between the CR and construction management team. **Question 12.2** helps identify how effective the builder was in managing the client by asking how effective the construction team manager was in gaining influence over the CR's decision making process and gaining a useful response regarding decision making.

### **3.16 MANAGEMENT RESPONSE DETAILS - CM PROCEDURES**

Appreciation of project complexity requires special and varied skills. Evidence from the literature has been presented in previous sections which suggests that a suitable management response is required. This being to anticipate likely problems, formulate appropriate plans to meet identified risks, monitor progress on plans formulated, and take appropriate corrective action based on feedback when unacceptable deviation from plans occurs. This requires effective implementation of planning, coordination and control management functions.

#### **3.16.1 CM PROCEDURES - THE LITERATURE**

Berkeley *et al.* (1991, p6) maintain that: *'no risk should be ignored; no project risk should be dealt with in a completely arbitrary way; project risks should be identified during the earliest project phases; no major project decisions should be made unless those risks having the greatest impact on the project manager's decisions be clearly understood; practical project risk appraisal should be subject to review. An assessment should also be completed of the variable risk factors acting upon the project and their likely extent and level of interaction; more project effort should be devoted to risk management as a rigorous and continuing activity throughout the project life.'* This statement firmly places risk management as a key component of the CM function.

Ireland (1983, p71) concluded that CTP was positively affected by increased planning prior to taking possession of a site and commencing construction activities. He also found

that increased use of time planning and control techniques by builders also proved significant in reducing construction time. His research indicates that construction planning during design assisted in good CTP (Ireland 1983, p111), specifically planning:

- *prior to construction by identifying potential problems and constraints and developing plans to overcome them;*
- *during design and incorporating elements of buildability into the design through generation of alternative design solutions;*
- *the design documentation process to better coordinate and prepare design solutions and minimise design gaps or omissions that may prove costly (in time) to overcome during construction.*

The process of initial planning helps identify and quantify the magnitude of potential problems related to resources availability, access to and within site, materials and manpower movement, industrial relations opportunities and threats and construction methods. Planning and monitoring throughout the construction phase of a project is necessary to effect control. Plans are, at best, intelligent guesses because they predict probable outcomes in an environment of complexity and uncertainty where too many factors affecting CTP exist to be fully examined and accurately quantified. By accepting that circumstances are constantly changing, it follows that plans quickly become out of date. It further follows that plans need to be regularly updated to reflect changes in circumstances. Failure to adequately monitor plans leads to a 'seat-of-the-pants' management approach. This is as equally true for management of the design process as it is for the construction process.

Planning and monitoring needs to take place by all project stake holders for control to be possible. Many clients appoint planning and scheduling consultants who advise the client on progress achieved by both design and construction team members. It was concluded from the pilot study (Walker 1987, p86-87) that significant computer-based planning systems were being used for project control, though subsequent research (Walker 1988/9, p83) indicates that effective use of computer tools in the Australian construction industry is being impaired by poor training. Widespread availability of sophisticated and inexpensive computer resources for planning and monitoring has provided the information technology (IT) framework within which effective planning for control can be achieved.

Planning techniques including simulation techniques (Hinkley 1989) and (Furusaka and Gray 1984) have been promoted for the construction industry for many decades and adequate discussion of these by others appears in the literature (Harris and McCaffer 1989; Halpin and Woodhead 1976; Oxley and Poskitt 1986). The key to planning is that it helps identify risks and enables counter measures to be devised to minimise negative effects and maximise opportunities presented.

Barnes (1989) suggests that planning and time control is not just a set of techniques but also a management philosophy. His summarised advice follows:

- ☐ *'set up time control arrangements, not just planning;*
- ☐ *always make management decisions with the benefit of a time forecast;*
- ☐ *look ahead at progress meetings, never back.'*

Bennett (1993, p4) observes from over seven years of studying the Japanese construction industry, that planning is an important element of Japanese success in delivering projects on time. He states *'The distinctive strength of the Japanese building industry is its ability to plan work on site in exceptional detail and then put the plan into effect, on every project, with remarkable consistency'*. The thrust of his analysis is: that plans are well considered by all involved in the production process; that planning is carried out at the design stage with adequate input of construction production personnel to influence designs to be buildable; and that there is excellent communication of plans. Control is achieved by means of a consistent sequence of daily meetings on site. At the start of each day teams of subcontractors are brought together to be briefed on the expected milestones for that day. These teams then move to their workplaces where they hold what is called 'toolbox meetings' so that each worker knows precisely what is to be achieved that day.

Bennett (1993) also observes that the Japanese contractors maintain rigidity in milestone events while maintaining flexibility of the deployment of resources to achieve milestone event times. Work is planned on the basis of a single shift for five days a week, if production slips for whatever reason then additional resources are committed or overtime is worked. A second or third shift will be worked if required or work may proceed on a

six or seven day week to ensure that milestones are achieved as planned. The Japanese concept of *kaizen* (Imai 1986), continual improvement, involves the consideration of each step in a production process as a series of deliveries to customers. The kaizen approach values quality as a paramount objective and the customer's needs as always being considered superior to one's own. This philosophy manifests itself in a commitment to quality because there is a conscious effort to avoid, in fact cease, passing inferior product to the next step in the process. It also incorporates the notion that planned delivery dates must also be met, exactly as planned.

While this appears at first sight to be a highly rigid way of conducting business, it is in fact highly flexible. If a worker or manager regards non-performance as a loss of face, which is widely believed to be a very serious sanction in a number of Asian cultures, then that person is prepared to ensure that targets are met, even if that involves working unpaid overtime. In the long run, this results in achievable targets being set and processes of continual improvement, *kaizen*, being instigated to ensure that failure to meet targets is eliminated.

Greater flexibility is being exercised more frequently in the construction industry. The pilot study was undertaken during the end of a period of poor IR climate which promoted a lack of flexibility involving trade demarcation disputes and other examples of a 'them-and-us' attitude. Contractors tended to take on projects with rise and fall clauses in their contracts and, with extension of time claims readily granted, an environment of lack of personal responsibility thrived. This has substantially changed as evidenced by the 33 case studies presented in this work. Fixed price contracts currently predominate which has been helped by low and negative inflation rates; workplace reform is obviating many demarcation problems. The result of this has been that builders have been able to take advantage of flexibility in resource deployment and work additional hours, shifts or days as and when required.

Project time success indicators derived from the literature appear to revolve around effectiveness of planning, coordination and control. Project planning effectiveness relies

upon the basics underpinning the process i.e. effectively: defining objectives and goals; forecasting data used in plans; analysing proposed work methods and resource requirements and availability; monitoring progress; ensuring flexibility to work around problems encountered or take advantage of opportunities presented; coordinating to meet the plan; and undertaking action. It is contended that these are the core issues relating to construction management procedures.

### **3.16.2 CM PROCEDURES - QUESTIONS ASKED**

The questionnaire was designed to investigate construction management procedures used in a broader context than asking the question 'is critical path method scheduling being used?'. It is postulated that this is important as planning is more than scheduling. It was important to avoid confusing a planning approach with planning techniques. Questions were framed in a way to determine if a planning approach was being applied even though informal or unorthodox planning techniques may have been used.

**Question 13.1** is posed to measure perceived impact of construction management systems and procedures, in their broadest sense, upon CTP. Detailed questions to discover what management techniques may be applied and how effective they may be are also asked.

Questions 13.2.1 to 13.2.3 identify formal planning techniques adopted by management. **Question 13.2.1** asks if the critical path method was used and, if so, how frequently plans were monitored and updated. **Question 13.2.2** seeks to identify projects where workflow techniques of planning such as line of balance (LOB) may have been used. **Question 13.2.3** similarly investigates whether simulation or queuing techniques were adopted.

**Questions 13.3.1 to 13.3.4** gather data to help shape a view of the effectiveness of construction planning approach, whether using critical path methods or any other technique. The use of a technique was considered less of an issue than adopting the optimum planning approach and this needed to be tested. In **Question 13.3.1** a response on the construction team's effectiveness in estimating and forecasting activity duration and resources required is sought. In **question 13.3.2** an assessment of the effectiveness of

analysing construction methods is sought. **Question 13.3.3** is used to measure the effectiveness of management strategies for resource handling and **question 13.3.4** measures effectiveness of planning the sequencing of activities. **Question 13.3.5** requests data on how monitoring and updating plans to appropriately reflect work status was undertaken. This is an important item of information to gather for an assessment of management performance. **Question 13.3.6** gathers data which helps to identify how well the CM team responds to change while **questions 13.3.7** and **question 13.3.8** are used to measure effectiveness of the construction management team in coordination and control of the project.

### **3.17 MANAGEMENT RESPONSE DETAILS - DEVELOPING ORGANISATIONAL STRUCTURES TO MANAGE RISK**

Morris (1994, ch9) believes that organisational forms that achieve effective coordination and communication are appropriately responsive to client objectives, project and external environment characteristics, management style, and the organisational cultures of project stake holders. He states that this is mainly due to the rate of change in the current business environment. Organisational structure should be responsive to the level of risk accepted. This may not necessarily mean quantity of people on a team but rather finding the right skills and attributes mix in individuals comprising a team so that it matches what is required of it. Walker (1989a, p210) highlights the complexity of designing organisational structures due to interdependency and relationships between teams.

Walker (1990/91, p15) identified factors shaping an organisation. The implication of these findings is that it may be unwise to assume that models can easily be established to represent an ideal site management structure. Many factors shape the ultimate site management structure that will be effective. Such factors include company policy, client characteristics, the industrial relations climate prevailing at the time of construction and available skills of the proposed team which itself may be affected by changing technology. The study indicated that project characteristics may have only a minor impact. Other situational factors may also contribute to effectiveness of teams such as team motivation, level of integration and company cultural influences. Many of these situational factors are

difficult to measure and model.

The previous section on management procedures for addressing issues of project complexity sets the scene for discussion in this section about the appropriate allocation of authority and responsibility of project team members commensurate with the degree of risk accepted and the capacity of team members to manage risk. Analysis of risk sharing arrangements is explored in this section in order that a useful perspective may be gained of the impact of risk management upon CTP. This led to the formulation of questions asked of case history participants in the questionnaire.

### **3.17.1 ORGANISATIONAL STRUCTURE - THE LITERATURE**

Allocation of risk for parts of the design, construction and management of projects are defined in contractual arrangements. Hayes *et al* (1986) state that *'The development of a contractual strategy is an important task for a client or project manager, and requires a thorough assessment of the choices available for both the execution and management of the design and construction processes. The decisions taken during the development of a contract strategy clearly affect the responsibility of those involved in the project. They influence the control of the design, construction and commissioning, and hence the coordination of the parties. They also allocate risk and define policies for risk management, as well as defining the extent of control transferred to contractors.'* A wide range of non-traditional form of contractual arrangements have been identified by others (Barnett 1988/9; Naoum 1991; Sidwell and Ireland 1987).

Ireland (1987, p188) provides a useful taxonomy of differences between contractual arrangements which indicates risk sharing (both time and cost) between contractor and client. At one end of the risk sharing continuum the client accepts all risk, paying those responsible for designing and building as an in-house team as well as paying the production cost. At the other end of this continuum, the client pays a fixed sum of money for others to undertake the work and accept all risks.

The issue is not the degree of risk that a contractor or client will accept, but what is the appropriate level of risk that these parties should accept and how organisational forms may be developed to manage risk accepted to facilitate good CTP.

Barnes (1987) discussed a new style of contract that better recognises risk apportionment to those best able to manage that element of risk. He states: *'Research into the effect of different allocation of risk in construction contracts has shown this is a principal factor governing the influence achieved by different forms of contract. Better understanding of risk now enables conditions of contract to be designed which strengthen motivation to manage particular aspects of the work well.'* Flexibility, stimulus to good management, clarity, and simplicity are some of the key objectives of the New Style Contract as well as flexible risk allocation and provision for partial or full completion to be provided by the contractor. The concept is clearly to allow contractual arrangements that reflect capacity and ability of team members to control risk.

The recommendations advanced in 'No Dispute' (NWPC/NBCC 1990, p6) state that a party to a contract should bear a risk where:

- ☐ *'The risk is within the party's control;*
- ☐ *The party can transfer the risk, e.g. through insurance, and it is most economically beneficial to deal with the party in question;*
- ☐ *The preponderant economic benefit of controlling the risk lies with the party in question;*
- ☐ *To place the risk upon the party in question is in the interests of efficiency, including planning incentive and innovation;*
- ☐ *If the risk eventuates, the loss falls on that party in the first instance and it is not practicable, or there is no reason under the above principles to cause expense and uncertainty by attempting to transfer the loss to another.'*

MacPherson (1991, p39) discusses success of phases 5, 9 and 10 of the Broadgate project in London. He describes the great effort expended on identifying risk, negotiating the acceptance of that risk by those able to control it, and the sensible management of people and resources in an environment of self-discipline, self-direction and recognition of the advantages of cooperation. The impression given is that risk was well planned for, accommodated and managed on the project.

NEDO (1988, p22) identifies different contract conditions between contractor and sub-contractor and contractor and client as cause for concern. The point is made that prominence of conflict in handling contracts has the effect of making people defensive



rather than positive in their relationships. Contract conditions are singled out as probable root causes for failures and conflicts on business relationships between parties. This conservative outlook appears at odds with comments made by MacPherson and others.

A key causal factor may be the way in which relationships are built on the recognition of a fair risk apportionment and how cooperation can be engendered between contracting parties rather than contractual relationships. Risk allocation issues flow into problems identified by Sidwell (1982); client sophistication and client experience. A more prepared client will tend to minimise design variations because the effect of introducing them and risk to completion time and cost is well appreciated, particularly when progress on construction is well underway. A more sophisticated client may also be more likely to appreciate limitations of members of the project team. Naïve clients may be so intimidated by potential risks associated with construction that a traditional building contract strategy may be adopted when inappropriate.

The pilot study indicated that a number of projects undertaken by contractors with a reputation for fast building occurred on fixed-time fixed-cost contracts, construction management projects, and design-build projects. In these projects the contractor not only accepted and effectively managed construction related risk but was able to influence design solutions. This was because the construction team had assumed, and was given, an appropriate mandate to manage risk where clear and direct influence had been identified.

It is evident from the literature (Burns and Stalker 1961; Woodward 1965; Lawrence and Lorsch 1967; Mintzberg 1979; Kast and Rosenzweig 1974; Khandwalla 1977; Hersey and Blanchard 1982) that organisational structure and management style is affected by the degree of differentiation of tasks to be undertaken and the rate of change experienced by teams. The management of construction projects poses interesting and challenging management problems as there is profound uncertainty surrounding the construction process and the organisational cultures of stakeholders are also diverse.

There is considerable diversity of organisational forms that challenge the integration of

project team members. A number of useful general impressions were gained from the pilot study about the nature of project team members:

- *designers (with concept design input) often operate in a highly organic organisational form;*
- *many detailed design team members exhibit comfort with a mechanistic style of organisational design;*
- *many of the principal suppliers and sub-contractor organisations have manufacturing responsibilities and operate in a highly mechanistic style of organisational form;*
- *often the client may be a government department or government controlled authority and used to a bureaucratic organisational structure;*
- *builders vary in their organisational form and style but those that offer alternatives to traditional project procurement strategies are often more comfortable with flexibility and change;*
- *few team members rarely remain within the project team group full-time, it is more likely that they work part-time on any single project;*
- *Design, client, builder and advisory consultant team members as well as sub-contractor and supplier team members may report to their own firm's organisational heads, who often adopt an organisational structure and style quite different to that encountered on-site.*

The manager of a project team must, therefore, build an entity that for the purposes of the project is flexible in approach and integrates disparate groups of professionals, manufacturers and sub-contractors. The most suitable organisational form suggested by Sidwell (1982) and Ireland (1983) is one that allows integration to facilitate communication, coordination and control of team members. Team members need to be aware of their decision making responsibilities for communication, coordination and control to be effective.

Client representatives need to pursue appropriate management action to ensure the client's goals are being continually addressed. A framework for analysing and classifying decisions made on a project which commit team members to given courses of action has been developed by Walker (1982). The technique known as linear responsibility analysis (LRA) can be used to assist in the design of an organisational structure. Walker and Hughes (1984, p94) argue that '*using this technique it is possible to see where the responsibility lies for decisions, and in what capacity any decision was taken, and most importantly, how effective a management structure has been.*' The strength of this technique is that personnel and their involvement

with decision making on a project can be identified and an assessment made of the effectiveness of decision making, communication of decisions made and control over actioning these decisions can be investigated and explored. The technique adopts a systems approach to management. LRA and other techniques which seek to consider how decisions are effectively made and carried out, can be useful in identifying gaps in the decision making process.

There are cases where a project organisation is established but lines of authority may be blurred, accountability for making and/or carrying out decisions may be unclear, and lines of communication between parties to the process ineffective. Walker and Hughes (1984) believe that an organisational structure is necessary to ensure that:

- ☐ planning is undertaken to anticipate potential problems, forecast data to investigate plans of action to overcome potential problems and to support decision making;
- ☐ planned courses of action are communicated to concerned parties and to allow feedback on progress achieved against that anticipated;
- ☐ coordinated action to be undertaken is identified and that parties agree to take responsibility for carrying out those actions as communicated;
- ☐ action undertaken is supervised to ensure that priorities and objectives are met.

Many of the larger construction projects in the pilot study used a project control group (PCG) comprising senior construction management, client representative(s), senior design team members, the quantity surveyor, time planning consultant(s) and executives of key suppliers/sub-contractors on an *ad hoc* basis. At a different level, but integrated to the PCG through the construction director, was an operational control level of team members comprising the construction management team, design representatives who were often resident on-site, and representatives of both sub-contractors and suppliers.

Senior level management interact with many and varied external organisations; this group may contain the PCG and the design team principals. Middle management of team members link senior site management staff with operational or production level team members who addressed *ad hoc* issues which require group-generated solutions. This group also may include a safety committee whose task includes ensuring that a safe

working environment is maintained. This committee often includes union representatives who frequently require site management to disclose method statements of construction processes which integrates this group into the team members responsible for planning, monitoring and controlling construction activities.

Organisational structures discussed above should provide integration of disparate groups and a channel of communication as well as facilitating coordination and control. Principal integrative mechanisms include meetings, coordination and control documentary systems such as plans and data bases of drawings and other documentation issued and received, requests for information and procurement schedules. Information systems such as planning schedules, documentation schedules and other paper-based administrative devices can have a negative input if they are carelessly prepared, inaccurate, or issued when out of date. Meetings can generate hostility if poorly managed but if well managed usually facilitate good coordination, communication and cooperation.

Informal integration systems can be achieved by engendering team bonding through a series of social events, these could include: brand naming - by providing printed project T-shirts, sweatshirts, car stickers etc.; sports fixtures; social functions - BBQs, dinner dances etc., however, these may not engender bonding if groups or cliques do not mix or have a focus that unites the group.

Clearly team integration is important if a high level of segregation or differentiation occurs. Interesting insights into organisational performance were reported by Hollands and Wilson (1988/9, p17) in a recent study of the operations of a leading Australian construction company, Civil and Civic. Company senior management was said to '*stress informality amongst staff which includes a combination of 'loose' decentralised functions and 'tight' centralised functions thriving on intense formal and informal communication, on open door policies, on personal informality, on fluidity and flexibility and on non-political shifts of resources.*' The human resource policy of Civil and Civic provides for an egalitarian approach exemplified by: elements of industrial democracy with 'workers', blue and clerical white collar, being represented on the company's board of directors; an employee share ownership scheme;

generous superannuation schemes for employees at all levels; and quality circle groups operating at office and site levels. At Civil and Civic, social and structural integrative mechanisms are in evidence.

The appropriate risk apportionment to teams who can best manage that risk has been identified as an important management consideration critical to CTP. Organisational design for success is a complex and demanding task. Project stake holders may have diverse 'home organisation' organisational structures, cultures and environments. They may also have very different pre-dispositions to change and uncertainty.

### **3.17.2 ORGANISATIONAL STRUCTURE - QUESTIONS ASKED**

It was discovered during the conduct of the pilot study that an organisational chart is not a useful descriptor of organisational structure (Walker 1990/91). Some projects had many staff involved who were of low experience or expertise. This may have been intentional as such individuals were acquiring on-the-job training and skills. Other organisations appeared stretched or had critical elements missing e.g. planning or cost control, when in fact that element was provided by team members taking on several functions or use of head-office personnel.

**Questions 14.1 to 14.4** are asked to help assess the impact of the organisational strength developed by teams to respond to management challenges encountered. Organisational structure is used in this work as a measure of the quantity and quality of management resources. A CR team could comprise a small organisation of, for example, one key person supported by an administrative assistant interacting with the client, be that an individual or joint venture board if several parties comprised the collective client.

The organisational structure is seen as an indicator of potential performance but the management of teams by their team leaders is considered a more useful data item to use in assessing the impact of management effectiveness upon CTP.

**Question 14.1** provides an impression of the impact of the construction management

team's organisational structure to manage identified risks. **Question 14.2** provides a similar impression for the design team's management organisational structure and **question 14.3** and **question 14.4** for the client representative and key sub-contractors respectively.

### **3.18 MANAGEMENT RESPONSE DETAILS - MANAGING HUMAN RESOURCES AND TEAM CONFLICT**

Management theory has been evolving for centuries in response to technical advances. A focus on the craftsman prevailed during the pre-industrial revolution era. Technologies were rudimentary and change was slow, allowing plenty of time to make adjustments to the way in which resources could be organised to achieve identified objectives. It is generally agreed that the rate of change has increased dramatically over recent decades so that managing teams has become a focal point in managing for success. Questions asked in this section provide important answers with which to analyse how important team management is to CTP.

#### **3.18.1 MANAGING HUMAN RESOURCES AND TEAM CONFLICT - THE LITERATURE**

Stoner *et al.* (1985, Section 2) trace the evolution of management theory from the early 1980s to the present. Management theorists such as Robert Owen, Frederick Taylor and Gantt are cited as contributors to a scientific approach to management. These theorists had varying levels of concern for the workers welfare to achieve a productive workforce that could live in dignity. Much of their work, however, led to workers losing the connection between individual effort and the end product as each worker performed only a small part of the total labour content of the product. The differentiation of effort and specialisation of tasks was a response to technological development, mass production techniques, mechanisation and de-skilling of work in an endeavour to replace manual labour with machine power. A reaction to this trend grew from the early stirring of the labour union movement in Europe, North America and Australia which sought not only to protect the living standards of union members but also their health, safety and welfare.

Recognition that workers are not machines but humans resulted in the development of the

classical organisation theory. Henri Fayol developed guidelines and procedures for managing people. He recognised human group behaviour and saw people as part of an organisational system. This work was extended by others. Weber offered bureaucracy as an ideal organisational form, however as March and Simon (1958, p36-47) note: "*.. the application of classical management theory principles has often produced unintended and unwelcomed consequences for managers. Some of these problems include excessive de-personalisation within organisation leading to alienation, rigidity in behaviour, and problems of employee motivation and innovation.*"

Constraints to models proposed by the classical management theorists became evident as organisations became more complex, job functions blurred and the workforce began to react and think independently. New elements of a model were added by theorists such as Mary Parker Follett, Chester Barnard, Lyndall Fowles Urwick and March and Simon. These later groups of theorists viewed companies as organic not mechanistic entities. System theory was applied to organisational theory and some understanding of individual and group behaviour was incorporated into productivity models.

The behavioural school of management theory gained much prominence with the analysis of results of the Hawthorne experiments led by Elton Mayo. His conclusions prompted other researchers to investigate social aspects of group performance and the whole concept of motivation. During the middle to last half of this century, management theory has evolved to include all aspects of an organisation's inputs and processes. The complexity of the management process is now widely accepted. A focus on effective human interaction is being sustained with the realisation that mankind is not the same as machinery. It is ironic that early work on cybernetics, artificial intelligence and robotics have indicated that the human brain is one of the most powerful and complex resources available to an enterprise.

More recent indications of the Japanese approach to HRM (Imai 1986; Bennett 1993) reveal a critical importance of a reasoning, flexible and skilled workforce as a crucial factor in CTP. Limitations of knowledge based expert systems (KBES) and the development and application of robotics and other artificial intelligence advances also

make the need for an intelligent and responsible workforce at the coal-face more pressing.

Many management theorists have attempted to define and describe the quality of leadership. Hersey and Blanchard (1982, p83) define leadership as '*the process of influencing the activities of an individual or group in efforts towards a goal achievement in a given situation.*' They see the leadership process as a function of the leader, the follower and the situation. Effective leadership is seen to be the ability to diagnose the situation, the characteristics of the followers and the characteristics of the situation and to offer an appropriate management style for leader, follower and situation.

Trait theory has been offered and researchers have generally attempted to define and measure leadership traits either from a comparison of the traits of those who have emerged as leaders or from a comparison of the traits of effective leaders with ineffective ones. Stoner *et al.* (1985, p594) in their review of the literature state that results of many studies have failed to identify any clear leadership traits that can be measured. Millions of people share key traits that provide leadership potential, however, positions of significant leadership often elude them. Traits such as physical prowess, mental strength and determination, tenacity, and powerful intellect are possible indicators of possible good leadership results, however, many of the recognised great leaders are only perceived to possess these traits after they have successfully exercising leadership.

The Ohio State University studies (Stogdill and Coons 1957) led to the identification of two management styles from research which attempted to discover how leaders carry out their duties using a two dimensional model. The degree of consideration was measured on one axis and the initiating structure on the other. Consideration was a measure of orientation towards the individual typified by the leader listening to group members, being willing to make changes and being friendly and approachable. Initiating structure refers to the leader's behaviour in establishing and using management structures such as rules procedures, channels of communication to lead.

Blake and Mouton (1964) later described these two measures as concern for people and



concern for production. The managerial grid was a useful breakthrough as it enabled leadership styles to be identified and measured (Blake *et al.* 1964, p136). This model tends to imply that a team approach is the best to adopt. Extensive research undertaken by Likert (1961, p7) supports this view. He concluded that general rather than close supervision led to higher productivity and that employee-centred rather than job-centred supervisors tended to be associated with high productivity. Higher producing supervisors make clear to subordinates what needs to be done and then give them freedom to get on with the job. Likert's studies concluded that of high producing sections, 90% of supervisors adopted general rather than close supervision and 86% were employee-centred rather than job-centred.

The Likert and Blake and Mouton models however, partially ignore the contribution that followers make. The situation in which management takes place also has an impact upon effectiveness. If followers do not understand how to achieve goals, then passing decisions over to them and leading in a employee-centred manner may be distressing to them. Similarly in crisis situations where there is little or no time to consider alternative options, a leader may be forced to give orders that must be unquestioningly obeyed immediately. This leads to a broader and more rich appreciation of leader effectiveness.

Stoner *et al.* (1985, p579) provide a useful illustration of the manner in which organisational policies and climate affect a leader's capacity to adopt a favoured style. If the organisation is highly job-centred rather than employee-centred and a leader attempts to adopt the latter style, then this may establish conflict with supervisors, other staff in the organisation and employees who may be uncomfortable with that organisational culture. This may lead to poor performance. Past experience and expectations of leaders their supervisors and subordinates also create an organisational culture.

Fiedler (1967) believes that three major situational variables seem to determine whether a given situation is favourable to leaders: *their personal relations with the members of their group (leader-member relations); the degree of structure in the task that their group has been assigned to perform (task structure); and the power and authority that their position brings (position power)*. He concludes

that the problem for leaders consists of getting into and remaining in situations where they can perform well and maintains that it is easier to change the situation than the leadership style. Task-oriented leaders placed in a situation of moderate control, for example, should take actions to gain more control over the situation by improving leader-member relations, by increasing the structure of the task or by having more power and authority bestowed upon them.

Recognition of the followers' potential to contribute to success has led to the adoption by many organisations of a participative management style. Participation means encouraging employees to become actively involved in developing and implementing decisions affecting their jobs. Major changes in the current IR environment in Australia and current practice in Japan (Imai 1986) are concerned with work restructuring to provide multi-skilling that will allow employees to participate in the decision making process.

Participative management has been seen to have the following advantages:

- *employees feel that they own decisions and are committed to ensure that objectives are achieved;*
- *change of direction can be more effectively achieved, for example when it is obvious that a plan will not work due to changed circumstances or incorrect assumptions having been made in formulating the plan. When people are part of the planning process they will know why the plan has changed and to what extent thus communication of the change in plan is more effectively achieved;*
- *participation increases the amount of available task-specific knowledge so that more informed plans and decisions can be made.*

Bresnen *et al.* (1986, p379) in a study of 43 site managers in the UK using Feidler's LPC contingency model conclude that '*... better performing contracts are more likely to have site managers with a strong relationship-orientation.*' They point out that larger and longer duration projects tended to be more problematical. One comment cited by a participant sums up the range of leadership styles experienced in the industry: '*You get different styles of management. I think a fast job, when there's no room for messing about, you get a much more directive style of management. I think if you get time on a job, it's a much more consultative style of management, you are more willing to get blokes in to sort the thing out, be together, you've got time for a joint approach.*' This study illustrates the complexity of factors that enter the equation when trying to decide

which management style is most appropriate for the situation at hand.

Vroom and Yetton (1973) developed a management approaches model forming a styles continuum from authoritarian through consultative to fully participative. Their contribution has been to demonstrate that decision making and appropriate management styles vary with the situation facing managers. There is no one correct style for a person. Time-efficient or authoritarian styles are shown to be appropriate when quick decisions have to be made. Time-investment or more participative styles are also shown to be appropriate on other occasions. Their work adds to Fiedler's in that it indicates how and why management styles can and should shift given the situation facing managers.

While the Ohio State University studies have proved useful to contemporary conditions, doubts were raised about the body of knowledge related to a '*systematic conceptualisation of situational variance as it might relate to leadership behaviour*' (Korman 1966). Emerging theories discussed earlier advanced with a focus on followers and their potential contribution to the decision making process.

The concept of 'maturity' was explored by researchers through the Centre for Leadership Studies, Escondido, California. This built on and paralleled other work being undertaken at the time (McClelland 1961) and (Argyris 1957, 1962, 1964). Hersey and Blanchard (1982) developed research instruments to measure maturity in two components, ability (job maturity) and willingness (psychological maturity) by using a five point rating scale.

This added dimension helps explain follower characteristics in a more meaningful way. Job maturity is purely specific to the task and the individual's breadth and depth of knowledge relating to the task. Psychological maturity relates to a person's willingness or motivation to do something. This is evidenced by enthusiasm to get on with task with the minimum of pressure. This has also been described in terms of a 'can-do' attitude or 'self-starter' approach.

The Blake and Mouton (1978) model was extended and developed by Hersey and

Blanchard (1982) to present a clearer picture of appropriate management styles. In place of concern for people in the Blake and Mouton model, Hersey and Blanchard use relationship behaviour (support). Task behaviour (guidance) is used in place of Blake and Mouton's concern for production. This analysis led to the classification of four management styles. These comprise: style **S1 'Telling'**- providing specific instructions and closely supervising performance; style **S2 'Selling'** - explaining decisions and providing opportunities for clarification of what is required; style **S3 'Participating'** - sharing ideas and facilitating the making of decisions; style **S4 'Delegating'** - turning over responsibility for decision making and the implementation of those decisions to followers.

The issue of power or influence was also addressed by Hersey and Blanchard (1982). They defined seven bases of power which affect management style. These are:-

- 1      *COERCIVE POWER - based on fear and punishment*
- 2      *LEGITIMATE POWER - based on the legal, institutional or traditional position held by the leader*
- 3      *EXPERT POWER - based on expertise and knowledge*
- 4      *REWARD POWER - based on the leader's ability to provide rewards*
- 5      *REFERENT POWER - based on the leader's personal traits*
- 6      *INFORMATION POWER - based on access to information*
- 7      *CONNECTION POWER - based on the leader's connections*

Appropriate leadership style is essential to the effective introduction of change as well as effective human resource management (HRM).

Motivation theories can be compared along a continuum of upper and lower level human needs. Maslow (1970) described a needs hierarchy ranging from physiological, safety, social esteem to self-actualisation needs in which a uniform progression was envisaged. Alderfer (1972) introduced a more staggered progression in his existence, relatedness and growth (ERG) theory where frustration of one level led to regression to a lower level. In his model he introduced a regression from desire for higher level needs with the onset of temporary or permanent frustration in achieving a progression from lower to higher level needs.

McClelland *et al.* (1953) argue that personality variables explain why some employees

achieve and others do not. Higher level needs were investigated and categorised as affiliation, power and achievement. McClelland (1975) concluded from his research that affiliation needs, the desire for friendly and close interpersonal relationships, give way to power needs, the desire to manipulate others and be superior to them. Finally achievement needs are characterised by individual responsibility, challenging but achievable goals and feedback on performance. His model suits a particular type of person but it is difficult to believe that elements of each does not motivate individuals at any given time.

Hertzberg *et al.* (1959) developed a two factor theory. Lower level 'hygiene' factors are met by pay, working conditions, interpersonal relations, supervision, company policy, and administration procedures. Higher level 'motivators' include recognition of achievement, intrinsic interest in the work itself, and desire for responsibility and advancement. The view was formed and supported by their research studies that hygiene factors could be improved but that sustained motivation for greater productive effort would fade over time whereas an improvement in motivators would lead to sustained motivation.

The issue of equity also impacts upon motivation. Equity theory holds that if employees see a discrepancy between outcomes they are experiencing and perceived inputs when compared to others, they will be either motivated or de-motivated to work at their current level of effort. In Australia the concept of 'comparative wage justice' has been a long standing tradition which has influenced the IR system and interaction between management and workers. It is difficult to explain the very high levels of remuneration for top level management in terms other than pure greed unless the concept of international 'comparative wage justice' is also introduced.

Vroom's expectancy theory (1964) argues that an employee's predisposition to behave in a particular way depends upon the likelihood that actions will bring about a specific attractive result. Vroom suggests that managers should know the *expectancy*, effort to performance linkage, which is the employee's perceived probability that exerting a given amount of effort will lead to performance. The *instrumentality*, performance to reward link, which is the degree to which the employee believes that performing at a specified

level will bring about a desired result should also be known by a manager. Finally, the *valency*, attractiveness, should be known by the manager, that is the value or importance that the employee places on the potential reward that can be achieved. Vroom suggests that managers should use this intelligence to customise rewards and provide opportunities for individuals to achieve those rewards they value.

Vroom's expectancy theory states that motivation can be assessed as the product of expectancy *times* instrumentality *times* valency. A low value in any of these variables will lower the result, motivation. The study conclusions suggest that some factors may interfere with a worker translating efforts into performance. Inadequate resource provision and generally poor managerial action can prevent workers from performing when they want to. These blockages are postulated to lowering expectation of performance and hence motivation.

The need for training and re-training was also highlighted by the research undertaken by McFillen and Maloney (1988, p43) in which they undertook a survey of 703 tradespersons from the United States. The sample average age was 43.3 years, 88.3% of them were married and 95.4% were the primary supporters of their family. The average years spent in their trade was 20.7 years and number of years in their union was 18.8 years. At the time of the study 60.9% of respondents were employed. Results indicate that instrumentalities perceived to be most influential were either intrinsic or punishing. Workers also believed that they were more likely to be punished for bad performance than rewarded for good performance. The data also provided evidence that workers possessed a very low level of self esteem and the workers believed that there was little connection between good performance and future job prospects. The impact of poor management upon worker performance is of considerable concern to the researchers. Clearly this research indicated that management attitudes towards work and workers must change if motivation to be productive is to be achieved. It would also be dangerous to assume that pay increases alone can be a viable long term motivator. As Neale (1980, p7) has shown, incentive bonus schemes are difficult to manage.

It is important for managers to realise that: employees must accept goals as their own; goals must be challenging but achievable; managers must give employees frequent feedback on performance. Locke (1968) identified clear goal setting as important for motivation.

A survey involving 1,385 Australian managers undertaken by Smith and Mckenzie (1981, p20) concluded that 'lack of objectives' is the number one time waster. This was evidenced by:

- ☐ 21% of managers did not know or were unsure of the goals they were expected to achieve;
- ☐ 15% of managers did not know or were unsure of what was expected of them in their jobs;
- ☐ 37% of managers had received no specific suggestions on performance improvement;
- ☐ 34% of managers received little or no assistance in improving their performance.

This result is confirmed by another survey (Geddes 1990) covering the project management of 150 information technology projects undertaken by Philips NV in Holland in the late 1970s. Clearly defined objectives was mentioned 96% of the time as a key to success while poorly defined objectives was mentioned as a cause of failure in 50% of the cases.

The management of construction projects involves many diverse groups, designers, suppliers, sub-contractors, the construction management team and client consultants responsible for advising on progress in terms of time, cost and quality. Many projects take several years to build and it is inevitable that at some stage during the project's construction conflict between groups will arise.

Blake *et al.* (1964) identified three attitudinal assumptions with associated likely behaviour. His model clearly indicates that a serious problem exists if key team members believe that conflict is inevitable and agreement is not possible or that if conflict is not inevitable agreement is not possible. The model also demonstrates that the client or client representative must establish an atmosphere where agreement can be achieved.

Construction projects are highly complex enterprises, rarely has one group the design and construction skills to complete the project in-house and as has been discussed in the section on risk sharing, the client may not view a design and construct procurement system as suitable. Even within design and construct organisations there may be conflict between teams of designers and constructors.

The builder also faces similar problems to that noted above when dealing with suppliers and sub-contractors. The important feature that needs to be encouraged with interlocking and mutually dependent organisations is that trust is engendered so that problems can be openly discussed and solutions to identified problems sought and developed. Design details that are not practical can be changed at little or no cost time or money if identified early enough. The offering of buildability design advice to the design team was a key issue stressed by many experienced builders in the pilot study. MacPherson (1991, p39) noted success factors that fit into a broad category of 'good team spirit' encompassing an open atmosphere for giving and receiving advice and integration of the construction manager into the design team at an early stage of design development.

The importance of goal setting was earlier stressed, however, various team members may have widely differing goals. The procurement process may exacerbate this tendency if builders win the construction contract based on the lowest possible price as it is likely that this will establish a profit recovery goal in the builder's mind, whereas the client or client's representative may have early completion time, little or no cost increase and high quality as goals to be achieved. Management of conflict by positively using creative energy available to the project team(s) to achieve good CTP is an important factor contributing to success. To achieve this, leaders need to convince followers that it is in their interests to invest good-will and energy to groups they may be in conflict with.

The development of a construction project, particularly a very large one, bears striking similarity to the development of company organisations over a long period of change. The project grows in commercial activity from the involvement of several consultants, defining the brief and concept design, to a large scale workforce during the peak construction



phase. On many projects of hundreds of millions of dollars construction cost, a site workforce of many hundreds of people may be employed with perhaps an equal sized workforce involved with design and construction management and off-site manufacturing.

Greiner (1972, p40) argues that there are five relatively calm periods of evolution that growing organisations experience, each of which ends with crisis and revolution. He concludes that growth continues after an appropriate management style is adopted at each crisis point.

Creativity, the first crisis point, occurs after the originators of the ideas/products are faced with problems associated with large scale production. Technical problems often arise that require different skills associated with more attention to detail. In the construction project example, this may occur when a project moves from the design phase to the construction phase. Crisis in leadership may arise if the key designer does not let go of the design to allow detailed designers and construction management staff to take over monitoring and control functions. This leadership crisis can occur on large projects if adequate budgets and plans have not been produced, evidenced by design drift i.e. the design seems always to be 90% complete. Delays may be caused which often are accompanied by cost implications. This may be overcome by a firmer management leadership style with the establishment of a project control group setting strategic and tactical design and construction plans.

The second crisis occurs when the level of detailed decision making grows beyond the scope of the staff in place to manage. A crisis of autonomy occurs which is solved through greater delegation. On many large construction projects this may occur as the construction activity gains pace, typically during the construction phase where the building gets out of the ground and is approaching peak construction activity. On projects where the builder has won the job on the basis of lowest price there is a tendency for this phase to be grossly under-staffed. This may result in more decisions being delegated to team members who are ill-equipped to accept responsibility. Lower level staff such as sub-foreman or gangers may have been demanding more resources or unplanned use and

timing of resources. On unsuccessful projects there may be pressure for more to be done with less, unpaid overtime for supervisors, and pressure that undermines trust and the capacity to think through problems.

This phase may rapidly degenerate into a third crisis of control. Budgets for time and cost may be seen to be exceeded. Waste may appear to be a problem as inadequate quality work may be ordered to be rectified or work started may be demolished because design changes were not communicated properly. It is at this stage that 'bad' projects tend to degenerate into a 'disasters' if appropriate management style and techniques are not adopted. Growth may continue through greater collaboration, sometimes this is instigated by the organisation recognising the need for more management effort and resources and ensuring that sufficient resources are effectively used.

The fourth crisis is one of red tape. This occurs when the management effort and the organisation becomes too large to be sustained. In his model Greiner sees collaboration as the path out of this crisis. On major projects the administrative load of monitoring, control and coordination activities may be reviewed and streamlined or additional temporary resources brought in to cope with the crisis. This phase often occurs during the final stages of the project, close to project handover when much overtime, weekend work and a 'crash or crash-through' mentality may prevail. At this stage the construction team members may feel sufficiently committed to an opening date that collaboration may be achieved.

Greiner (1972, p40) is unclear of the nature of what the fifth crisis might be. In terms of a construction project it may be the 'snagging' and commissioning stages which fall under pressure from short cuts taken to achieve the handover date. The construction team involved at the earlier stages will have probably moved on to another project at this stage and it will be up to those left or taking over the completion of works, agreeing final accounts, and negotiating contract claims to 'pick up the pieces'.

The major problem facing project teams is that once a project is committed to start there

is often little time to stop and contemplate. The pace of change in this environment is far greater than most observers can appreciate. The culture of the project team organisation changes rapidly from a creative phase of design, planning and problem solving to a production phase. Those involved at the early stage may not have the temperament to continue. Concept architects, for example, may become very agitated as their designs change to meet the exigency of achieving practical construction time and cost budgets constraints. Construction planners who revelled in the creative process of developing clever ways of constructing may become acutely bored with the monitoring and control functions. Construction supervisors may come and go from site as their specialised phases are completed with loss of continuity and job related knowledge.

Previous discussion indicates that closer and more collaborative management styles are appropriate for establishing a framework to achieve CTP. Failure of project stake-holders to see 'the big picture' may be a significant contributor to disharmony inhibiting involvement of critical parties in design and construction processes, making planning, coordination and control more difficult. Recent contributions to the literature (CII 1991) suggest that a concept of 'partnering' should be initiated to assist in better management of real and potential disputes by parties to a project.

Themes emerging from this literature centre around changing the workplace culture from a competitive and authoritarian one to a collaborative and flexible culture where all contributions can be freely offered and worked upon by groups with the aim of improving the traditional system. The Japanese *kaizen* (Imai 1986) approach is one model used over an extensive period in the 'East'. Indeed the traditional handshake of years gone by in the 'West' is a partnering concept. We used to hear phrases such as 'my word is my bond' earlier in this century and it appears that projects where this philosophy is adopted are likely to achieve more success. The BCA report (1993, p10) also recommend the partnering approach as an improved working arrangement for construction projects.

Partnering is defined (CII 1991), as '*A long-term commitment between two or more organisations for the purposes of achieving specific business objectives by maximising the effectiveness of each participant's*

resources. This requires changing the traditional relationships to a shared culture without regard to organisational boundaries. The relationship is based on trust, dedication and common goals, and understanding of each other's individual expectation and values.' Seven key elements of partnering have been identified (MBA-CHAA 1992, p2):

- ☐ commitment, being given from top-management as a commitment and not a contract;
- ☐ equity, recognition that all project stake-holders interests are considered to allow win-win strategies to be promoted;
- ☐ trust, through developing personal relationships which engender mutual trust in relationships;
- ☐ mutual goals and objectives, specific goals may be agreed upon so that respective goals can be identified and efforts made to overlap these with project goals.
- ☐ helpful systems and procedures, strategies for making the partnering arrangements work have to be developed and agreed upon;
- ☐ continuous joint evaluation, stake-holders agree upon a plan to review goals and ensure that the relationship continues to the advantage of the project and all participants;
- ☐ timely responsiveness, mechanisms are established to ensure that disputes are dealt with quickly, effectively and fairly.

The partnering process involves educating organisations involved in the project about the aims and objectives of the partnering arrangements so that the new cultural requirements are understood. Partnering intentions are made clear so that objectives and goals can be identified and patterned into project aspirations. Union or labour representative organisations may, for example, have enunciated objectives relating to safety, working conditions and profit sharing arrangements. Sub-contractors may lay resource planning commitments and payment schedules on the table for agreement. It is important that commitment be gained from top level management of organisations concerned.

Generally a partnering workshop/retreat is arranged with a neutral facilitator where key project participants (stake-holders) can discuss the arrangements and agreements to be established. The outcome of this meeting will be that specific goals will be identified, these will form the partnering charter. It is important that this be a collaborative agreement and that measurable milestones be agreed upon. These may include objectives that may specify that cost growth will be limited or diminished by a set amount and that benefits for this be also identified. A value engineering/analysis, for example, may be agreed to be

undertaken to reduce the construction cost by 'x' % and the construction time by 'y' working days. Cost savings may be shared or benefit gained from time savings.

A dispute resolution procedure is agreed upon at the workshop. A schedule of decision makers with escalation levels of decision makers is also agreed. Typically an agreement may provide for the site foreman to be committed to a trigger point of agreement, after that point the site manager will become involved and after that a director of the firm, designated as project sponsor, will quickly take action. At each level of the decision making chain the contact person responsibility level will be escalated once the designated trigger point is reached. Various scenarios may be talked through and simulation exercises undertaken to test reactions and reaction times in the event that should these problems arise, appropriate dispute resolution mechanisms are in place to rapidly resolve the dispute. A great deal of face is involved once these arrangements are agreed. It is unlikely that the level closest to the dispute will shirk responsibility and try to push the dispute procedure into a bureaucratic non-decision making mode as this will result in loss of face.

Joint evaluation processes are often agreed so that workshops are scheduled throughout the project life span. This avoids the creation of statements being made which have no means to monitor and control deliverable outcomes. The workshops may be scheduled at specific dates or by stages e.g. when structural frame is complete, then at 50% of finishes completion etc. If this is successfully achieved then momentum for progress may be initiated and followed through.

Individual rôles and concerns can be worked through at the workshops. This is where there is great value in sub-contractor and supplier team members being involved as they may have deep concerns about delivery times and resource balancing at specified periods. MB-CHAA (1992, p4) states *'Workshop discussions should include definitions of each key player's unique rôle and what makes the job successful for that rôle - what individuals feel and how it is needed.'* The exercise can be a highly creative process to identify and minimise waste.

Facilitators may be drawn from behavioural or organisational psychologists, management

consultants, alternative dispute practitioners and others who can be perceived to be neutral and will elicit from the project stake-holders their true concerns and open enunciation of perceived difficulties and potential problems. The process is akin to that of planning, monitoring and control. In this case it is the organisational culture and management procedures that are being planned rather than construction time or cost or quality.

Practitioners offer generalities on how to be successful construction managers; human resource management (HRM) figures strongly. Issues of good IR management are issues of good HRM. Occupational health and safety issues are partially a legal requirement, duty of care provisions, and mainly a requirement for motivating a totally unionised workforce on Australian commercial and industrial construction projects. Current workplace reform initiatives instigated by the union movement and supported by employers indicate that a cooperative and participative management style is achievable. Sound team management is essential for the potential of good CTP.

Construction managers should also take note of Hersey and Blanchard (1982), particularly when deciding which management style is appropriate and what use of power is appropriate in getting the most out of HRM.

McFillen and Maloney (1985, p47) believe that job redesign, review of specialisation and compartmentalisation of work require close attention to increase intrinsic rewards. The influence of poor management practices, particularly planning and coordination also was seen to require close attention. This supports recent changes in the Australian construction industry where a greater focus on workplace reform is stressed as a means to increase worker participation in the decision making process and improve productivity through a better organised and motivated workforce.

The most recent available large scale research offers useful insights into worker and management attitudes in the 1990s. A workplace study (AGB 1991) undertaken in 1991 sought data from 1,210 respondents from a variety of trade and supervisory levels on 462 sites in New South Wales. Of the sample, 378 were managers and the remainder

tradespersons or labourers. The study provides the following general conclusions:

- ❑ *Over 70% of the managers interviewed had worked in the industry for more than 10 years and tended to have worked for their current employer (especially those working for sub-contractors) for longer than tradespersons or labourers.*
- ❑ *Managers tend to rate the job giving a sense of achievement as the best thing about working in the building industry whereas labourers place more importance upon good pay and working conditions;*
- ❑ *Medium and small sites tend to have older employees, a higher percentage of trade qualified personnel, a more 'hands-on' approach to management, and a less positive feeling towards job security;*
- ❑ *Overall, there is generally a high level of job satisfaction in the industry and the introduction of multi-skilling is generally favourably viewed although aspects of job security are of concern*
- ❑ *Better management, planning and improving overall communications between workers, employees and contractors are the important areas of action for improving jobs.*

Of the 53% of participants who reported low or non-existent levels of conflict on-site, the dominant reasons mentioned as contributing to this positive outcome were good communications (49%), good safety practices (41%), pay and conditions (33%), a good employer (30%), good head contractor management (21%) and good union delegate organisers (21%). Evidence presented in the AGB (1991) work indicates a workplace environment where there is substantial evidence to indicate that a collaborative atmosphere with constructive changes to the workplace is evolving.

In earlier sections we saw how project related factors and environment related factors can impact upon a project's potential CTP. People make decisions and coordinate activities. People generally undertake most of the physical work; robotics has not yet advanced to a stage where they can take over this aspect of building. People generate the ideas that result in design and construction methods and people formulate plans.

A review of the literature strongly suggests that people have a pivotal rôle in formulating and implementing plans. It follows that careful management of human resources is a crucial factor in achieving project success and sound CTP.

This section assists in identifying issues of human resource management so that appropriate questions may be formulated in the empirical research instrument. These include the nature of the management organisation and style, management of power and motivation of team members which all contribute to the way in which teams are managed and the impact of this upon CTP.

### **3.18.2           MANAGING HUMAN RESOURCES AND TEAM CONFLICT - QUESTIONS ASKED**

Construction teams generally perceived themselves as the group at the coal-face having to compensate for errors and omissions perpetrated by others. In the pilot study many interviewed expressed the view that team management, whether under the control of the construction team or outside their control, is a crucial element contributing to project success or failure in any terms - time, cost, quality, client satisfaction etc.

**Question 15.1** seeks the general impression of the impact of the construction management team upon CTP. Organisational culture can be measured in terms of the degree to which teams are constrained and their autonomy, their task and relationship behaviour and the way in which power and influence is wielded.

The questions in the 15.2 series measure the extent to which team leaders exhibited mechanistic and flexible management styles. Questions 15.2.1 to 15.2.6 are asked to obtain an index of team constraint and autonomy. Questions relate to assessment of respondents regarding their opinion of how key team members reacted during team interactions. These team members included the CR, the design team member, the building contractor and key-subcontractors. The questions use Burns and Stalker's (1961) criteria for measuring mechanistic and organic management approaches.

**Question 15.2.1** 'conform with a fixed hierarchal framework through rules and procedures', **question 15.2.2** 'need to confer with organisational superiors before making commitments', and **question 15.2.5** 'reliance on formal channels of communication' are measures of mechanistic managerial philosophy. Thus, a response of 6, high, to the rating of 'need to confer with organisational superiors before making commitment' indicates a



strong tendency for a mechanistic management style and one would suspect low flexibility. These questions are structured to discover the extent to which teams are comfortable with procedural constraints or perceive themselves to be constrained by contractual or organisational requirements. The average score for these questions was used to develop a measure of mechanistic management style.

**Question 15.2.3** 'influenced by those with project related expertise rather than formal organisational authority', **question 15.2.4** 'readiness to explore options outside the immediately obvious' and **question 15.2.6** 'focus on problems to be solved rather than the procedural mechanism for problem solving' helps measure the degree of autonomy and flexibility that teams are perceived to possess. The average score for these questions was used to develop a measure of flexible management style.

The next bank of 10 questions gather data on the degree of perceived task and people oriented management style exhibited by team leaders. The questions use Hersey and Blanchard's criteria (1982, p160) for measuring management task or relationship oriented style.

**Question 15.3.1** 'specified goals people are to accomplish', **question 15.3.2** 'organised the work situation for people', **question 15.3.3** 'set time lines', **question 15.3.4** 'provided specific direction', and **question 15.3.5** 'required regular reporting on progress' measure task-oriented management style, i.e. the degree to which team managers set objectives, timelines and the degree to which they directed and supervised tasks. The average score for these questions was used to develop a measure of task-oriented management style.

**Questions 15.3.6** 'provided support and encouragement', **question 15.3.7** 'involved team members through discussion of work', **question 15.3.8** 'facilitated group interaction', **question 15.3.9** 'sought peoples opinions and concerns', and **question to 15.3.10** 'provided feedback on accomplishments', measure relationship management style orientation. The average score for these questions was used to develop a measure of people-oriented management style.

Hersey and Blanchard's ideas of power (1982, p304) were used to develop a measure of direct power used as part of the management style. **Questions 15.4.1** 'fear of punishment', **question 15.4.2** 'the legal or traditional position held', and **question 15.4.4** 'ability to provide rewards' are direct power measures. **Questions 15.4.3** 'respect for expert knowledge', **question 15.4.5** 'personal qualities, being liked', **question 15.4.6** 'access to valuable information' and **question 15.4.7** 'leader's connections with influential persons inside or outside the organisation' are reverse score factors of degree of power exercised so that an answer of high (6) would indicate low (2) for direct power used.

Questions 15.5.1 to 15.5.9 are asked to secure information which helps draw a picture of the factors that motivate team members. Low level needs as defined by Maslow such as **question 15.5.1** 'pay and allowances', **question 15.5.3** 'job security', and **question 15.5.4** 'a sense of belonging', are mixed with higher level Maslow needs in questions such as **question 15.5.5** 'recognition of contribution made', **question 15.5.6** 'opportunity to extend skills and experience' and **question 15.5.9** 'opportunities for career advancement'. **Question 15.5.7** 'equitable rewards relative to other's', relates to the ideas of Vroom (1964). **Question 15.5.8** 'exercise of power', relates to the work of McClelland (1975).

**Question 15.6.1 to 15.6.9** assist in determining what factors de-motivate teams. These questions are drawn from survey questions used in the workplace study (AGB 1991) and are asked to investigate whether facets of motivation correlate to team management performance. Some of the questions relate to classical 'hygiene' factors (Herzberg et al. 1959) such as **questions 15.6.1** 'pay and conditions', **question 15.6.2** 'physical working conditions', **question 15.6.3** 'being accountable for unclear or conflicting objectives', **question 15.6.4** 'sense of isolation or marginalisation' and **question 15.6.7** 'having to work to unreasonable time frames'. Others relate to factors that frustrate 'motivator' factors (Herzberg et al. 1959) such as **question 15.6.5** 'lack of recognition of contribution made', **question 15.6.6** 'having to re-do work', and **question 15.6.8** 'having insufficient authority to meet contractual or ethical obligations'. **Question 16.5.9** relates to team relationships and relates to affiliation needs.

### **3.19 MANAGEMENT RESPONSE DETAILS - COMMUNICATIONS MANAGEMENT FOR DECISION MAKING**

Effective decision making relies upon sound timing. Information required for decision making needs to be available when required, to the appropriate level of accuracy and presented in the appropriate context and form. Speed of decision making may be an important factor in ensuring that good CTP is achieved.

Plans are based on information. Coordination involves making choices and setting priorities, monitoring is predicated upon plans and an information system that communicates progress achieved and control requires communication for actions to be carried out. Communication is the key in all aspects of management decision making.

Communication may be undertaken using a variety of forms. Imai (1986) and Bennett (1993) draw particular attention to the Japanese practice of conducting exhaustive consultation and discussion with all groups in an organisation so that decisions can be made and communicated clearly to all involved in the organisation. They stress that while Japanese decision-making may appear slow by 'western' standards, it is carried out remarkable effectively and quickly.

Management of information and decision making is important not only within teams but between teams because the construction process involves the interaction of many teams. The successful management of information and decision making also has a time element. Relationships between teams may deteriorate, remain static or improve over time reflecting changes in the effectiveness of information management. The empirical research instrument developed in this work measures the effectiveness of communication management between teams and within teams across the lifespan of a project from the inception phase to construction completion.

Effective action making requires three vital elements: decision making, communicating decisions made and coordinating resources to take appropriate action to carry out the decision. Written and graphic forms of communication provide a hard copy record which

is often required as part of the communication process. Electronic forms of communication are being used more and more extensively.

### 3.19.1 COMMUNICATIONS MANAGEMENT FOR DECISION MAKING - THE LITERATURE

A decision support system (DSS) is a system or suite of systems that support decision making. It is important that the words support and system be understood in this context. 'Support' means that a DSS assists and facilitates decision making. 'System' implies a logical connection of interacting entities. A DSS does not supplant the human element in decision making and it does not comprise a series of non-integrated non-interacting elements. Betts (1991, p243) expresses concern that information handling systems fail to deliver flexibility in accessing required data because many systems generally mimic manual systems. He has shown that while many current systems are efficient at data processing, storage and retrieval they still do not integrate information in a manner that facilitates open access, even though relational data base technologies allow this. This may explain why difficulty arises when attempting to frame a question relating to effectiveness of information technology used on a project.

Kendall and Kendall (1988, p315) describe the rôle of a DSS in terms of:

- ☐ *'organising information for decision making situations;*
- ☐ *interacting with decision makers;*
- ☐ *expanding the decision-makers's horizons by providing the facility for more options to be considered;*
- ☐ *presenting information for clarifying a decision-maker's understanding of the criticality and sensitivity of data used;*
- ☐ *adding structure to decisions;*
- ☐ *enabling multi-criteria decision-making models to be used.'*

It is evident from the above that a DSS is required to manage the gathering and processing of data to add value to it by turning it into information which can be presented to users who combine this information resource with their experience and judgement to facilitate good decision making. For this to occur the quality of processed information and its timing must be appropriate. Quality can be defined in terms of user expectations of

accuracy, relevance and level of detail. Appropriate presentation of information is also important as information must be easily understood to be used effectively.

Elements of analytical and heuristic approaches are combined to cope with decision making under conditions of risk and uncertainty. The analytical approach is characterised by analysis of the situation, using step-by-step procedures, evaluating quantitative data, building mathematical models and seeking optimal solutions. Analytical decisions tend to be made when there is sufficient available information processing and presentation power to adequately consider, deliberate and arrive at an acceptable solution within given time constraints.

An heuristic approach is characterised by learning through doing, using trial and error experiences, valuing common sense or 'gut-feelings', reacting intuitively based to circumstances, and seeking satisfactory but not necessarily optimal solutions. Heuristic decisions tend to be made when the time frame for decision making is short relative to the time available to gather, process, analyse and present vital information. They also tend to be made when reliable information is unavailable.

Computerised systems developed for heuristic decision making mimic the reasoning process that experts adopt. These are generally referred to as expert systems (ES), or more recently, knowledge based expert systems (KBES). These tend to be rules-based using knowledge about a problem domain following a decision tree approach. A KBES also may form part of a DSS. There are many examples of prototype KBES but few examples of 'real world' systems operating widely in the construction industry, however, over the next 5 years and beyond it is anticipated that KBES will become common application software (Mathur and Maver 1993, p592).

Two classes of decision affect CTP, design decisions and building-production decisions. Decision making emerges at the planning stage. Plans use information inputs from time, cost, quality, safety and other aspects that impact upon design. Decisions continue with the administration and translation of plans into actions. There are two kinds of plans. Strategic

plans set the framework within which problems will be solved. Tactical or operational plans address specific problems identified, defined and scoped by strategic plans.

Table 3.1 summarises strategic and tactical plan information needs and presents a continuum of information access, processing and presentation requirements. Information needs differ for managers at different levels of management and differ depending on the nature of the decision being made. These differing needs require information to be managed and presented in different forms in response to user needs.

<b>Information Element</b>	<b>Strategic Planning Information needs</b>	<b>Tactical or Operational Information Needs</b>
<b>decision horizon</b>	long range	short range
<b>decision objectives</b>	mainly multiple	mostly single
<b>problem identification</b>	often difficult	often easy
<b>nature of problem</b>	mainly semi-structured	mainly structured
<b>set of alternatives</b>	difficult to articulate	often easy to enumerate
<b>decision nature</b>	often one-time	repetitive
<b>decision style</b>	mainly heuristic	mainly analytical
<b>information source</b>	mainly external	mainly internal
<b>timing and accuracy of information</b>	out of date or predictive and approximate estimates	current and highly accurate

**Table 3.1 - Information Needs by Decision Type (Burch *et al.* 1979, Ch3)**

Design decisions often include strategic choices i.e. consideration of the structural frame, cladding system, roofing system, services required etc. These types of decision usually occur before construction activity commences (except for fast-track projects), though re-design decisions are frequently made as part of a value-analysis or program crashing exercise during the construction phase.

Tactical design decisions may include consideration of minor design changes such as colour scheme changes, types of hardware, design changes forced by exigencies of the project or design errors e.g. needing to provide penetrations in walls, ceilings, beams etc. for pipes. These decisions may have wide ranging ramifications upon construction plans. A decision to change from clear to bronzed glazing may impose scheduling problems, especially if the glass specified is not readily available. Design changes may also be complicated by trade demarcation which may in turn affect time and cost budgets.

Design decisions, whether strategic or tactical may require consideration of design alternatives. The sort of information required to make a design decision, its form and tools available for producing and presenting information to make this decision follows:

- ☐ Information may be stored in readable hardcopy form such as freehand drafts, sketches, drawings, specifications, notes, correspondence, and scaled models;
- ☐ Information may also be stored in filing cabinets, compactus, or in reduced form such as microfiche, microfilm, on computer disk or CD-ROM;
- ☐ Design information is presented in drawings, sketches, specifications;
- ☐ Time related and buildability information is presented in method statements, CPM schedules, trend graphs, and simulation studies;
- ☐ Cost related information is presented in cost plans, estimates, budgets, feasibility studies, and sensitivity analysis studies;
- ☐ Safety related information is presented in risk analysis studies, method statements and models used to test risk.

Information may be rapidly or slowly accessed depending upon the ability of those retrieving it to identify where it is, how to access it and how to present it. Burch *et al.* (1979, p30) maintain that information demands arise out of user needs such as quantifiability, accessibility, comprehensiveness, accuracy, appropriateness, timeliness, clarity, flexibility, verifiability and freedom from bias. Consideration of an information system includes reliability, cost, installation schedule, flexibility, life expectancy, growth potential and maintainability. Processing considerations include volume, complexity, and processing time. Another information demand was described as 'tailoring' which requires consideration of filtering, monitoring, interrogation methods, linkages between information

sets, and modelling characteristics. Cost effectiveness, both direct and indirect, and technical, economic, legal and operational feasibility also has to be considered when designing an information system.

Planning, monitoring and control decision making by the construction management team is affected by information management systems employed, including management and distribution of design documentation. Drawing and design schedule information is rarely static; revisions are continually made to reflect design changes and contract variations raised. The effective coordination and distribution of this information is vital to maintaining construction progress. There are a number of software package for monitoring document issue. Crow (1990, p17-18) outlines a proprietary system IMoP/Artemis built around a relational database management system which includes modules for shop drawing control, documentation management and control, variation control, authority approval control and furniture, fixtures and equipment control. Recent research into benchmarking Australian construction projects reveals that an open electronic information system provided important advantages to project stakeholders (Noy 1994).

The rôle of information management systems is to facilitate the gathering, linking, preparation and presentation of information in a variety of forms and media in a useable and effective manner that enables sound decision making to take place. This does not mean that such systems necessarily be computerised.

Information systems are complex entities and matching user's information requirements with the delivery of useable information is critical to the decision making process. Project organisations are also highly complex with numerous groups requiring the coordination, sharing and transfer of information. These groups include but are not limited to the client's representative team, the design team, the construction team and supporting subcontractors and suppliers, and regulatory agencies associated with a project. The inability of the construction industry to effectively manage IT has been demonstrated (Mathur and Ofori 1988/89; Toakley 1986; Walker 1988/89). The source of this problem lies in a number of managerial areas. Drewer and Hazelhurst (1993, p183) identify a lack



of coherent IT integration of applications as being of serious concern.

Merely implementing computer systems is also not the answer to sound information management. While there has been a clear increase in the use of computer applications in the construction industry (Walker 1987) their effectiveness has been doubtful (Drewer and Hazelhurst 1993, p193). 'Quickly providing poorly structured or presented information does not increase effectiveness of decision making. Quickly providing accurate and valuable information in a manner that is not user-friendly also fails to be effective. Gonzales et al. (1993, p48) conclude, from a study of six European construction industry firms, that firms should target their IT application program to applications that provides them with a competitive edge as many applications adopted are obsolete as soon as they are installed.

The human factor in information management cannot be ignored. Humans are often used in gathering and preparing data which may be processed by computer for later human interpretation. There is generally a human interface with IT at the front and back ends of the information processing cycle. The introduction of bar coding for example, while it may speed up and be more accurate in logging items, does not eliminate human input. The range, diversity and complexity of human intelligence had not thus far been successfully encoded into any artificial intelligence system. Human activity still predominates in the front-end, i.e. data formulation and input, and back-end of information processing and decision making, i.e. analysis, synthesis, evaluation, and interpretation.

In a study of 15 organisations in 1987 it was concluded that a vital factor in successful implementation of computer systems is the manner in which the human element of the business system is treated. Any company that implements new technology and ignores this crucial element does so at its peril (Walker 1988/9). A study of the implementation of office automation (OA) by 110 companies in the USA (Westin *et al.*, 1985) supports Walker's (1988/9) conclusions. Westin's principal findings regarding organisational and behavioural changes stemming from the use of office automation indicate that:-

- *'The tasks performed by principals and secretarial personnel can change significantly with the introduction of OA equipment - expectations change;*

- ☐ *There are significant changes in the allocation of professional's time to various tasks.;*
- ☐ *There are changes in the content of job interactions among professionals, secretaries and managers;*
- ☐ *Work flows through different paths and personnel ;*
- ☐ *The rôle and need for existing support organisations (administrative departments) changes radically;*
- ☐ *Personnel increase their span of control over work in progress. Intermediaries (secretaries, support services, assistants) can be by-passed. The possibility of collaboration with peers is enhanced;*
- ☐ *The work pace is often quicker and more intense, with interruptions and other forced waits becoming less tolerable;*
- ☐ *Dependency upon newly available facilities becomes almost addictive;*
- ☐ *People lose their ability to work effectively without the equipment;*
- ☐ *The amount of face-to-face personal contact is changed. In some cases the availability of the equipment increases such contact, while in others it is decreased;*
- ☐ *There will be new rules of business etiquette established to cope with the use of new technology.'*

The USA experience parallels that of many Australian firms. In an Australian study into new office technology (ASTC 1986, Vol. 2, p75) it was argued that the reason Australian firms encountered difficulty assessing implications for productivity is due to introduction of information technologies without sufficient analysis of work and organisational structures prior to its introduction. The report also supports the view that IT often gives qualitative, rather than quantitative, improvements which often lead to new capacities, greater flexibility in working and better ways of doing things. The human element of change has to be addressed in the form of job enrichment, job redesign and organisational analysis before tangible benefits can be seen and measured. A vital rôle for management in managing change to a more effective use of IT is to encourage and effect training programs that prepare personnel at all levels, reshape jobs to seize the positive effects that computerisation can make and to ensure that IT remains relevant to information management.

Application of IT is also reported to have an impact upon management style. The Hong Kong experience indicates the possibility of greater centralisation of decision making but with increased levels of participation from employees (Ng and Lansley 1993, p58). This may be the case worldwide for single application software products, however, with

widespread distributed processing and proliferation of spreadsheet use, an argument can be made for higher levels of management losing tight control over information.

Design drawings, sketches and specifications make up much of the design information used on projects. Many design consultants still operate entirely on hardcopy, however, there is growing use of computer aided drawing (CAD) for design development. Wide use of CAD on projects in Melbourne has been evident with interchange of data from design documentations even when different CAD software is used by different design consultants on the same project.

Office automation has advanced from the use of electronic typewriters in the 1970s and early 1980s to substantial use of word processing in the 1990s. This has provided the facility for electronic data interchange though it is unclear to what extent this is taking place. Extensive use of facsimile (fax) machines has allowed information to be rapidly transmitted. Electronic mail (e-mail)' has yet to make a great impact upon the construction industry but it is expected that this will supplant much of the use of fax as a means of information transmission. E-mail has the ability to attach documents, files and scanned images to messages which can be transmitted and communicated in a matter of seconds or minutes. E-mail also has the advantage of being 'posted' to a mailbox address so that if the receivers of messages are unavailable then once they log into their computer they are informed by their computer's operating systems that an e-mail message is ready for their attention. While e-mail is not used on many building projects the technology has been and is being extensively used by academics' and research bodies such as the CSIRO. Once builders and others in the project team are convinced of e-mail's efficacy it will no doubt be used with the same enthusiasm as fax machines and mobile telephones are today.

Walker (1987) indicated that computers are being used by builders for spreadsheet and planning applications at an increasing rate. Planning and scheduling applications are particularly useful for undertaking simulation studies and for rapidly building up time programs from elements of past projects held on file. This advance in the use of planning software has allowed more options to be tested and considered which may increase the

quality of decisions being made. Advances in presentation techniques of this software has allowed information to be customised, colour coded and presented in a highly targeted way so that only pertinent information can be presented to decision makers for consideration. Spreadsheets have been and are used extensively for contract administration purposes but they can also be used for extensive 'what if' analysis (Walker 1988a) as well as for monte carlo simulation exercises (Walker 1988b).

Database applications are another area where more extensive use of computer technologies for information management (Crow 1990) is being experienced. Maintenance of registers that maintain records of drawings, requests for information, contract variations, subcontractor listings etc. allow for rapid access to useful data for monitoring the status of various information sources transmitted as well as access to valuable procurement source resources such as suppliers and sub-contractors. There is no discrimination of information media in a DSS.

Many techniques of planning and work study are devoted to reduction of the need to multiple-handle materials. Double handling fragile or sensitive materials such as glass, plaster board, tiles etc is avoided to eliminate waste and breakages and avoid impairing the integrity resource. Comparatively little regard is paid to the multiple handling of another important resources, information, and the effect that this has upon its integrity. These effects may include: damage, i.e. inaccurate transportation; perishability i.e. being delivered too late to be of use; and loss. Multiple entry of data is wasteful and potentially dangerous, leading to poor decision making and the potential for sensitive information to become generally available.

Information overload also represents a potential inefficiency for information users. Too much information or poorly presented information often impairs the quality of decisions made. Examples of badly handled information follow:

- ☐ delivery of uncoordinated design drawing information caused by delays in issuing them, drawings may arrive that are superseded and thus no longer accurate;
- ☐ monitoring information such as time, cost and quality status information being presented too late to

- be acted upon, worse still if out of date then wrong decisions may be made;
- ❑ programs, plans and schedules being out of date and reflecting historical positions that may have been rectified or deteriorated;
- ❑ lack of accurate and time forecasting data used to decide actions on proposed changes in design leading to paralysis in construction progress while 'holds' on work areas are maintained.

Lack of timely and appropriately accurate information also imposes a considerable constraint on decision making which is often undertaken in conditions of uncertainty. The use of computers for processing, adding value, presenting and communicating information is in its infancy in the construction industry, however, there is evidence of a trend towards greater use of these technologies. The rapid adoption of fax and mobile telephones by the industry demonstrates a willingness to invest in cleverer and more effective technologies once their value is appreciated.

It is important to realise that much of the information communicated in the early stages of construction management is ideas and conceptual models. These may be effectively transmitted using voice, sketches and other visual media. While technologies discussed in this section can assist with generating this information, the most likely use of more advanced information technologies such CD-ROM for storing audio and video information will be for recording historical information rather than using it for DSS.

One important element addressed in this section was the part that humans play in effective information management. Evidence was offered on studies undertaken on the impact of IT and information management on organisational performance. As Bodi (1987, p21) cogently points out *'In the management of the technology within the organisation, managers need to understand human interface issues, implications of technology for job and skill changes, and overall organisational consideration. Finally, the deepest and hardest challenge is to harness the new technology to create internationally competitive products and services.'* The last part of her statement could well apply to competitive CTP.

Finally the essence of this section has been discussion of information management to facilitate effective decision making. A picture of information management can be gained

of an organisation from a description of the forms of information used and how it is stored; how it is collected, processed, accessed and presented; how it is coordinated, transmitted, distributed and shared; and lastly how human and organisational interfaces have been created to facilitate effective use of information for decision making.

### 3.19.2 COMMUNICATION MANAGEMENT FOR DECISION MAKING - QUESTIONS ASKED

**Question 16.1** measures perceived impact of management communications upon CTP. Communications management includes all forms of exchanging information including: personal forms, e.g. speech, use of telephones, meetings etc.; hardcopy, e.g. written documents, drawings and illustrations etc.; and IT which includes electronic data exchange, computing and fax. This question does not seek to assess the effectiveness of media used but does assess the overall impact of the mix of media and the appropriateness of the situation in which the chosen medium was used.

More detailed data is sought on the way in which communications was managed in the case studies using questions 16.2.1 to 16.2.3 and 16.3.1 to 16.3.3.

Questions 16.2.1 to 16.2.3 measures the effectiveness of communication management for effective decision making between major project team leaders. **Question 16.2.1** measures effectiveness of communication management between the client/CR and construction team leaders, **question 16.2.2** between the Client/CR and design team leaders, and **question 16.2.3** between the design team and construction team leader.

Question 16.3.1 to 16.3.3 measures effectiveness of communication within each of those teams. **Question 16.3.1** measures effectiveness within the client/CR team, **question 16.3.2** within the design teams, and **question 16.3.3** within the construction team.

Communications management is linked to decision making effectiveness, usually based on quality and appropriate timeliness of information used to make decisions. Effectiveness of decision making is also affected by the effectiveness of communication of decisions and the ability of teams to get others to act on decisions made i.e. coordinating action flowing

from a decision being made. **Question 16.4.1** measures these facets for the CR, **question 16.4.2** for the design team, and **question 16.4.3** for the construction team. **Question 16.4.4** provides an overall impact of these facets upon the project.

**Question 16.5** reveals the extent of IT use by the CR, design team and builder. **Question 16.6** reveals the effectiveness of IT use by these three team groupings.

Questions concerning communication management gather data on the overall impact, the specific impact between and within teams as well as drawing out information on how IT is being implemented.

### **3.20 OVERALL MANAGEMENT CONTROL PERFORMANCE INDICATOR**

It was considered to also obtain an impression of the overall management effectiveness of the CM team in case a single index measure might prove to be a useful measure for analysing CTP.

**Question 17.1** provides the overall measure of management performance in identifying project and environmental risks and devising strategies, systems and procedures to deal with these risks.

### **3.21 SUMMARY**

The advance that this empirical research instrument has made in extending the boundaries of knowledge is that it was structured to obtain data on causal rather than symptomatic reasons why some buildings are constructed more quickly than others.

The survey was developed from two sources. The literature and industry expertise accessed from the pilot study. This chapter has explained and justified the development of this research instrument.

#### 4.0 INTRODUCTION

The initial model used in this work and the development of the research was discussed in chapter one. To summarise, a model was developed to predict construction time based on data from a representative sample of projects. The predicted construction time was compared with actual construction time to produce an index value which was useful in analysing identified factors that may affect each project's CTP relative to the sample. Justification for the methodology and research approach was provided in chapter two. The model used to determine construction time was also justified and explained in chapter two. In chapter three, the justification and explanation of the research instrument was extensively discussed.

It is recommended that the reader refer to appendix 2 for detailed ANOVA and correlation results while interpretation of the statistical results is provided in detail for each sub-hypothesis and its correlation with other factors in this chapter. Appendix 2 is a detailed summary comprising 226 pages of detailed statistical evidence.

The purpose of this chapter is to discuss the model used to predict construction time from data gathered and also restate the research hypotheses and report upon the results

#### 4.1 DISCUSSION OF THE PREDICTIVE CONSTRUCTION TIME MODEL

Construction time in workdays is predicted from the formula:

$$\begin{aligned} \text{WORKDAYS} = & \text{Construction Cost in \$000's}^{0.481294} \\ & * \exp [(1.187976 * \text{eot\_act}) - (0.488867 \text{ if it is a fit-out project}) + \\ & (0.105097 * \text{obj\_qual}) - (0.125269 * \text{cr\_people}) + (0.079837 * \\ & \text{cm\_des\_com}) + (0.104343 * \text{cm\_IT\_use})] \end{aligned}$$

The model describes predicted construction time in workdays in terms of end\_val (construction cost in \$000's indexed to January 1990 taken at the mid-point of construction), eot\_act (the ratio of extensions of time granted to actual construction period e.g. 0% = 0 and 22% = 0.22), work\_type = 'fit' (applicable if the project is a fit-out), obj\_qual (the case study's data for the CR's objective for high quality of workmanship scaled measured on a 1 to 7 point scale where 1 = very low and 7 = very high), cr\_people (the case study's data for the CR's people-orientated management style measured on a 1 to 7 point scale where 1 = very low and 7 = very high), cm\_des\_com (the case study's data for the communications



management for decision making between the construction and design team measured on a 1 to 7 point scale where 1 = very low and 7 = very high), and cm\_IT\_use (the case study's data for the effective use of information technologies by the construction management team measured on a 1 to 7 point scale where 1 = very low and 7 = very high).

The time prediction model is surprising in that 'effectiveness of communication for decision making between CM and design teams', and 'effectiveness of the CM team's use of information technologies' have positive coefficients. This means that an INCREASE in the value of either or both factors results in INCREASED predicted time. Survey respondents cited experiencing difficulties with both these management aspects due to extensive discussion and analysis of data and information. A general disquiet was seen to emerge that there may have been 'too much talk and not enough action.' This may be explained by a perception shift in the respondents away from effectiveness to efficiency. More efficient use of IT may be less effective or more communication between the CM and design team may lead to delays due to discussion time.

The predictive model brings with it factors of scope, complexity and management performance. This model represents an advance on previous predictive models which are restricted to scope only measures.

## 4.2 DISCUSSION OF RESEARCH HYPOTHESES

The thesis tested by this research was that *'variance between actual performance and trend line performance can be substantially explained by managerial effectiveness of the project team in response to challenges posed by factors outside the control of the construction management team.'*

More specifically, four principal hypotheses are tested by this work:

### **CR team's management effectiveness -**

$P_1-H_0$  that CTP IS NOT significantly affected by the management effectiveness of the client's representative;

$P_1-H_1$  that CTP IS significantly affected by the management effectiveness of the client's representative;

### **CM team's effectiveness -**

$P_2-H_0$  that CTP IS NOT significantly affected by the management effectiveness of construction management teams;

$P_2-H_1$  that CTP IS significantly affected by the management effectiveness of construction management teams;

### **Design teams' effectiveness -**

$P_3-H_0$  that CTP IS NOT significantly affected by design team management effectiveness;

$P_3-H_1$  that CTP IS significantly affected by design team management effectiveness;

### **Project challenges -**

$P_4-H_0$  that CTP IS NOT significantly affected by a small number of challenges posed by factors outside the

control of the construction management team;  
 $P_4-H_1$  that CTP IS significantly affected by a small number of challenges posed by factors outside the control of the construction management team.

Investigation of evidence to support or reject the principal hypotheses involved testing 102 sub-hypotheses because the principal aim of this work is to investigate the reason why some projects are built more quickly than others by establishing a 'league table' (see table 4.1) of factors for the sample group to also indicate the strength of each factor tested.

HY	Question	Group	Sub-hypothesis (Short-hand) Description - In Significance Order	Sig.
62	14.1	CM	HI+ CM's organisational structure to manage risk	0.0010
58	13.3.6	CM	HI+ CM's planning - responding to problems or opportunities	0.0016
59	13.3.7	CM	SH+ CM's effectively coordinating resources	0.0028
60	13.3.8	CM	SH+ CM's developing an organisational structure to maintain workflow	0.0032
30	2.7.1	CR	SH+ the project design team's confidence in the CR contribution	0.0040
88	16.2.1	CR/CM	SH+ CR and CM team communication effectiveness for decision making	0.0043
93	16.3.3	CM	HI+ decision making communication within the CM team	0.0094
96	16.4.3	CM	SH+ CM decision making, communicating and actioning	0.0113
17	2.4.2	CR	HI+ client/CR's time minimisation objective	0.0136
28	2.6.5	CR	SH+ ability of the CR to contribute ideas to the design process	0.0137
32	2.7.3	CR	HI+ the construction team's confidence in the CR's contribution	0.0142
18	2.4.3	CR	client/CR's quality performance objective	0.0151
84	15.3	KEY S-C	SH+ key sub-contractor's task-oriented management style	0.0156
9	1.11	CM	5% (Est.+EOT) workdays being within 5% of actual duration	0.0161
38	3.1	PROJ	inherent site conditions	0.0173
45	9.1	PROJ	economic environmental complexity	0.0177
56	13.3.1-4	CM	SH+ CM's forecasting planning data	0.0188
89	16.2.2	CR/DES	SH+ CR and design team communication effectiveness for decision making	0.0237
87	16.1	CM	SH+ CM's communication management to facilitate decision making	0.0258
36	2.7.7	CR	AVG+ CR's willingness to contribute effective and positive ideas	0.0267
61	13.3.5-8	CM	HI+ effectiveness of the construction team's monitoring and control	0.0269
1	1.1	PROJ	construction cost being greater than \$20 million (january 1990 dollars)	0.0272
100	17.1	CM	HI+ effectiveness of the CM team in managing the construction process	0.0273
52	13.3.1	CM	SH+ CM's forecasting planning data	0.0275
57	13.3.5	CM	HI+ CM's monitoring and updating plans to reflect work status	0.0305
53	13.3.2	CM	AVG+ CM's analysing construction methods	0.0315
90	16.2.3	CM/DES	SH+ CM and design team communication effectiveness for decision making	0.0448
99	16.6	CM	AVG+ CM's effective use of information technologies	0.0452
49	12.1	CR/CM	SH+ impact of CR/CM working relationship	0.0468
29	2.6.6	CR	SH+ ability of the CR to contribute ideas to the construction process	0.0489
			From the regression model (but accepting the null sub-hypothesis)	Regression Model Sig.
		PROJ	Log of: construction cost	0.0000
10	1.12	PROJ/CR	ratio of EOT:actual construction time	0.0002
5	1.6	PROJ	type of work = 'fit-out'	0.0011
70	15.3	CR	CR's people-oriented management style	0.0011

Table 4.1 - Factors Significantly Affecting CTP (In Rank Order)

Threshold values are indicated in Tables 4.1 and 4.2 in the sub-hypothesis short-hand description column. These indicate the point or level at which the factor become significant. SH+ means slightly high and better, AVG+ means average and better, HI+ means high and better. Variables used in the derivation of the CTP index have also been included in table 4.1 and appear in the shaded rows.

P<sub>1</sub>-H<sub>1</sub> is supported by results of testing sub-hypotheses 17, 18, 28, 29, 30, 32, 36, 49, 88 and 89; P<sub>2</sub>-H<sub>1</sub> by sub-hypotheses 9, 32, 49, 52, 53, 56, 57, 58, 59, 60, 61, 62, 84, 87, 90, 93, 96, 99 and 100; P<sub>3</sub>-H<sub>1</sub> by sub-hypotheses 89 and 90; and P<sub>4</sub>-H<sub>1</sub> by sub-hypotheses 1, 38 and 45.

HY	Question	Group	Sub-hypothesis (Short-hand) Description - In Significance Order	Sig
75	15.3	DES	design team's people-orientated management style	0.0573
54	13.3.3	CM	CM's analysing resource movement	0.0659
6	1.7.1	CR	project procurement method	0.0681
78	15.2	CM	flexibility of the CM's management style	0.0711
19	2.4.4	CR	stability of client/CR objectives	0.1033
42	7.1	PROJ	access to and within site	0.1053
66	15.1	CM	CM's effectiveness in team management to achieve synergy	0.1240
71	15.4	CR	direct use of power in the CR's management style	0.1382
23	2.5.2	CR	complexity of CR's influence upon the project's management	0.1596
41	6.1	PROJ	quality management procedures used on-site	0.1654
101	15.5.3	CM	Motivation - job security	0.2457
7	1.7.2	DES	design development stage at start of construction	0.2469
39	4.1	PROJ	design buildability complexity	0.2669
16	2.4.1	CR	client/CR's cost minimisation objective	0.2907
26	2.6.3	CR	CR's ability to effectively brief the design team	0.3140
12	2.2.2	CR	client company size	0.3275
50	12.2	CM	CM's effectiveness in influencing the CR decision making process	0.3338
55	13.3.4	CM	CM's analysing work sequencing to achieve and maintain workflow	0.3503
51	13.1	CM	CM management systems and procedures	0.3813
46	10.1	PROJ	socio-political environmental complexity	0.4035
37	2.7.8	CR	the overall CR contribution to project team harmony	0.4045
2	1.3	PROJ	number of basement levels	0.4111
82	15.2	KEY S-C	key sub-contractor's mechanistic-orientated management style	0.4180
79	15.3	CM	task-orientation of the CM's management style	0.4289
33	2.7.4	CR	the CR's confidence in the construction team	0.4385
34	2.7.5	CR	the CR's ability to mould shared project goals and aspirations	0.4555
95	16.4.2	DES	design team's decision making, communicating and actioning	0.4661
40	5.1	DES	design coordination complexity	0.4782
86	15.4	KEY S-C	direct use of power in key sub-contractor's management style	0.4793
27	2.6.4	CR	stability of CR decisions	0.4863
4	1.6	PROJ	the building's end use	0.4882
47	11.1	PROJ	impact of the IR environment	0.4955
65	14.4	KEY S-C	key sub-contractor's organisational structure to manage risk	0.4991

**Table 4.2 - Factors NOT Significantly Affecting CTP (In Rank Order)**

HY	Question	Group	Sub-hypothesis (Short-hand) Description - In Significance Order	Sig.
69	15.3	CR	task-orientation of the CR's management style	0.5198
77	15.2	CM	CM's mechanistic-orientated management style	0.5577
80	15.3	CM	CM's people-orientated management style	0.5806
44	8.1	PROJ	physical environmental complexity	0.5887
3	1.4	PROJ	number of floors being greater than two	0.5939
92	16.3.2	DES	decision making communication within the design team	0.5962
11	2.2.1	CR	client representative form	0.6344
72	15.2	DES	design team's mechanistic-orientated management style	0.6463
8	1.9-10	PROJ	construction time period	0.6520
91	16.3.1	CR	decision making communication within the CR team	0.6567
83	15.2	KEY S-C	flexibility of key sub-contractor's management style	0.6666
76	15.4	DES	direct use of power in the design team's management style	0.6800
15	2.3.3	CR	client organisation's confidence in the CR	0.6838
74	15.3	DES	task-orientation of the design team's management style	0.7062
64	14.3	CR	CR's organisational structure to manage risk	0.7319
35	2.7.6	CR	the CR's willingness to accept effective and positive ideas	0.7327
73	15.2	DES	flexibility of design team's management style	0.7479
31	2.7.2	CR	CR's confidence in the project design team	0.7550
43	7.3	PROJ	general project complexity	0.7588
63	14.2	DES	design team's organisational structure to manage risk	0.7829
24	2.6.1	CR	CR's understanding the project's constraints	0.7887
22	2.5.1	CR	the level of influence exercised on CTP by the CR	0.8001
98	16.6	DES	design team's effective use of information technologies	0.8341
67	15.2	CR	level of CR mechanistic-orientated management style	0.8344
94	16.4.1	CR	CR decision making, communicating and actioning	0.8388
21	2.4.6	CR	credibility of achieving goals established by the CR/Client	0.8440
25	2.6.2	CR	CR's ability to quickly make authoritative decisions	0.8553
48	11.3	PROJ	impact of general environmental factors	0.8681
102	15.5.9	CM	opportunity for career advancement	0.8696
81	15.4	CM	direct use of power in the CM's management style	0.8759
68	15.2	CR	flexibility of the CR's management style	0.8825
20	2.4.5	CR	clarity of communication of client/CR objectives	0.9145
85	15.3	KEY S-C	key sub-contractor's people-orientated management style	0.9342
14	2.3.2	CR	CR's experience with the building procurement process	0.9356
97	16.6	CR	CR's effective use of information technologies	0.9622
13	2.3.1	CR	client organisation's experience with the building procurement process	0.9858

Table 4.2 (Cont'd) Factors NOT Significantly Affecting CTP (In Rank Order)

Evidence supporting or rejecting sub-hypotheses are based upon ANOVA testing. Before discussing the results in detail, a step-by-step explanation is provided for the procedure using the statistical package STATGRAPHICS which was the tool used in this research.

#### 4.2.1 A STEP-BY-STEP DISCUSSION OF SUB-HYPOTHESIS 1 TEST RESULTS

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. A significance level measure of **less than** 0.05 indicates that

the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  hypothesis is rejected and the alternative hypothesis,  $H_1$ , is accepted. (STATGRAPHICS reference manual page O-11)

Sub-hypothesis 1's null and alternative hypotheses are:

$H1A_0$  Construction time performance is **NOT** dependent upon construction cost level.

$H1A_1$  Construction time performance **IS** dependent upon construction cost level.

The data being tested is the CTP index value for construction cost, indexed to Australian \$1990, categorised into five data levels: \$4 million up to \$8 million; \$8+ million to \$14 million; \$14+ million to \$20 million; \$20+ million to \$30 million; and over \$30. This variable was obtained from question 1.1 in the questionnaire as described in chapter three. First the cost category data was tested against the CTP index data value for each case study. The result indicates a significance level of 0.1363, that is a weak indication of variation between groups relative to the within groups of the mean values of CTP. Thus the null sub-hypothesis is accepted.

Level	Count	Average	Standard Error (internal)	Standard Error (pooled)	95% Tukey HSD	
					intervals for mean	
1	12	0.95	.0483227	.0583695	.8311962	1.0717393
2	9	0.94	.0904712	.0673993	.7979081	1.0756633
3	5	0.97	.0939685	.0904256	.7876012	1.1602489
4	4	1.05	.0625785	.1010989	.8402862	1.2569191
5	3	1.28	.0627211	.1167390	1.0406820	1.5217682
Total	33	0.99	.0351981	.0351981	.9200916	1.0651445

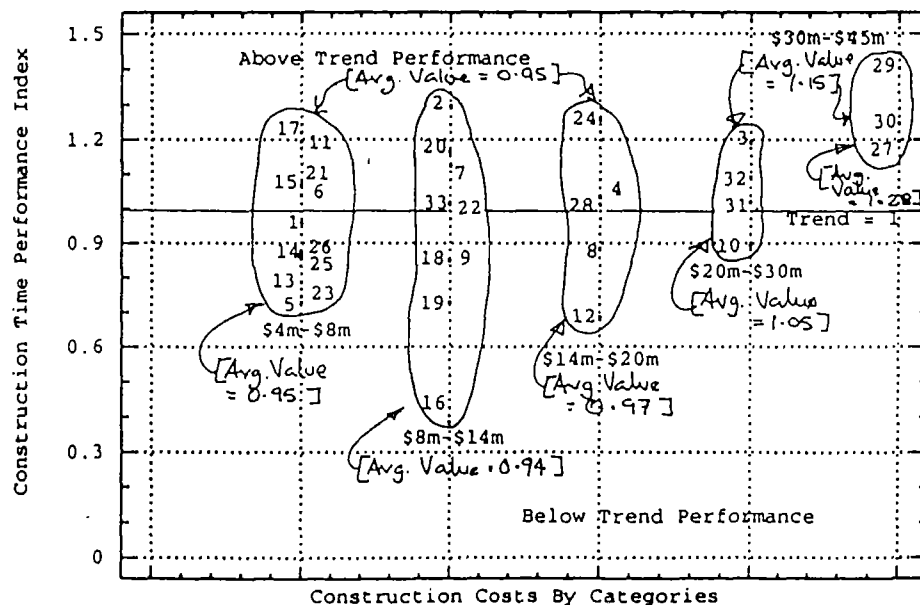
**Table 4.3 - Table of Means for CTP Index by Cost Category**

Table 4.3 illustrates the table of means result which provides the following information for each data level: the level e.g. 1 for \$4million up to \$8 million; count, i.e. number of cases in each level; average value for each level; the internal standard error for the category; the pooled standard error for the category; and the 95% Tukey honest significance differences (HSD) intervals for the mean. This table provides interesting insights of the data.

The Tukey HSD intervals provide a measure of 'honest' spread of values about the mean (Peterson 1985, p77). This measure provides a range of mean values for that data level within which that level can be expected to lie given the confidence level which was accepted. For

level 1 the HSD intervals for mean CTP index value of 0.95 is between 0.8311962 to 1.0717393. It can be seen from the HSD mean data ranges that none of the levels 1 to 5 comprise a distinct range. Level 1 overlaps level 2's Tukey HSD intervals which overlaps level 3. The conclusion drawn from table 4.3 confirms the ANOVA test result for a significance level of 0.1363, i.e. that the null sub-hypothesis is accepted.

Figure 4.1 illustrates a plot of CTP index against construction costs in the five data levels 1 to 5 as described above. Each cluster of case study projects has been identified for each construction cost category. This analysis indicates that at levels 1, 2 and 3 the average CTP index value is closely grouped with averages below trend-line, whereas there appears to be a significant difference between the value for levels 4 and 5 which have average CTP index values above trend-line.



**Figure 4.1 - Graph of CTP Index against Construction Cost Category**

It was decided to investigate this further by re-running the ANOVA test for cost category greater than three. The revised sub-hypothesis test was:

H1B<sub>0</sub> Construction time performance is **NOT** dependent upon construction cost being greater than A\$20 million (January 1990).

H1B<sub>1</sub> Construction time performance **IS** dependent upon construction cost being greater than A\$20 million (January 1990).

Results of this test indicates a 0.0272 significance level. The null sub-hypothesis is rejected and the alternative sub-hypothesis accepted, i.e. CTP is dependant upon construction cost being greater than \$20 million. The table of means provides additional explanation for this conclusion.

Level	Count	Average	Standard Error (Internal)	Standard Error (pooled)	95% Tukey HSD	
					Intervals for mean	
0	26	0.95	.0407356	.0392543	.8940764	1.0073320
1	7	1.15	.0623664	.0756527	1.0391621	1.2574339
Total	33	0.99	.0348431	.0348431	.9423537	1.0428823

**Table 4.4 - Table of Means for CTP Index by Cost Category Greater Than Three**

This result demonstrates that there are two significantly separate clusters of projects, at the 95% level. Projects up to \$20 million in construction cost indexed to January 1990 has a group mean CTP index of 0.95 and tend to lie in the 0.894 to 1.007 range, rounded to three decimal places. The second cluster of projects over \$20 million have a group mean CTP index of 1.148 and tend to lie in the range 1.039 to 1.257, rounded to three decimal places. The 95% Tukey HSD interval for means ignores outlier values in its calculation of the range. This result is illustrated with case numbers identified in figure 4.1.

In this manner 102 sub-hypotheses were tested using the ANOVA technique to produce results illustrated in tables 4.1 and 4.2 and detailed in appendix two. In some cases it was necessary to cluster data by category such as 'greater than average' or 'greater than high' for data values categorised under a seven point scale of 'very low' to 'very high' as described in the step-by-step discussion of development of sub-hypotheses 1A and 1B.

Spearman ranked correlation tests were also undertaken for each variable against all other data variables. Results of these tests were then grouped in appendix 2 into two clusters, those that are shown to significantly affect CTP and those that do not.

#### 4.2.2 CLIENT REPRESENTATIVE (CR) FACTORS

ANOVA testing for sub-hypotheses 17, 18, 28, 29, 30, 32, 36, 49, 88 and 89 reveal significant association between CR sophistication and managerial performance. Appendix 2 illustrates the results of those tests together with correlation analysis undertaken for all data

items with the variable tested. Reported results only include variables with a correlation of greater than 0.45 or less than -0.45, i.e. close to being moderate.

#### 4.2.2.1 CR FACTORS AFFECTING CTP

Table 4.5 illustrates the sub-hypotheses tested and their ANOVA significance level, significance levels of less than 0.05 results in rejection of the null sub-hypothesis and acceptance of the alternative sub-hypothesis.

HY	Sub-hypothesis (Short-hand) Description - In Significance Order	Sig.
30	SH+ the project design team's confidence in the CR contribution	0.0040
88	SH+ CR and CM team communication effectiveness for decision making	0.0043
17	HI+ client/CR's time minimisation objective	0.0136
28	SH+ ability of the CR to contribute ideas to the design process	0.0137
32	HI+ the construction team's confidence in the CR's contribution	0.0142
18	client/CR's quality performance objective	0.0151
89	SH+ CR and design team communication effectiveness for decision making	0.0237
36	AVG+ CR's willingness to contribute effective and positive ideas	0.0267
49	SH+ impact of CR/CM working relationship	0.0468
29	SH+ ability of the CR to contribute ideas to the construction process	0.0489
	<b>From the regression model</b>	<b>Regression Sig.</b>
70	CR's people-oriented management style	0.0011

**Table 4.5 - CR Sub-Hypotheses Supporting P<sub>1</sub>-H<sub>1</sub>**

The above 11 reasons why CTP is affected by CR factors falls into three broad groups.

- ☐ HY-17 and 18 indicate a client with well defined goals indicating client sophistication;
- ☐ HY-88, 28, 89, 36 and 29 indicate a CR that is closely involved with the management of the project and contributes to its overall management indicating CR sophistication;
- ☐ HY-30, 32 49 and 70 indicate a CR who works well with project teams and has their respect and cooperation indicating good CR/team relationship and mutual understanding.

It is interesting to reflect upon the nature of factors with high or moderate correlation to the above factors significantly affecting CTP. Appendix 2 contains detailed variable correlation data so that underlying influences to the results of the sub-hypotheses tested can be better appreciated. Strong evidence supporting sub-hypothesis 17, 'Construction time minimisation', being an important factor was to be expected. Evidence supporting sub-hypothesis 18, 'client/CR's quality performance objective', to be an important factors affecting CTP was,



however, less obvious. Several case study respondents maintained that high quality demands often led to things being done correctly the first time, reducing delays due to re-working and coordinating rectification work. There were few projects with formal QA/QC or QM procedures though most respondents felt that they had adequate informal systems in place to address that issue. Evidence of moderate association of factors relating to planning and control with both hypotheses 17 and 18, leads to the conclusion that the client's time and quality objectives significantly encourages better planning by the CM and better communication between and within CR and CM teams.

A CR, capable of contributing ideas to the design and construction teams, sub-hypothesis 28 and 29, indicates an encouraging level of client commitment and involvement to a project. This provides supporting evidence that an involved and actively participating CR is likely to appreciate problems associated with the project and strategies employed by the project teams in overcoming difficulties which may lead to inter-team confidence building.

Correlation results for sub-hypotheses 28 and 29, provide evidence to suggest that the CR's ability to contribute ideas to the design process may be based on team bonding, confidence-building, and good team communications. The results also highlight a requirement for high levels of client sophistication through high correlation of these factors with the CR's understanding of the project's constraints. Analysis of data for testing sub-hypothesis 36 also indicates high correlation between a CR management style that is inclusive and people-oriented which may encourage flexibility in the project team's management style. This impression is supported by test results for sub-hypotheses 88 and 89.

Test results for sub-hypotheses 30 and 32 supports the view that project teams must have a high level of trust and confidence in the CR. It is interesting that results for testing sub-hypotheses 31 and 33 indicate that CR confidence in the project team is not critical to CTP whereas team confidence in the CR is critical. If the CR is subjecting the project team to uncertainty then it would make sense that the teams, as executioners of decisions and those responsible for finding ways of overcoming identified problems, must have confidence in the CR. The CR must also be able to manage the client to ensure that changes to decisions are minimised, that timely decision making is taking place, and that the briefing stage is properly undertaken.

Correlation analysis data for sub-hypothesis 30, 32 and 49 reveal high association between confidence in the CR and impact of CR/CM working relationship and moderate association with general issues relating to within and between team communications. Moderate to high correlation exists between this factor and the CM team's team planning and general management performance suggesting that a good CR/CM working relationship provides a sound basis for good CM team performance to be realised. There is strong evidence provided in the correlation analysis for these sub-hypotheses that confidence and good working relationships are moderately to strongly associated with positive management performance characterised by flexibility, responsibility and cooperative management styles. Others (Blake *et al.* 1964, p136; Blake and Mouton 1964; and Hersey and Blanchard 1982, p160) believe that management style is important to team performance.

The model used to determine CTP derived from a multiple regression analysis includes the CR's people-oriented management style factor, the coefficient value is -0.125269 times the rating where 1 = very low and 7 = very high. Thus higher CR's people-oriented management style results in lower construction time. While the ANOVA analysis of sub-hypothesis 70 does indicate acceptance of the null sub-hypothesis, the model determining construction time partially compensates for this, hence the ANOVA test fails to reject the hypotheses. This also occurs for several, but not all, other variables in the model. Correlation analysis results indicate that it is moderately associated with team management style of project teams and also communication related factors. Correlation of this factor with CR motivation and de-motivation factors is revealing. A number of higher order motivators are shown to correlate with 'CR's people-oriented management style' including 'CR's sense of belonging & identification with the team project team', 'CM's recognition (money/kudos) of contribution made'. De-motivation was associated with frustration factors, though 'pay and conditions' rated strongly 'CM's having to work to unreasonable time frames' and 'CR having insufficient authority to meet obligations' also had high correlation with a people-oriented management style'.

#### **4.2.2.2 CR FACTORS NOT AFFECTING CTP**

Results of ANOVA tests for sub-hypotheses pertaining to CTP and the nature of the client that were accepted at the 95% follow. CTP is NOT dependent upon :

##### **CLIENT FACTORS:**

- ☐ HY-6 procurement method;

- ☐ HY-11 client representation form;
- ☐ HY-12 client company size;
- ☐ HY-13 client organisation's relevant experience;
- ☐ HY-16 the client's construction cost minimisation objective;
- ☐ HY-19 stability of client's objectives;
- ☐ HY-20 clarity of client's objectives;
- ☐ HY-21 credibility of client's objectives;

**CLIENT'S REPRESENTATIVE FACTORS**

- ☐ HY-14 client representative's relevant experience;
- ☐ HY-15 the client's confidence in the client representative;
- ☐ HY-22 the extent of CR influence upon the project's management;
- ☐ HY-23 complexity resulting from CR influence upon management of the project;
- ☐ HY-24 the CR's understanding of the project's constraints;
- ☐ HY-25 the CR's ability to make quick authoritative decisions;
- ☐ HY-26 the CR's ability to effectively brief the design team;
- ☐ HY-27 the CR's stability of decision making;
- ☐ HY-31 the confidence of CR in the design team's contribution to the project;
- ☐ HY-33 the confidence of CR in the construction team's contribution to the project;
- ☐ HY-34 the CR's ability to mould shared project goals and aspirations;
- ☐ HY-35 the CR's willingness to accept effective and positive ideas;
- ☐ HY-37 the CR's contribution to team harmony;
- ☐ HY-64 an appropriate CR team structure;
- ☐ HY-67 a CR mechanistic management style;
- ☐ HY-68 a CR flexible management style;
- ☐ HY-69 a CR task-oriented management style;
- ☐ HY-71 a CR direct use of power in the management style;
- ☐ HY-91 CR within-team communication effectiveness;
- ☐ HY-94 CR decision making and implementation effectiveness;
- ☐ HY-97 the CR's effective use of information technologies.

Differences in conclusions between researchers may be explained by changes in working and organisational culture which also vary by region and over time. Research undertaken by Sidwell (1982), Bresnen *et al.* (1990) and Naoum (1991) was conducted in the UK while Ireland's (1983) work and this study reflects Australian conditions.

Sidwell (1982, p58) concludes that public funded projects take longer to build than privately funded projects. Inspection of test results for sub-hypothesis 11 clearly indicates that there are not significantly more projects appearing below the trend-line CTP index line than above for both government and private clients/CRs. While there appears to be more projects performing better with private or government appointed consultant CRs than government department CRs, the difference is statistically insignificant. Additional correlation evidence indicates no significant links between client type and other factors shown to affect CTP.

Sidwell (1982, p58) also concludes that traditional contracts have lower levels of control than non-traditional forms (Sidwell 1982, p79-80). Ireland (1983) supports Sidwell's conclusions and indicates that non-traditional procurement methods are likely to lead to better CTP than traditional ones. Naoum (1991 p31) in reporting results for a study of 69 projects, concludes that *'the major factors that affect cost and time overruns are the procurement method adopted and the designer's experience ...'*, however, Bresnen *et al.* (1990, p15) in a study of 138 projects, which included 23 housing projects, conclude that there was only a slight association between type of client and CTP and insignificant association between contract type and CTP. Results reported upon in this thesis indicates at the 95% confidence level, that CTP is NOT dependent upon procurement method based on contractual arrangements, however, at the 90% confidence level significant difference occurs. Correlation analysis indicates moderate relationship between direct use of power as a management style for the CR, CM and key sub-contractors which may indirectly inhibit CTP. Alternative contractual arrangements such as construction or project management, and design and construct provides for more involvement of the CM team prior to construction and helps build relationships with the CR and design teams.

Results from Spearman Rank Correlation analysis reveals no significant relationship between factors affecting CTP and client representative form, client organisation size and experience, client's construction cost objective or with the building procurement process adopted. These factors appear to clearly have no impact directly or indirectly upon CTP.

There is evidence of moderate correlation of the quality of client decision making, in terms of stability and clarity of communicating objectives and their credibility, with CM team's management performance. Evidence presented in appendix 2 clearly indicates that a moderate link exists between the CM team's risk management and planning and control and stability of client objectives. The client's clarity of communication of objectives is also strongly linked to CM team confidence in the CR and the flexibility of the CR's management style. Moderate correlation is also proved between credibility of client objectives and CR/design team communication effectiveness and design team performance. This evidence links client performance in management of goal setting and both CM and design team performance.

Moderate correlation is shown between both CR experience and client confidence in the CR and client sophistication measures which gauge the CR's capacity to make good decisions and

interact positively with the CM team and design team. Appendix two provides the detailed correlation evidence which clearly support this view. While the ANOVA test for sub-hypothesis 14 reveals no significant effect upon CTP, correlation analysis reveals moderate association with effectiveness of the CM team in managing the construction process and communication effectiveness between CR and CM teams. Moderate association is also evident with variables which could be described as comprising a grouping of 'client sophistication' variables.

The extent of the CR's influence exercised on the project's management appears to be small, however, the complexity resulting from CR influence is highly significant to the CM team's confidence in the CR. Strong evidence is presented in appendix two to link CR performance with CR objective setting and communication of objectives.

Spearman Rank Correlation of the variable 'the level of influence exercised on CTP by the CR' reveals no strong associations with other factors. Results from testing sub-hypothesis 23, however, yields more understandable results. While this was found to be a factor not affecting CTP it is associated with many other factors affecting CTP. There appears to be high correlation between this factor and a confidence of the CM in the CR and high correlation with both 'clarity of decision making' and 'CR's ability to quickly make authoritative decisions'.

A number of client sophistication factors tested by sub-hypotheses 24 to 27 were found not to significantly affect CTP. This presents a surprise as one would expect these to characterise good decision making. Strong and moderate associations are reported with factors that build project team confidence in the CR and affect the CR/CM team relationship. While these factors do not directly affect CTP they do contribute to a measure of CR management performance. NEDO (1988, p53) demonstrated a key client or CR influence on the outcome of building projects which is mirrored by skill in:

- ☐ *clearly expressing project objectives in terms of building requirements, cost and time budgets;*
- ☐ *defining the procurement strategy and the input that the client can make to the project;*
- ☐ *bringing together a - possibly unique - configuration of specialist to work as a team;*
- ☐ *determining the level of service expected from each member of the project team.*

Test results from sub-hypotheses 31 and 33 indicate that the CR's confidence in the design and construction teams are not significant factors affecting CTP. Correlation analysis evidence

presents few surprises. CR confidence in these teams appears to be moderately associated with team performance, communication effectiveness and management style. The CR's confidence in the design team appears to be highly associated with flexibility of design team's management style.

Results from testing sub-hypotheses 34, 35 and 37 portray an active and strong leader of the project team being non-essential to CTP. This appears contrary to the image of a successful CR who can mould teams and focus them upon the client's goals and priorities. While some respondents state a preference for a CR that does not interfere with the CM team's management others welcome a cooperative approach with an active CR becoming involved in decision making. This may affect the CM's capacity to deliver high CTP. Results from testing these sub-hypothesis provides strong evidence of a high correlation between these factors and others affecting CTP. Strong association is also demonstrated between this factor and 'the construction team's confidence in the CR's contribution' and 'CR and design team communication effectiveness for decision making'. Other moderate associations point to sound CR team relationships building confidence in the CR which significantly affects CTP.

The CR's willingness to accept ideas is shown to be highly associated with CR/CM team effective communications. It is interesting to note which factors are highly associated with 'the overall CR contribution to project team harmony'. 'The construction team's confidence in the CR' and 'CR/CM communication effectiveness' are highly correlated, as is 'the CR's ability to mould shared objectives'. The high negative correlation between 'the CR's direct use of power as a management style' and 'the CR's contribution to team harmony' reinforces the destructive impact that a confrontationalist approach can have upon team relationships.

Results from the ANOVA testing of case studies indicate that management style, with some exceptions for several participants, does not affect CTP. Spearman Rank Correlation testing for sub-hypotheses 64, however, indicates a strong association between this variable and most of the other factors affecting CTP. Evidence of moderate and high correlation between 'CR's organisational structure to manage risk variables' and most other variables affecting CTP strongly indicates that 'CR's organisational structure' indirectly affects CTP by tending to supply sufficient quantity or quality of skills to nurture a good CM/CR relationship and inspire confidence in the CR.

Sub-hypothesis 67, 68, 69 and 71 test the impact of CR management style on CTP. Evidence is also provided in appendix two to illustrate how a mechanistic style may have a negative impact. Moderate or near-moderate associations between aspects of design development appear to be affected by this. A mechanistic CR style also has moderate association with a mechanistic CM style which is not surprising it also has a moderate association with low order motivation factors, specifically job security.

CR flexible management style has some interesting correlation with factors affecting CTP. The weight of evidence presented suggests that flexible management style indirectly assists CTP through team building and communications; the high association between this variable and 'clarity of communication of client/CR objectives' also supports this conclusion. Flexibility in management style also appears to correlate moderately with higher order motivation factors.

Correlation analysis between task-orientation of the CR's management style and factors affecting CTP uncovers significant moderate association with confidence building, team communication, and decision making performance variables. Motivation and de-motivation factors also reflect achievement and commitment in the correlation between motivation and de-motivation with a task-oriented management style.

Sub-hypothesis 71 test results indicate that the CR's use of direct power has no significant affect upon CTP, however, interesting associations are revealed by correlation analysis. High negative association between 'direct use of power in the CR's management style' and 'the overall CR contribution to project team harmony' suggests that a confrontationalist approach may have a negative impact upon team relationships, communication and the impact of CR/CM working relationship. It is clear from correlation analysis between this management style and motivation and de-motivation factors that the result is an inverse correlation with 'CR's a sense of belonging & identification with the project team' and a moderate correlation with 'design team's a sense of belonging & identification with the project team'.

The CR's effectiveness in communications management for decision making and working with teams is also investigated by testing sub-hypotheses 91 and 94. The results indicate that these factors do affect CTP. Correlation analysis reveals high association between 'decision

making communication within the CR team', 'effectiveness of the construction team's monitoring and control', and 'decision making communication within the CM team'. Moderate association with other aspects relating to planning and decision making also support the conclusion that this variable affects others, which in turn directly impact upon CTP.

Results for sub-hypothesis 97, which proposes that the CR's effective use of IT affects CTP, may be questioned as many respondents were unsure of the impact of the CR's use of IT and how that may affect project success. None of those questioned in the survey had experience of widespread use of IT in terms of electronic mail (e-mail), linking FAX and e-mail and other communication technologies. It can be reasonably speculated that the introduction of electronic mail and better information management tools will make effective IT use an important issue impacting upon CTP in the future. Correlation analysis reveals some evidence to support that it affects construction planning and decision making within the CM team.

#### **4.2.2.3 GENERAL DISCUSSION OF CR RELATED FACTORS AFFECTING CTP**

CR characteristics emerging from the results indicates that CTP is positively affected by a CR who can: work well with people in teams; communicate well with teams; and is willing to contribute ideas. This does not preclude a strong, goals-orientated, determined, focussed, and strict manager of the development process provided that the CR also possess relevant people management skills and be open to other's ideas. A management style that relies on direct use of power has been shown to be limiting, it limits the contribution of others and even demotivates the CR who uses power directly.

An impression unfolds from the correlation analysis of the above sub-hypotheses. CR performance appears to be dependent upon the CR working relationship with the client to effectively define project scope and project brief. This maximises clarity and stability of project goals and helps the CR understand the project constraints. This creates an environment where trust can develop between teams, particularly between the CR and the design and construction teams. This leads to confidence of project team members in the CR which facilitates a good working relationship and can be associated with a less confrontationalist management style leading to greater cooperation. More open communication between and within teams helps the development of open relationships which in turn facilitates effective planning and control. Effective planning and control and effective communication helps establish greater CTP as teams may now be able to develop sufficient realisation that it is in



all their interests that problems are solved more openly and cooperatively.

CR performance can be classified by the 11 sub-hypotheses described in table 4.5 at the 95% confidence level. This performance is also strongly supported by those factors found NOT to affect CTP but are highly correlated to those factors that DO affect CTP namely:

- ☐ *CR's understanding the project's constraints;*
- ☐ *clarity of communication of client/CR objectives;*
- ☐ *CR's ability to quickly make authoritative decisions;*
- ☐ *the CR's ability to mould shared project goals and aspirations;*
- ☐ *the overall CR contribution to project team harmony;*
- ☐ *complexity of CR's influence upon the project's management;*
- ☐ *CR team's organisational structure to manage risk.*

The CR should represent the client's interest. Objectives and priorities can shift over time, particularly when the CR is dealing with several committees each seeing themselves as a client group. More of the educational projects and the hospital projects in the 33 case study survey performed below trend-line performance than above. This may be a function of the client rather than the project as office projects displayed an equal distribution of above to below trend-line performance. There are generally several facilities management interest groups in the case of educational and hospital clients, who channel requests and recommendations to the CR for implementation. This may result in the CR at various times reversing decisions, changing priorities and appearing to lack direction and focus. There may be better understanding, if the project teams understand the nature of constraints facing the CR, of the reason for CR action or inaction and alternative decision making management strategies may evolve to maintain construction momentum while maximising options and flexibility for changes in design, construction priorities and other appropriate considerations. This may also explain why test results for sub-hypotheses 25 and 27 indicate that the teams need to have a high level of confidence in the CR.

The first principal hypotheses advanced by this work is:

- $P_1-H_0$  *that CTP IS NOT significantly affected by the management performance of the client's representative;*  
 $P_1-H_1$  *that CTP IS significantly affected by the management performance of the client's representative.*

Given the weight of evidence presented in testing the cluster of CR related sub-hypotheses and the Spearman Rank Correlation analysis for all data variables tested, the alternative hypothesis  $P_1-H_1$  is accepted.

### 4.2.3 CONSTRUCTION MANAGEMENT TEAM (CM) FACTORS

Table 4.6 The ANOVA test (at the 95% confidence level) reveals that important summary and detailed CM related factors affect CTP. Six of the seven factors affecting CTP with a significance level of less than 0.01 are CM related. This demonstrates overwhelming support for the conclusion that CTP is most significantly affected by CM team performance. The 0.01 significance level means that this result may occur by chance in one in one hundred cases.

#### 4.2.3.1 CM FACTORS AFFECTING CTP

Table 4.6 illustrates the sub-hypotheses tested and their ANOVA significance level for summary CM variables and table 4.7 for detailed variables.

HY	Sub-hypothesis (Short-hand) Description - In Significance Order	Sig.
62	HI+ CM's organisational structure to manage risk	0.0010
56	AVG+ effectiveness of the construction team's planning	0.0188
87	SH+ CM's communication management to facilitate decision making	0.0258
61	HI+ effectiveness of the construction team's monitoring and control	0.0269
100	HI+ effectiveness of the CM team in managing the construction process	0.0273
49	HI+ impact of CR/CM working relationship	0.0468

**Table 4.6 - Summary CM Sub-hypotheses Supporting  $P_2-H_1$**

HY	Sub-hypothesis (Short-hand) Description - In Significance Order	Sig.
58	HI+ CM's planning - responding to problems or opportunities	0.0016
59	SH+ CM's effectively coordinating resources	0.0028
60	SH+ CM's developing an organisational structure to maintain workflow	0.0032
93	HI+ decision making communication within the CM team	0.0094
96	SH+ CM decision making, communicating and actioning	0.0113
84	SH+ key sub-contractor's task-oriented management style	0.0156
9	5% (Est.+EOT) workdays being within 5% of actual duration	0.0161
52	SH+ CM's forecasting planning data	0.0275
57	HI+ CM's monitoring and updating plans to reflect work status	0.0305
53	AVG+ CM's analysing construction methods	0.0315
90	SH+ CM and design team communication effectiveness for decision making	0.0448
99	AVG+ CM's effective use of information technologies	0.0452

**Table 4.7 - Detailed CM Sub-hypotheses Supporting  $P_2-H_1$**

The 18 reasons highlighted in tables 4.6 and 4.7 indicate why CTP is affected by CR factors. Reasons fall into three broad groups, with HY-100 being a summary sub-hypothesis, which describe good CM practice:

- ☐ HY-9, 52, 53, 56, 57, 58 and 61, CM planning management and control procedures;
- ☐ HY-49, 59, 60, 62 and 84, CM organisational structure, coordination and management style;
- ☐ HY-87, 90, 93, 96 and 99, CM communication skills.

Results from the sub-hypothesis 9 test indicates that CTP is dependant upon 'the building duration time being within 5% of estimated duration adjusted for approved EOT'. The only significant association with any of the factors compared in the analysis was a moderate correlation with impact of CR/CM working relationship. This may indicate that projects constructed ahead of approved revised schedule tend to have a better CTP index, 7 out of 8 cases. It may also mean that in those cases the estimated duration was generous and could be reduced, that the CR was generous in approving EOT, or some combination of both. It is probably more realistic to assume, given that projects are awarded under market conditions, that the estimated duration was reasonable. The most likely explanation for these results is that this measure indicates good time management on the part of the construction team and that the CR granted reasonable EOT claims.

Sub-hypothesis 56 is a summary of sub-hypotheses 52 to 55 of which sub-hypothesis 52 'CM's forecasting planning data' and sub-hypothesis 53 'CM's analysing construction methods' are indicated to significantly impact upon CTP. Sub-hypothesis 61 is a summary of sub-hypotheses 56 to 60 and each of these impact upon CTP, i.e. sub-hypothesis 57 'CM's monitoring and updating plans to reflect work status', sub-hypothesis 58 'CM's planning - responding to problems or opportunities', sub-hypothesis 59 'CM's effectively coordinating resources' and sub-hypothesis 60 'CM's developing an organisational structure to maintain workflow'. These hypotheses generally have high correlation with each other and with team communication variables. Test results for sub-hypothesis 56 indicate moderate correlation with a number of CR factors. This supports the hypothesis that a sophisticated CR, who can facilitate an environment in which a CM team plans and controls well, can achieve high CTP.

Correlation results for sub-hypothesis 61 also indicate high correlation with factors that do not directly affect CTP such as 'CM's management's systems and procedures' and 'CM's effectiveness in team management to achieve synergy'. Management style has been shown to have moderate influence on 'effectiveness of the construction team's monitoring and

control', particularly 'CM's people-orientated management style', 'task-orientation of the CM's management style' and flexibility of both the CR and the CM's management style. The general picture emerging from the Spearman Rank Correlation analysis is that CM performance is linked, and is probably assisted, by positive CR sophistication and managerial effectiveness factors.

The importance of team relationships, organisational structure and management style is indicated through the results of those sub-hypotheses tested and found to significantly affect CTP, notably sub-hypotheses 49, 59 60, 62 and 84. These pertain to a well organised, well managed and cooperative CM team.

Sub-hypothesis 49 test results for 'impact of CR/CM working relationship' suggests that a better quality relationships between the CR and CM leads to better CTP. Spearman Rank Correlation results support this, indicating high correlation between this factor and 'confidence of the CM and design team in the CR' and also with 'CM's communication management to facilitate decision making'. Most of the factors affecting CTP have moderate correlation with this factor. There is also high correlation between this factor and 'the CR's ability to quickly make authoritative decisions'. The weight of evidence suggests that the CR's influence upon this factor is strong with elements of good management performance being linked to a good CM/CR working relationship, which is also shown to influence good CTP. The importance of positive CM/CR working relationship is supported by this factor's moderate NEGATIVE correlation between 'direct use of power in the CR's management style'. This indicates that a power rather than cooperative approach results in lower CTP.

Test results for sub-hypothesis 59, 'CM's effectively coordinating resources', highlights the importance of good CM managerial practice. It is not surprising that Spearman Rank Correlation analysis reveals very strong association between this variable and 'CM's planning', 'responding to problems or opportunities' and 'effectiveness of the construction team's monitoring and control'. The high correlation between the variables 'CM management systems and procedures' and 'CM's analysing work sequencing to achieve and maintain workflow' supports the overall assessment of good team management skills reflected in its association with 'CM's effectiveness in team management to achieve synergy'.

Results from testing sub-hypothesis 60 revealed a strong correlation between 'CM's developing an organisational structure to maintain workflow' with the summary CM management variable. The particularly strong association with this variable and 'effectiveness of the construction team's monitoring and control' confirms an expectation that strong evidence could be found to link the CM's organisational skills and good managerial practice. The moderate correlation between this variable and with CM and CR management style suggests a CM 'hands-on' and involved but team-oriented style is associated with positive CTP results.

Sub-hypothesis 62 test results clearly demonstrate a strong link between the CM team structure, its quality of personnel and staffing level being appropriate for the management task, and good CTP. Correlation analysis strongly links this factor with 'effectiveness of the construction team's monitoring and control' and 'CM's analysing work sequencing to achieve and maintain workflow'. A strong association exists between this variable and 'the construction team's confidence in the CR's contribution'. This association, together with moderate correlation with the CR's ability to contribute both construction and design ideas, indicates that an involved and sophisticated CR assists the CM team to achieve management effectiveness. The moderate association of this variable with 'stability of client/CR objectives' and 'clarity of communication of client/CR objectives' supports this view.

The only management style factor shown to directly impact upon CTP is the 'key sub-contractor's task-orientated management style'. This factor has moderate association with a number of CM planning, control and communication variables that directly impact upon CTP. Associations with factors not directly affecting CTP include the management styles of other team members. The picture emerging from association with both people-oriented and task-oriented managements styles of the CR and CM suggests a task-oriented and people-oriented management style encourages key sub-contractors to be results-oriented, using people's skills to overcome task related problems in a flexible manner.

CM communication skills is an important element for good CTP. Sub-hypothesis 87 test results provides clear evidence of CM's communication management facilitating decision making affecting CTP. This variable has strong correlation with impact of 'CR/CM working relationship', 'CM's effectively coordinating resources', 'effectiveness of the construction

team's monitoring and control', and 'CM decision making, communicating and actioning'. This evidence links communications management with planning and control and developing sound CR/CM relationships as well as the effectiveness of decision making. The moderate association indicated of this factor with others not directly affecting CTP indicates that CR sophistication and management style also plays a part. The moderate negative correlation between this variable and direct use of power in the CR's management style supports the contention that a confrontationalist management style has negative impact upon CTP.

Test results for sub-hypothesis 90 'CM and design team communication effectiveness for decision making', sub-hypothesis 93 'decision making communication within the CM team', and sub-hypothesis 96 'CM decision making, communicating and actioning' support the evidence that general communications and decision support affects CTP. The argument is further strengthened by CM and design team communication effectiveness being moderately associated with a design team people-oriented management style. CM decision making effectiveness is moderately linked to both 'planning and control' and 'general communication performance'. CM decision making performance is also moderately associated with a task-oriented CR and CM and people-oriented management styles. 'CM decision making, communicating and actioning' is highly correlated with CM planning and control and is also highly correlated with 'CM's effectiveness in team management to achieve synergy' and communication management to facilitate decision making.

Sub-hypothesis 99 test results 'CM's effective use of information technologies' also suggests that good CM communication skills in using decision support technology assist the CM to become a more effective manager.

#### 4.2.3.2 CM FACTORS NOT AFFECTING CTP

Results from the ANOVA tests for sub-hypotheses pertaining to CTP and the nature of and interaction between the CM and key sub-contractors that were accepted at the 95% follow, CTP is NOT dependent upon :

- ☐ HY-33 the confidence of CR in the construction team's contribution to the project;
- ☐ HY-41 the impact of quality management procedures adopted during construction;
- ☐ HY-50 the impact of the influence the construction manager may have over the CR decision making process;
- ☐ HY-51 effective construction management procedures;
- ☐ HY-54 effective analysis of resource movement for planning;
- ☐ HY-55 effective analysis of activity sequencing to achieve & maintain workflow;

- ☐ HY-77 a CM's mechanistic management style;
- ☐ HY-78 a CM's flexible management style;
- ☐ HY-79 a CM's task oriented management style;
- ☐ HY-80 a CM's people oriented management style;
- ☐ HY-81 a CM's direct use power as a management style;
- ☐ HY-82 key sub-contractor's mechanistic management style;
- ☐ HY-83 key sub-contractor's flexible management style;
- ☐ HY-84 a slightly high or greater level of key sub-contractor's task oriented management style;
- ☐ HY-85 key sub-contractor's people oriented management style;
- ☐ HY-86 key sub-contractor's direct use power as a management style;
- ☐ HY101 CM's motivation factor - job security ;
- ☐ HY102 CM's motivation factor - opportunity for career advancement.

Sub-hypothesis 41 tests the impact of quality management procedures on CTP. It is surprising that this did not significantly affect CTP given evidence to suggest that the client's QM objectives affects CTP. Some moderate association with other factors affecting CTP were found which, being concerned with communications management and decision making, appear logical. A contractor with defined QM arrangements in place should be more organised, employ better planning and better communicate with other team members. The Spearman Rank Correlation lends limited but not strong support for this conclusion.

Few of the above sub-hypotheses are related to CM planning management and control procedures except sub-hypotheses 51, 54 and 55. This indicates the critical importance that planning and control has upon CTP as most of these factors are proved to significantly affect CTP. Perusal of the correlation factors affecting CTP confirms this for sub-hypothesis 51, 54 and 55. These results indicate high correlation with other planning and control related factors, as is also the case with sub-hypothesis 33 'CR's confidence in the construction team'. Decision making and communication related factors also have medium to high correlation with these factors. This gives rise to a pattern of CR sophistication emerging as an infrastructure for good CTP.

The impact that various management styles have upon CTP is particularly interesting. A mechanistic style, for example, appears to have no significant influence whatsoever for both the CM and key sub-contractors. A flexible CM management style has moderate correlation with both CM and CR decision making and communications variables as well as CM planning variables. No significant correlation was discovered between key sub-contractor flexible management style and factors shown to significantly affect CTP. Task orientation of CM

management and key sub-contractors appears to affect planning, control and communications factors which affect CTP as well as other team's management styles.

Spearman Rank Correlation analysis of CM motivation and de-motivation with management style reveals interesting insights. A mechanistic management style has no impact on CM motivation or de-motivation. A flexible management style is moderately associated with higher order motivation factors related to achievement, a sense of belonging and opportunities for self-improvement, as does a task-oriented management style. Moderate correlation is found between 'CM's people-orientated management style' and both the CR and CM achievement motivators. A 'CM direct power management style' is also shown to be destructive to general morale. High negative correlation is seen between this management style and the on-site management team's sense of belonging and the CR's opportunity to extend skills and experience. The near moderate correlation with the on-site workforce's de-motivation due to having insufficient authority to meet contractual/ethical obligations is interesting. It is concluded from this analysis that direct use of power by the CR has moderate to high negative impact upon other factors affecting CTP.

The CM's people-oriented management style appears to correlate moderately with communications related variables and key sub-contractor's people-oriented management style has moderate impact upon CM planning and control factors. There appears to be a strong link in management styles between the CM and key sub-contractors.

Sub-hypothesis 81 and 86 test results indicate no significant correlation between direct use of power and CTP and there is moderate correlation between the CR, CM and key sub-contractor's team's power-oriented management style suggesting that when this style is used by one team it tends influence the style of other teams. In revisiting the CR's power-oriented management style it can be seen that this style is shown to have moderate to strong associations with poor team relationship factors which in turn can inhibit good CTP. The moderate correlation of CM and CR power-oriented management style draws an interesting inference on the link between confrontationalist management styles and CTP.

The analysis of correlation between the CM's motivation from job security and other factors tested show no significant correlation. The same can be broadly said for the CM motivation



from opportunity for career advancement, with the exception of moderate association with project procurement method and a negative correlation with the 'CR's direct use of power in the CR's management style'. This could mean that more inclusive management styles encourage higher levels of CM motivation.

#### 4.2.3.3 GENERAL DISCUSSION OF CM RELATED FACTORS AFFECTING CTP

The ANOVA and Spearman Rank Correlation analysis has provided valuable statistical evidence which helps explain why good CTP is significantly affected by CM team performance. The CM's professional approach to planning and control contributes to good CM team performance. This approach is evidenced by the CM team's:

- *initially thinking through the plan and defining the issues, planning construction methods effectively, and putting in place a coordination strategy that allows for adequate monitoring and control;*
- *communication both with internal and external team helps to facilitate decision making, decision communication and decision action;*
- *adoption of a management style that maximises cooperation but still maintains a focus on results, this does not mean that task-orientation and flexibility or people-orientation are mutually exclusive.*

The useful application of this work is that it proves, within the statistical constraints and sample definition, that good CTP has strong association with good CM management performance and that the CR has a strong influence on providing an infrastructure of cooperation, communication and commitment which significantly affects CM performance. This work draws to our attention the critical importance that leadership on the part of the CR has upon CM performance.

In the past some CR's have been able to influence client's into believing that a confrontationalist management style, direct use of power and an unyielding results-oriented approach to management produces sound CTP outcomes. It is always difficult *post-hoc* to fairly allocate praise and blame for CTP results because issues get muddled by details, personality factors, and the time taken to design and build. This work has provided a clear picture of CR and CM best practice for achieving good CTP and as such can form a sound basis for developing benchmarks for achieving these best practices.

The second principal hypothesis advanced by this work is:

$P_2-H_0$  *that CTP IS NOT significantly affected by the management performance of construction management teams;*

$P_2-H_1$  *that CTP IS significantly affected by the management performance of construction management teams;*

Given the weight of evidence presented in the cluster of sub-hypotheses identified as CM related factors affecting CTP and evidence presented from Spearman Rank Correlation analysis, the alternative hypothesis  $P_2-H_1$  is accepted.

#### 4.2.4 DESIGN TEAM PERFORMANCE FACTORS

Key issues affecting CTP were identified from the literature related to design coordination and buildability. It was suspected that they are symptomatic of inter-team and intra-team communication. Questions asked reflect this proposition and the reason why questions about number or percentage of documents with technical or coordination errors was not asked was because errors inevitably occur and they can be intercepted and rectified, or at worst accommodated, providing that good communication is evident and good teamwork exists to obviate problems.

##### 4.2.4.1 DESIGN TEAM FACTORS AFFECTING CTP

Table 4.8 illustrates the ANOVA test at the 95% confidence level reveals that two important design team related factors affect CTP.

HY	Sub-hypothesis (Short-hand) Description - In Significance Order	Sig.
89	AVG+ CR and design team communication effectiveness for decision making	0.0237
90	AVG+ CM and design team communication effectiveness for decision making	0.0448

**Table 4.8 - Sub-hypotheses Supporting  $P_3-H_1$**

Correlation of 'CR and design team communication effectiveness for decision making' sub-hypothesis 89 and other factors affecting CTP reveals that this can affect communication for decision making of other teams, which is to be expected. There is also moderate correlation evidence linking this variable with 'the CR's sophistication and management style' and team relationship factors. It is inferred from this evidence that the design team's influence upon CTP is critical as it is part of the team's communication and decision making system.

Correlation analysis for 'CM and design team communication effectiveness for decision making' and other factors underscores the above comments about sub-hypothesis 89. There appears to be less association between this variable and others when compared to sub-hypothesis 89 and no significant correlation between this variable and 'design buildability complexity' or 'design coordination complexity'.

#### **4.2.4.2 DESIGN TEAM FACTORS NOT AFFECTING CTP**

Sub-hypotheses pertaining to CTP and the nature of the client that were accepted at the 95% follow, CTP is NOT dependent upon :

- ☐ HY-7 design development stage at start of construction;
- ☐ HY-26 the CR's ability to effectively brief the design team;
- ☐ HY-31 the confidence of CR in the construction team's contribution to the project;
- ☐ HY-39 design buildability;
- ☐ HY-40 the quality of design coordination;
- ☐ HY-63 an appropriate design team structure;
- ☐ HY-72 a design team leader's mechanistic management style;
- ☐ HY-73 a design team manager's flexible management style;
- ☐ HY-74 a design team leader's task oriented management style;
- ☐ HY-75 a design team manager's people oriented management style;
- ☐ HY-92 design team within-team communication effectiveness;
- ☐ HY-95 design team decision making and implementation effectiveness;
- ☐ HY-98 the design team's effective use of information technologies.

The above falls into three clusters of factors, design production, design management and management and communication style.

Spearman Rank Correlation analysis results for sub-hypothesis 7 indicates no significant correlation between 'stage of design development at start of construction' with any other factors. It is surprising that design buildability, sub-hypothesis 39, did not appear to affect CTP. There were also no significant associations with factors affecting CTP. Moderate or near-moderate association exists between 'design buildability complexity' and 'design coordination complexity' and other factors not affecting CTP. These include 'CR's ability to effectively brief the design team', 'design coordination complexity', and 'general project complexity'.

This issue may have been difficult for respondents to answer. Generally they were faced with the building design and planned accordingly. In some cases, the CM team had an input into changing design details to improve buildability and the design was improved from a buildability standpoint. This issue was mitigated against through the respondent's influence. This may explain, in part, the result of ANOVA test and the rating given for the variable by case study participants. 'Complexity of projects due to design documentation coordination' appears to be related to communications management. The moderate correlation with the design team's structure indicates that resource constraints may play a part in this issue.

The 'CR's ability to effectively brief the design team', sub-hypothesis 26, has importance as a CR/design team relationship issue as well as providing the infrastructure for good inter-team communication. Some important associations with factors not directly affecting CTP include strong correlation with 'CR's understanding the project's constraints' and 'stability of CR decisions'. The evidence suggests from Spearman Rank Correlation analysis of 'CR's confidence in the project design team' that moderate correlation exists between this variable and 'CR and design team communication effectiveness for decision making'. Other factors with moderate association are related to management style.

Results from testing sub-hypotheses 72 to 76 regarding management style reveals few if any surprises. These factors affect team relationships and aspects of management style. 'design team's mechanistic-orientated management style' has no significant associations with other variables except a moderate association with 'CR's mechanistic-orientated management style'. Flexibility of design team management style is strongly associated with a design team people-oriented management style and this appears to strongly influence the 'the CR's confidence in the design team'.

The general impression gained by the analysis is that the CR has considerable impact upon the design team's flexible management style. 'Task-orientation of the design team's management style' is moderately associated with internal factors concerning management style and communication and decision making, however, no strong associations are found. Motivation and de-motivation factors have not been commented upon as respondents expressed caution in being able to answer these questions on behalf of the design team, especially as on many projects there was little interaction between design and CM teams.

Variables associated with communications management and decision making, i.e. sub-hypotheses 92, 95 and 98, also present no surprises and correlation analysis reveals moderate association between management style and ability to effectively communicate for decision making. A strong association exists between 'decision making communication within the design team' and 'design team's people-orientated management style' and a moderate correlation is found with internal decision making processes. 'Design team's decision making, communicating and actioning' has moderate correlation with communications between and within teams.

Computer aided design is the major IT application that the design team is involved with. It has moderate influence upon CR/design team relationships and a strong relationship exists between the CR and design team effective use of IT, however, this is most likely because traditional contractual relationships use the CR and design team as one group.

#### **4.2.4.3 GENERAL DISCUSSION OF DESIGN TEAM FACTORS AFFECTING CTP**

The design team's influence is mainly centred around, as is to be expected, communication effectiveness between teams. Naoum (1991, p31) highlights designer's experience as a clear factor determining CTP. The study reported upon in this thesis ranks the two design team factors in the lower half of the 30 factors identified as affecting CTP. This suggests that the design team's communication rôle is important, but less important than CM team or CR team influences.

The third principal hypothesis tested in this thesis is:

$P_3-H_0$  that CTP IS NOT significantly affected by design team communication effectiveness;

$P_3-H_1$  that CTP IS significantly affected by design team communication effectiveness.

Given the weight of evidence presented in clusters of sub-hypotheses which identified design team related factors and evidence presented from Spearman Rank Correlation analysis, the hypothesis  $P_3-H_1$  is accepted.

#### **4.2.5 FACTORS OUTSIDE THE CONTROL OF THE CM**

Thus far, identified factors affecting CTP have been concerned with managing teams, design and the construction process. There are occasions when managers are forced to react to circumstances facing them.

Three factors were discovered affecting CTP; inherent site conditions, the economic environment and project scope. Complexity associated with inherent site conditions appears the most significant risk factor outside the control of the CM team. This is closely followed by that of the economic environment. This is followed by project scope as measured by construction cost.

##### **4.2.5.1 FACTORS OUTSIDE THE CONTROL OF THE CM AFFECTING CTP**

Table 4.9 presents factors found to significantly affect CTP.

HY	Sub-hypothesis (Short-hand) Description - In Significance Order	Sig.
38	inherent site conditions	0.0173
45	economic environmental complexity	0.0177
1	construction cost being greater than \$20 million (january 1990 dollars)	0.0272
	<b>From the regression model</b>	<b>Regression Sig.</b>
	Log of construction cost	
10	EOT:Actual duration	0.0002
5	Type of work = 'fit-out'	0.0011

Table 4.9 - Sub-hypotheses Supporting P<sub>4</sub>-H<sub>1</sub>

The ANOVA test establishes that 'inherent site conditions' affects CTP but the graph of CTP against complexity level of inherent site conditions and Spearman Rank Correlation against all other factors fails to indicate any clear pattern between CTP and level of complexity of other factors. This is surprising as significant correlation between CM planning performance and this factor should be expected if it inhibits workflow. One explanation of this is that problems associated with ground conditions general occur at a time when little opportunity exists for diverting the workforce to other workfaces. The sort of problems encountered in this category includes demolition or restoration works, water table/flooding problems, underground services and problems associated with supporting adjacent properties.

Testing sub-hypothesis 45 provides interesting insights into the impact of the economy upon CTP. The ANOVA test clearly indicates that this factor affects CTP. The Spearman Rank Correlation results indicate moderate impact upon the CM's organisational structure and internal decision making capacity. This supports comments made by survey respondents that in time of 'boom conditions' there is difficulty in obtaining resources, such as skilled human resources as well as equipment. In 'bust condition' times there is less difficulties with locating resources though an equilibrium point arises when elements of the industry either voluntarily or are forced to leave the industry. During 'boom' times inexperienced personnel can be placed in positions of authority beyond their capacity. This was the case in project 16 which proved very problematic and had very poor CTP. An interesting point is that in 'bust' times builders and sub-contractors are left with a stockpile of equipment which, having been already amortised across past projects, appear to cost 'nothing' and are used on projects to gain a competitive edge. This practice, however, may lead to inappropriate use of equipment or use

of equipment that would be better sold and upgraded if the owners had sufficient financial resources to fund this action. Extensive downsizing of organisation has also led to shortages of firm's knowledge infrastructure which can lead to serious mistakes being repeated in organisations when lessons should have been remembered. Moderate correlation between this factor and the IR climate was also found, but this appears to be barely moderate during the period studied.

ANOVA test results for sub-hypothesis 1 indicate that when project scope, as measured by construction cost indexed to January 1990 Australian dollars, exceeds \$20 million the relationship between scope and CTP becomes significant. There is no significant correlation between this and other factors affecting CTP and only moderate correlation between this variable and the CR's confidence in the construction team.

ANOVA testing for sub-hypothesis 5, 'type of work undertaken', reveals no significant impact upon CTP, however, this is probably due to it being a variable in the model used to derive construction time. Spearman Rank Correlation yields no significant correlations between this variable and others. Thus, on the basis of the multiple regression analysis, it can be concluded that 'type of work' does affect CTP.

The ratio of extension of time (EOT) claims granted to actual construction period was built into the model which formed the basis of the CTP index. This factor is a measure of project scope as it measures agreed time to cope with unidentified work or implications of unforeseen risks. Table 4.10 illustrates the basis for EOT as a percentage of actual construction time granted for scope changes, i.e. inclement weather, IR, and other reasons. All but 5 projects had some EOT granted. Project 19, which performed below trend, did experience IR on-site problems and was the only project with a large EOT for IR reasons. The results shown in table 4.10 portrays quite a different picture to the high levels of industrial unrest reported by Ireland (1988). Several interesting inferences can be drawn from the evidence provided in the above table. 'IR' is only a major component of EOT for one of the 33 projects. 'Weather' is the only a major component of EOT on 8 of the 33 projects and scope EOT changes are the major factor for one third of the sample. Five of the 33 projects had no EOT claims granted which indicates the builder has either experienced no EOT changes or has absorbed these into their tendered construction time.

Case	CTP Index	Total EOT	Scope EOT	Weather EOT	IR EOT	Other EOT
1	0.960	34.07%	30.40%	3.66%		
2	1.296	0.00%				
3	1.190	39.66%	11.90%	27.76%		
4	1.032	18.65%		18.04%	0.61%	
5	0.729	0.00%				
6	1.040	16.34%				16.34%
7	1.124	20.15%	17.91%			2.24%
8	0.883	24.42%	15.12%	3.95%	3.49%	1.86%
9	0.849	0.00%				
10	0.892	12.20%		12.20%		
11	1.193	17.22%	7.78%	8.89%	0.56%	
12	0.685	2.36%			1.71%	0.66%
13	0.788	22.47%	4.87%	14.98%	1.12%	1.50%
14	0.866	0.69%	0.69%			
15	1.070	14.62%		10.67%		3.95%
16	0.386	40.24%	16.71%	13.18%	4.94%	5.41%
17	1.221	52.85%	12.20%	40.65%		
18	0.851	21.63%	17.30%		1.02%	3.31%
19	0.729	43.80%	17.52%	4.56%	21.72%	
20	1.164	27.37%	20.87%	5.96%	0.54%	
21	1.072	1.81%		0.91%	0.91%	
22	1.013	40.37%	35.71%			4.66%
23	0.746	21.73%	4.97%	12.83%		3.93%
24	1.257	13.46%		12.91%	0.55%	
25	0.856	11.11%	11.11%			
26	0.876	42.89%	29.64%	4.58%	5.30%	3.37%
27	1.194	7.97%		3.14%	4.83%	
28	1.011	0.00%				
29	1.403	0.00%				
30	1.247	38.59%	38.41%		0.18%	
31	1.021	14.72%	7.36%	7.36%		
32	1.092	0.35%			0.35%	
33	1.018	0.72%			0.72%	

Table 4.10 - Table Of EOT As A Percentage Of Actual Days Worked

Moderate negative association between this variable and CM team effectiveness may be interpreted as lower management effectiveness leads to higher ratio of EOT to actual



construction time.

#### **4.2.5.2 FACTORS OUTSIDE THE CONTROL OF THE CM NOT AFFECTING CTP**

Sub-hypotheses pertaining to CTP and the nature of the client that were accepted at the 95% follow, CTP is NOT dependent upon :

- ☐ HY-2 number of basement levels;
- ☐ HY-3 numbers of floors being greater than two;
- ☐ HY-4 the building's end use;
- ☐ HY-8 construction time period;
- ☐ HY-42 the impact of access to or within site;
- ☐ HY-43 the impact of general project complexity factors;
- ☐ HY-44 the impact of the physical environment surrounding the site;
- ☐ HY-46 the impact of the socio-political environment prevailing during construction;
- ☐ HY-47 the impact of the industrial relations environment prevailing during construction;
- ☐ HY-48 the impact of general environmental factors prevailing during construction;

The variable for sub-hypothesis 2, 'number of basements', and sub-hypothesis 3, 'number of floors', appear to have no correlation with CTP. The building's end-use, sub-hypothesis 4, indicates from has moderate correlation with factors which are determined by the sample characteristics. The results of the ANOVA test and the Spearman Rank Correlation analysis for sub-hypothesis 8 reveals no significant associations, except for a moderate negative correlation with 'flexibility of the CR's management style'.

Sub-hypothesis 42 'access to and within site' Spearman Rank Correlation analysis results indicates few significant associations with other variables. Conversations with the study respondents revealed an impression that it was resolved by planning to cope with constraints presented.

'General project complexity', sub-hypothesis 43, does not seem to significantly affect CTP and the Spearman Rank Correlation analysis only serves to indicate the ranking of importance of factors comprising this variable.

Evidence presented in the ANOVA analysis for sub-hypotheses 44, 46, 47 and 48 indicates no significant impact of these factors upon CTP. Spearman Rank Correlation analysis reveals little useful data with the exception of sub-hypothesis 47. Sub-hypothesis 47 correlation analysis results indicate that 'impact of the IR environment' has high correlation with the 'impact of general environmental factors' meaning that it is considered to be a major

component of general environmental complexity. It also has a moderate association with the economic environment which does affect CTP. The IR climate is perceived to be associated with the economic climate, though the 'IR' EOT evidence presented in table 4.10 indicates that IR issues are of a minor importance for the period and location studied.

#### 4.2.5.3 GENERAL DISCUSSION OF FACTORS OUTSIDE THE CONTROL OF THE CM

Project characteristics seem to play a minor part in explaining CTP. The only factors that appear to influence CTP are: inherent site conditions; the economic environment; whether the project is a 'fit-out' project or not; and the scope of the project expressed in constant dollars.

The fourth hypothesis advanced in this work is that:

$P_4-H_0$  that CTP IS NOT significantly affected by a small number of challenges posed by factors outside the control of the construction management team;

$P_4-H_1$  that CTP IS significantly affected by a small number of challenges posed by factors outside the control of the construction management team.

Given the weight of evidence presented in the sub-hypotheses testing for clusters of CM related factors and evidence presented from Spearman Rank Correlation analysis, the  $P_4-H_0$  proposition is rejected and the alternative proposition  $P_4-H_1$  is accepted.

### 4.3 SUMMARY

Results reported in this chapter stem from a multi-stage approach to investigating why some building are built more quickly than others.

A construction time predictive model was developed from multiple regression analysis of data gathered. This model allows each projects' predicted duration to be calculated, based upon the data sample gathered. This data sample was established to be representative of the Metropolitan Melbourne area in chapter two.

Predicted time for each case study's forms a trend-line or benchmark for comparative investigation. The predicted construction time was divided by the actual time to arrive at a CTP index. Projects with an index of less than 1.00 are deemed to have performed below trend for the sample. Projects with an index of greater than 1.00 are deemed to have performed above trend. Figures 2.1 to 2.5 in chapter two illustrate the distribution of predicted to actual construction times for each case study based on five predicted construction time options. Figure 2.5 demonstrates the level of accuracy achieved and tests the time prediction

model.

Having established a benchmark CTP index for each project, 102 data variables were then tested using the ANOVA technique to investigate the significance of impact of the variable upon CTP. A clear picture of which factors affect CTP emerged from this analysis, however, the ANOVA technique did not help explain why these factors affect CTP. Further investigation was undertaken using Spearman Rank Correlation for ordinal scale data and Pearson Product Moment Correlation for interval scale data.

The results of rigorous statistical analysis of the data support the principal hypotheses that CTP is affected by four broad clusters of factors. These are presented in order of significance. CM Team performance is followed by CR Team performance. Project scope and complexity factors were also shown to significantly affect CTP. The least significant factor cluster is the communication performance between the design team and CM and CR teams. A more detailed discussion of the study's general conclusion follows in chapter five which includes presentation of a revised CTP model.

Results indicate that the CM team is the filter through which scope, complexity and the impact of other teams' performance is passed. High CM team performance mitigates difficulties and challenges presented to result in high CTP while poor CM team performance leads to poor CTP.

The contribution that these results make in closing gaps in knowledge is that they provide fertile ground for explaining both what factors affect CTP and why identified factors affect CTP.

## 5.0 INTRODUCTION

Four general topics of discussion are addressed in this chapter. General conclusions drawn from results of testing the principal hypotheses are discussed. The research model of CTP is modified following results from this research. Identified gaps in the knowledge which were bridged are discussed in terms of the value of this research. Finally, application of the research work in addressing current construction industry needs is discussed.

## 5.1 GENERAL CONCLUSIONS

The thesis tested by this research was that *'variance between actual performance and trend line performance can be substantially explained by managerial effectiveness of the project team in response to challenges posed by factors outside the control of the construction management team.'*

More specifically, four principal hypotheses are tested by this work:

### **CR team's management effectiveness -**

$P_1-H_0$  that CTP IS NOT significantly affected by the management effectiveness of the client's representative;

$P_1-H_1$  that CTP IS significantly affected by the management effectiveness of the client's representative;

### **CM team's effectiveness -**

$P_2-H_0$  that CTP IS NOT significantly affected by the management effectiveness of construction management teams;

$P_2-H_1$  that CTP IS significantly affected by the management effectiveness of construction management teams;

### **Design teams' effectiveness -**

$P_3-H_0$  that CTP IS NOT significantly affected by design team management effectiveness;

$P_3-H_1$  that CTP IS significantly affected by design team management effectiveness;

### **Project challenges -**

$P_4-H_0$  that CTP IS NOT significantly affected by a small number of challenges posed by factors outside the control of the construction management team;

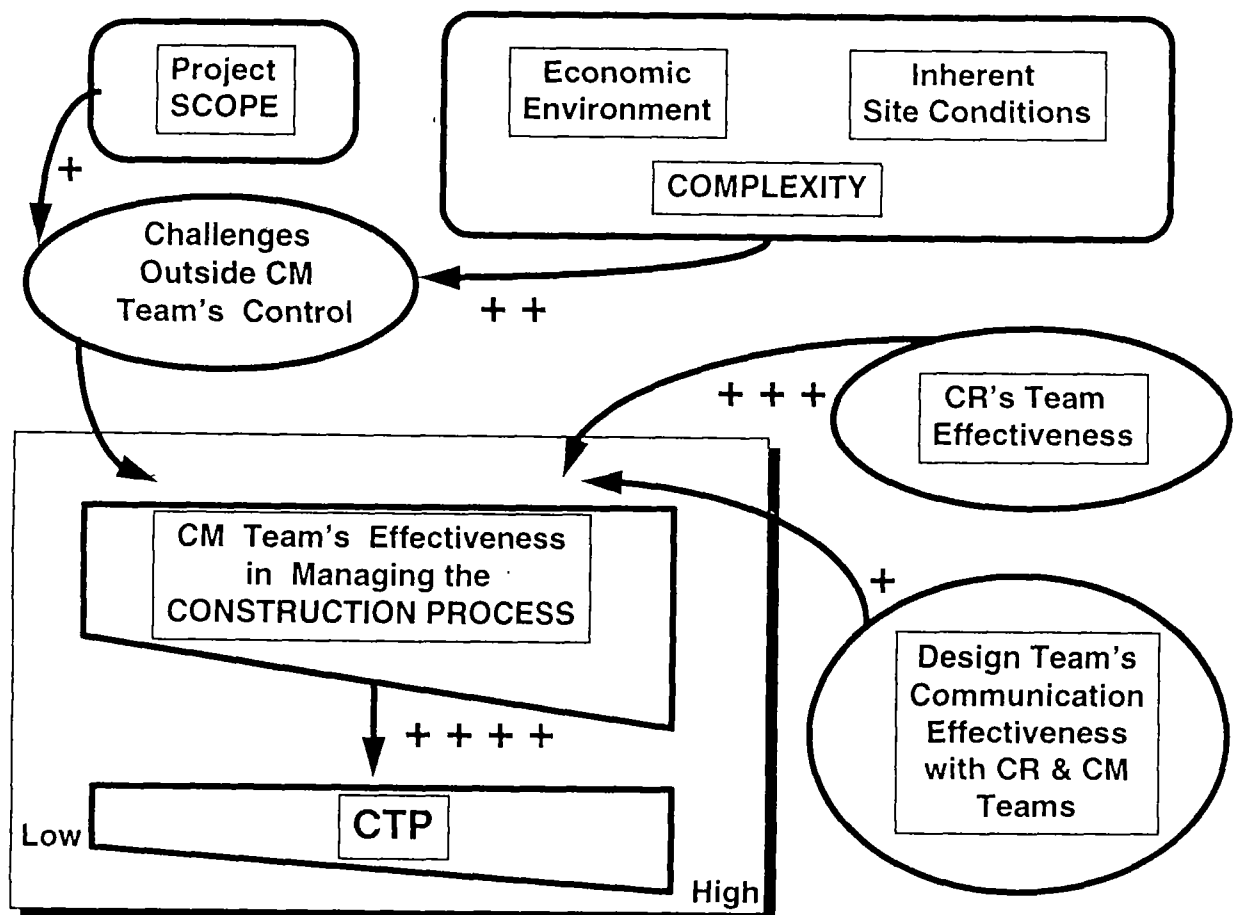
$P_4-H_1$  that CTP IS significantly affected by a small number of challenges posed by factors outside the control of the construction management team.

These results provide strong evidence to support alternative hypotheses P1-H1, P2-H1, P3-H1, and P4-H1. Thus, it can be concluded that good CTP is principally affected by effective performance of the CM team and CR team and effective communication between both these teams and the design team. Project scope and complexity associated with inherent site conditions and the economic environment present challenges to the CM team. A well prepared and effective CM team deals with these challenges through effective management.

## 5.2 THE CTP MODEL REVISED MODEL

The model initially developed and presented in figure 1.1 in chapter one, illustrated general factors suspected of affecting construction time. It contained, however, no relative strength of association between identified variables. One of the variables, project complexity, was initially hypothesised to be formed from a combination of other factors: client complexity; project complexity; and environmental complexity. Project team performance related to the overall impact of the performance of individual teams: the CR team, design team and CM team. All teams should be aiming to achieve project goals as established by the client and risk should be viewed as risk of not achieving these goals.

This model, based upon the literature and findings from a pilot study, has been refined and expanded through knowledge gained in analysing results from this 33 case study research. Figure 5.1 helps explain the strength of relationship between factors affecting CTP.



**Figure 5.1 - Model of Factors Affecting CTP**

Note that the '+' symbols provide ordinal scales of significance. A '+++' significance is not three time more significant than a '+' influence. Significance means likelihood of the result NOT happening by chance.

Figure 5.1 expresses two ideas. CTP is directly affected by the CM team's managerial performance. This performance is affected by challenges outside the CM team's control, the CR's team effectiveness and the design team's communication effectiveness.

This model places responsibility for good CTP firmly with the CM team. Berkeley *et al.* (1991, p5) state that *'the fact that it may be difficult to control the occurrence of risk does not absolve the manager from the need to anticipate the risk, and thus find ways of lessening the impact of its occurrence on the achievement of project goals. This may involve ensuring that the planning for the project is flexible in the face of the occurrence of the risk and/or that subsequent contingency planning can be made in the event of its occurrence.* Their view that CTP is substantially in the hands of those capable of dealing with risk supports the conclusions of this research. It is proposed that this group is generally the CM team.

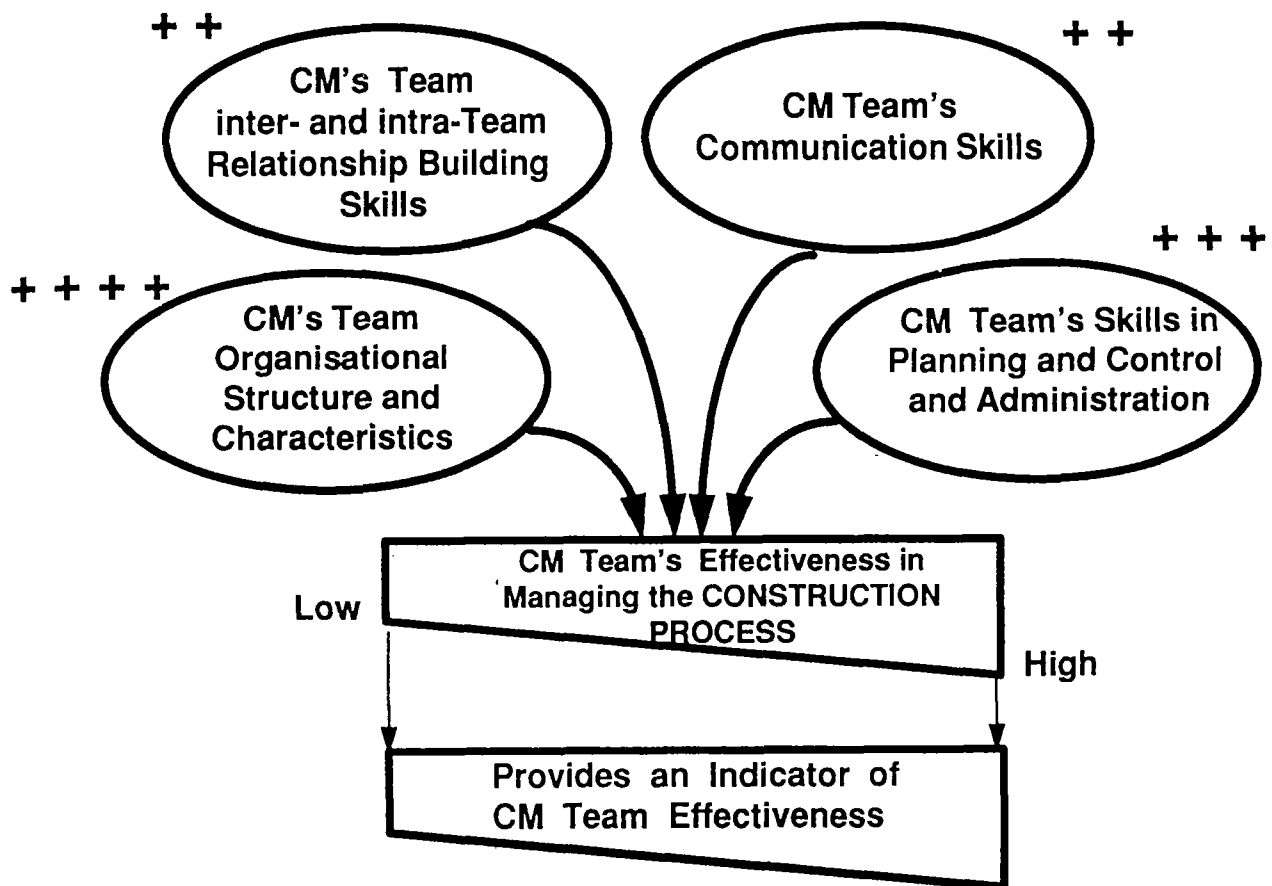
Table 4.1 in chapter 4 provides a list, ordered by significance level, of factors found to affect CTP. CR team performance was found to be more influential than project complexity. Project complexity factors identified as 'inherent site conditions' and 'economic environmental complexity' were found to be more significant than scope or design team communication effectiveness. Project scope and design team communication effectiveness with the CR and CM teams were found to be less significant factors than others presented in the model.

The model indicates that the most significant cluster of factors relate to the CM team's effectiveness in managing the construction process which forms the filter through which CTP is determined. The CM team are in direct control of construction activities and it is they who can best formulate plans to control and mitigate risks to achieve satisfactory CTP. High CM team performance results in high CTP and low CM team performance results in low CTP.

Two models, illustrated in figures 5.2 and 5.3, explain the relationship between CM and CR team effectiveness and other factors acting on these two teams.

The CM team's effectiveness in managing the construction process is affected by developing an organisational structure that is best suited to meet the challenges and risks accepted (Morris 1994, p219). No specific team structure is proposed, however, the results strongly support the idea that team member's qualities are crucial. A well functioning CM team will be able to identify risks and plan to mitigate detrimental impact upon CTP, be able to

effectively communicate using appropriate media and have the capacity to develop sound inter- and intra-team synergies. Though the CM team's management style was not identified as a factor affecting CTP, it is moderately correlated to CM team management related factors that do affect CTP. The model in figure 5.1 indicates that high CM team effectiveness leads to high CTP.

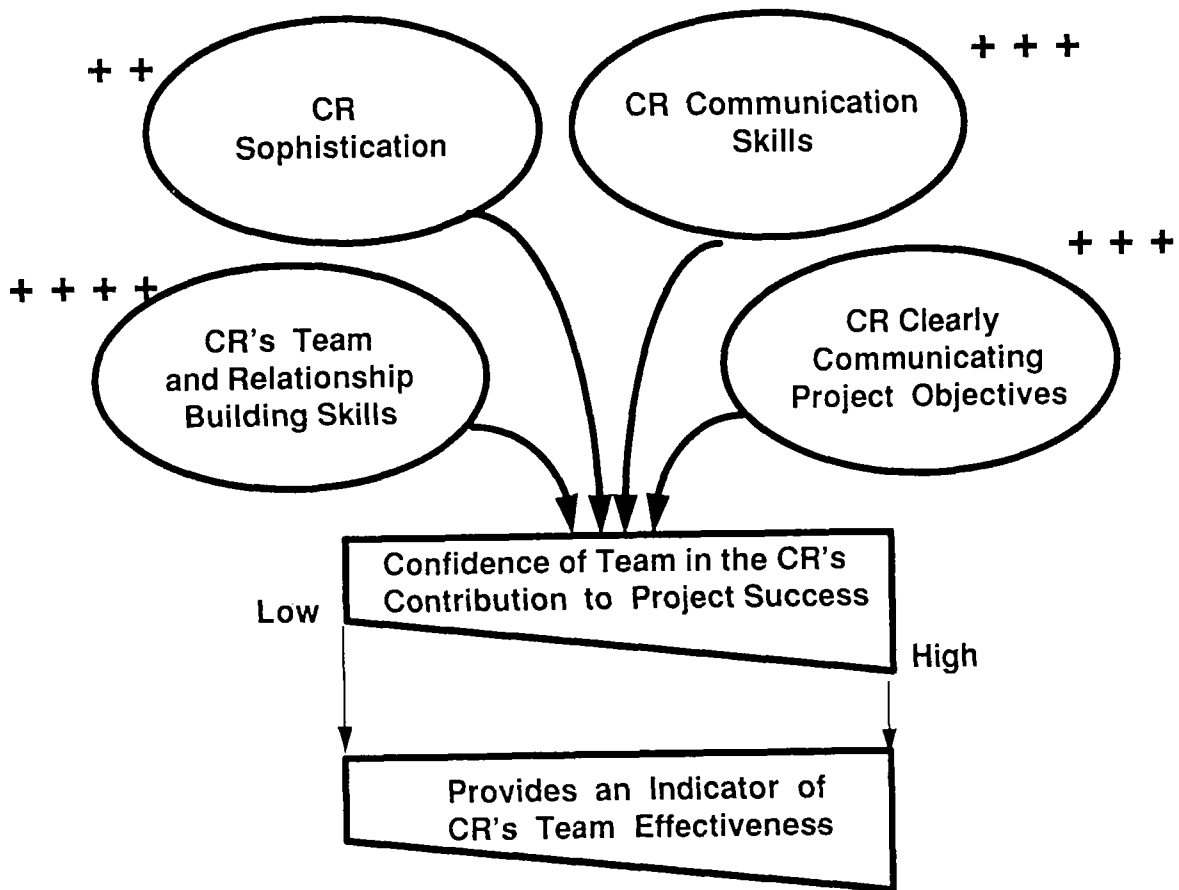


**Figure 5.2 - Indicator of CM Team Effectiveness**

Note that the '+' symbols provide ordinal scales of significance. A '+++' significance is not three time more significant than a '+' influence. Significance means likelihood of the result NOT happening by chance.

The CR team has almost as strong an impact upon CTP as the CM team. While most of the top ten in the 'league-table' of factors affecting CTP are CM team related, the CR team related factors follow closely behind. The initial model envisaged CR in terms of complexity and management performance; chapter three explains the elements of CR complexity. Project team confidence in the CR has been identified as being highly significant to CTP and so the CR's team and relationship building are shown to be very important. Four groups of factors are seen to impact upon confidence of the CM and design teams in the CR. These have been discussed previously under section 4.2.2.3 and listed in table 4.5.

The most significant cluster of CR factors relates to the CR's skills in team building and gaining the confidence of the CM and design teams. This is underpinned by sound CR skills using appropriate media for communication. Project teams appear to require the CR to be capable of making good decisions. CR stability and clarity of communication of objectives are not factors found to directly affect CTP, however, they were found to have significant impact upon other factors related to CM performance.



**Figure 5.3 - Indicator of CR Team Effectiveness**

Note that the '+' symbols provide ordinal scales of significance. A '+++' significance is not three time more significant than a '+' influence. Significance means likelihood of the result NOT happening by chance.

CR clarity of communicating the client's objectives was strongly correlated to the construction team's confidence in the CR. A sophisticated CR appears, from results presented, to better understand what is involved in designing and constructing the project. While the CR team need not solve any of the project teams' problems, a participative and understanding management approach appears to be a significant factor in achieving good CTP.



### **5.3 VALUE OF THIS RESEARCH IN BRIDGING EXISTING GAPS IN KNOWLEDGE AND IDENTIFYING NEW GAPS**

More is now known, as a result of this research, about causes of CTP variation between projects and what influences this variation. Ireland (1983) and Sidwell (1982) did not collect the level of detailed qualitative data about team interaction and how this may affect CR and CM team performance that this study provides. Their data was gathered from projects constructed in the late 1970's and early 1980's. Data gathered in this work spans the boom-bust of the late 1980's and early 1990's. This work, therefore, adds breadth by bringing an historical perspective to this research area which links knowledge gained in past decades to that of recent years. The work also adds depth to the body of knowledge by providing the level of detail of causal links and measures of correlation between variables which is to be found in appendix two of this thesis.

Figure 2.5 in chapter 2 indicates that the results from this work provides a closer fit between predicted and actual construction time. This work offers an improved model for predicting construction time from a representative sample of projects. Previous models relied on scope as measured by building area or construction cost with constants used to describe complexity and managerial performance. The predictive model described in this work, together with its methodological approach, was proved in chapter two as representing the most current and robust approach. The formula derived from the methodology adopted by this work will change over time due to changed circumstances, however, the methodology used in this work allows causal factors of CTP to be identified and it is this feature that presents a useful contribution to the understanding of why some buildings take longer to build than others. The case study sample included projects from across the boom and bust cycle, thus a more representative data sample was achieved for investigating factors directly or indirectly affected by the economic environment. Thirteen projects were commenced before January 1990 and twenty projects after that time.

Interesting gaps in knowledge are identified by this work. Similar studies need to be undertaken elsewhere to investigate how regional and cultural factors may qualify this work's findings. There needs to be more work undertaken on understanding why the CM team's communication with the design team and the CM team's effectiveness of use of IT have produced positive coefficients in the construction time prediction model. Work is underway

in the investigation of how problem solving effectiveness is related to communication structure and project team behaviour (Loosemore 1993; Loosemore 1994).

Results presented in this thesis strongly indicate that a greater understanding of project team performance provides fertile ground for research, particularly inter- and intra-team communications and team building for achieving team confidence in the CR.

Contractual arrangement systems have been examined extensively by others. Research results presented in this thesis provide useful data with which to investigate why particular contractual arrangements may be more conducive to good CTP than others. The result of sub-hypothesis 6, which tested CTP against contractual arrangements, produced a result indicating no significant impact upon CTP at the 95% confidence level. A different conclusion emerges, however, at the 90% level. This suggests that more research in this area, drawing upon findings presented in this thesis, may make a significant contribution to understanding to what extent contractual arrangements may affect CTP. The concept of partnering has been examined more recently (CII 1991; Patching 1994) and opens gaps in knowledge in understanding how this approach may differ from other contractual arrangements.

The research has facilitated a new approach in research methodology through the development of a prediction model that uses both quantitative and qualitative measures. Use of the predictive model to then construct a performance index with which to then test the reasons why projects vary in performance has wider application than investigating CTP.

Construction cost is one such area that could be investigated in this manner. Indeed data gathered in the 33 case survey, with additional data such as tendered cost, may be used for this purpose. A cost performance index (CCP) could be used to gain fresh insights into the reasons why some buildings cost more than others. Investigating the impact of client characteristics and CM team performance may bring important new knowledge to the area.

The work presented in this thesis is confined to commercial/industrial and institutional building. It could be extended across market sectors to include residential construction, civil engineering and heavy engineering projects in the classes studied. Additionally, projects over Australian \$45 million in construction cost could be investigated as projects studied in this

work were restricted to projects between \$4 million to \$45 million indexed to January 1990 Australian dollars. A longitudinal study could also be undertaken, perhaps over decades or spanning several boom and bust cycles, to test how CTP may change over time or from one boom and bust cycle to another. The existing study could be widened by interviewing each project's design team leader, CR team leader and the client.

#### **5.4 APPLYING THIS RESEARCH METHODOLOGY TO CURRENT INDUSTRY PROBLEMS**

The research undertaken can also be fruitfully applied in identifying work practices for benchmarking and studying for identifying world best practice in those areas found to significantly affect CTP. This work can be successfully applied to undertaking *post mortem* analysis of projects within firms and between firms so that knowledge can be gained about factors affecting CTP.

It is unfortunate that clients and companies engaged in projects restrict their audit requirements to cost, time, and quality. Costs are audited in terms of profit and loss statements. Time is audited in terms of EOT or time related liquidated damage claims. Quality is audited in terms of post occupancy surveys and rectification of unsatisfactory workmanship. It is rare that an audit or study is undertaken of the value of what was learned from designing and building a project, unless it is the subject of academic scrutiny (Jashapara 1993).

Knowledge is often spoken of as a key resource. Porter and Millar (1985, p149) present a convincing argument for analysing processes to identify 'value chains'. They argue that knowledge gained from such analysis leads to competitive advantage through either developing cost advantages from changing work practices and technologies or identifying and understanding what differentiates the process under review that makes customers willing to pay a premium for it. If a rigorous *post mortem* of a project was undertaken so that value chains could be identified and understood, then this knowledge could be used to improve processes, products and service to the customer. In this way value of knowledge gained can be incorporated into an output of a project. Individuals may or may not reflect upon what mistakes were avoidable or could have been better mitigated against. Without a systematic approach to reviewing what may be learned from a project, much valuable knowledge resource is lost. Individual and corporate memory fades over time; while a rigorous review of a project has a greater chance of success in positively influencing future project outcomes.

There are a number of lessons to be learned from the research findings which construction companies and building clients could implement to their advantage.

- 1 Results indicate that a well organised and functioning construction management team can offer much to the achievement of CTP. This is exemplified by effective planning and communication for decision making. A construction team's flexibility in responding to problems and opportunities is based upon sophisticated planning for control where plans are seen as a focus for action rather than static or rigid commands or procedures. This implies that effective use of planning tools should be encouraged for simulation analysis to predict a range of possible futures of which a 'preferred future' can be selected. Close involvement of team participants in the construction planning and implementation of work is needed to achieve this. This needs to be integrated into the monitoring cycle, checking reality against the 'preferred future' of the plan. If construction teams can see plans as 'preferred futures' which are subject to impact of reality and unexpected events, then they may be more prepared to see plans as goals to be constantly aimed for rather than predictions in which guilt may be attached to those who prepared them or those who 'failed' to realise them.

It is proposed that construction companies should ensure that team members, charged with defining plans and those closely involved with carrying out the work, be trained in the use of planning techniques, idea generation and problem solving. This will provide a better chance for enhancing a team's responsiveness to changed environments and circumstances.

- 2 The research results also draw clear conclusions about a favourable nature of the client and construction team relationship. Research evidence presented in this thesis suggests that where a good relationship exists there is a better chance of good CTP. Interesting results from correlation analysis (see appendix 2 pages 64 and 65) indicates that the CM team's confidence in the CR's contribution is influenced by factors that engender mutual confidence between these two teams.

It is proposed that the CR team should gain a good understanding of the project's complexity and constraints to assist the development of confidence of the CM team in the CR team. This can be achieved through mechanisms such as partnering

(Patching 1994) or other models which better integrate the CR and design team with the CM in problem solving and investigation of strategies for construction. These have been documented as being successful in many cases in Japan and the USA (Bennett 1991; Walker 1989a).

- 3 The research results give clear indication of the need for competent team members. This may seem obvious and the evidence provided confirms this requirement to achieve high CTP. According to Bennett (1991, p254) competent people require not only a good technical and general education but also practical skills in problem solving and analytical thinking.

It is proposed that the construction industry invests in its future by promoting life-long learning. This can be achieved in a number of ways. Formal training at trade, undergraduate, and post graduate levels can be, and in many cases are, encouraged. The methodology developed for this thesis also provides a useful framework for project team members to learn from experience.

This short and by no means exhaustive list, explores how industry can adapt to improve CTP. It attempts to link what has been learned from the research to provide a few practical and useful recommendation for industry to improve CTP.

## **5.5 LIMITATIONS INHERENT IN THE RESEARCH METHODOLOGY**

The research methodology relies to a great extent upon the perception of respondents in answering many of the questions posed in the research instrument. It was pointed out in chapter 3 that the CM representative was viewed as the project team member closest to the production of the building. Data gathered in this way is a reflection upon the respondents' perception, experience with similar work, prejudice, and bias.

While this in no way negates the validity of the approach or research findings it does place the work as being a reflection of, and influenced by, the sample respondent's characteristics. Respondents, generally, had decades of industry experience. The level of experience for the types of work they controlled varied and so it is possible that some measure of inconsistency in attitude is inevitable. The sample size was chosen to be statistically significant to help

obviate problems of bias and prejudice, however, caution must always be taken when dealing with impressions rather than hard facts.

The second aspect of this limitation is that the CM's impressions were not verified by interviewing other team member's. Given that one's experience of an event is influenced by many factors including mind sets and prior educational viewpoints it is unrealistic to expect corroboration of 'facts' surrounding issues discussed. The CR may be exposed to very different pressures and influences about priorities and urgency from that of the CM, and similarly the design team leader. An attempt to find a 'truth' which is shared by all team members may prove illusory and so analysis of this work must remain limited to the perspective taken.

In conclusion, the results reported in this work provide valuable insights and findings that can be further analysed by other researchers in helping them explain their research findings into aspects discussed in this thesis. The statistical analysis, the ANOVA results and particularly the correlation work undertaken will provide useful explanations of the reason why buildings within the sample characteristics achieved varying levels of CTP. These results reflect the CM team's view and experience of projects studied, and cannot be applied with certainty to other team members. It is possible that a study undertaken by interviewing the design team leader or CR will arrive at agreement with some causal factors and disagreement with others. As Green (1984) points out, perceptions of reality are founded upon ontological arguments of what is 'real' and what is not.

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## APPENDIX 1

### THE QUESTIONNAIRE



## The Questionnaire Blank

### PROJECT SURVEY IDENTIFICATION INFORMATION

<i>Case History No.</i>		<i>Date Interviewed</i>	
<i>Company Name</i>			
<i>Project Name</i>			
<i>Contact Name</i>			
<i>Contact Position &amp; Experience</i>			
<i>Contact Address</i>			
<i>Contact Phone</i>		<i>Contact Fax</i>	

### Q1 - PROJECT SCOPE DETAILS

<b>1.1</b>	<i>Construction Cost At Completion \$m</i>	(a)
	<i>(a) building cost</i>	
	<i>(b) external works</i>	(b)
	<i>(c) prefabricated structural components</i>	(c)
<b>1.2</b>	<i>Gross Floor Area in M<sup>2</sup></i> <small>(using BQ data from AIQS definition)</small>	

<b>1.3</b>	<i>Maximum Number Of Floors Below Ground Level</i>	
<b>1.4</b>	<i>Maximum Number Of Floors Above Ground Level</i>	

**1.5 Construction Materials/System Used For:**

<i>Frame:</i>	<i>Floors:</i>	<i>Roof:</i>	<i>Cladding:</i>

RC = reinforced concrete, PC = precast concrete, SF = steel frame, TI = timber,  
 HY = hybrid steel/pre-cast concrete, BD = bond-deck plus topping, GL = glazed,  
 SC = stone/marble, MA = brick/block, MD = sheet metal, TL = tiled.

<b>1.6</b>	<i>Project End Use:</i>	<i>Totally</i>	<i>Principally</i>	<i>Partially</i>
	<i>Residential</i>			
	<i>Commercial - Office</i>			
	<i>Commercial - Retail</i>			
	<i>Commercial - Recreational</i>			
	<i>Hotel/Motel</i>			
	<i>Car parking</i>			
	<i>Industrial</i>			
	<i>Institutional - Education</i>			
	<i>Institutional - Health</i>			
	<i>Institutional - Other</i> <i>(state what function)</i>			
	<i>Other (state)</i>			

*If possible give %age of each end-use by approximate project cost*

## 1.7 General Project Team Contractual Arrangements

Contractual Arrangement:
Degree Of Design and Construction Overlap (shade in the following squares to indicate the extent of design at construction start): <div style="display: flex; align-items: center; justify-content: space-around; margin-top: 10px;"> <span>0% designed</span> <input style="width: 20px; height: 20px;" type="checkbox"/> <input style="width: 20px; height: 20px;" type="checkbox"/> <input style="width: 20px; height: 20px;" type="checkbox"/> <input style="width: 20px; height: 20px;" type="checkbox"/> <input style="width: 20px; height: 20px;" type="checkbox"/> <span>100% designed</span> </div>

<b>1.8 Description of External Works</b>
--

1.9	Actual Construction Start Date	
1.10	Practical Completion Date	
1.11	Original Construction Period at Tender Award (in working days)	
1.12	Total Agreed E.O.T. (working days)	(a)
	(a) for Scope Changes	(b)
	(b) for Inclement Weather	(c)
	(c) for IR Disputes	(d)
	(d) for other reasons	
1.13	Actual Working Days Worked (excluding RDO's & Public Holidays)	
1.14	Estimated Average Hours/Day Worked On-site	

## Q2 - PROJECT COMPLEXITY DETAILS - RÔLE OF THE CLIENT

### 2.1 Client Identification

Client Organisation's Name:

### 2.2 Client Organisation Nature and Approximate Size Characteristics

(size definition by the approximate number of employees as a measure of the organisation's size)

General Organisational Characteristics	Yes/No
2.2.1 Public Sector	
2.2.2 Private Sector	
2.2.3 Large Corporation (1000+ employees)	
2.2.4 Medium sized (100+ to 1000 employees)	
2.2.5 Small sized (up to 100 employees)	

where: 1 = very low, 2 = low, 3 = slightly low, 4 = average,  
5 = slightly high, 6 = high, 7 = very high.

Rate the response that best describes your opinion of the following:

	Client's Building Experience Characteristics	Rating
2.3.1	client <u>organisation's</u> experience with the building procurement process	
2.3.2	<u>client's representative</u> experience with the building procurement process	
2.3.3	client organisation's <u>confidence</u> in the client representative	

## 2.4 Client Objectives

where: 1 = very low, 2 = low, 3 = slightly low, 4 = average  
5 = slightly high, 6 = high, 7 = very high.

Rate the response that best describes your opinion of the strength of the client's project objectives (as established and amended to reflect client changes and authorised release of contingency reserves to accommodate unidentifiable risks).

	<i>Project Objectives</i>	<i>Rating</i>
2.4.1	<i>Low construction costs</i>	
2.4.2	<i>Quick construction time from handover of site to the builder to practical completion of building works</i>	
2.4.3	<i>High quality of construction</i>	

Rate the response that best describes your opinion of the client's communication effectiveness of the strength of the client's project objectives (as established and amended to reflect client changes and authorised release of contingency reserves to accommodate unidentifiable risks).

	<i>Client Communication Of Project Objectives</i>	<i>Rating</i>
2.4.4	<i>Stability of project objectives (as stated by the client) during the construction period</i>	
2.4.5	<i>Clarity of communicating the client's enunciated project objectives and goals</i>	
2.4.6	<i>Credibility of being able to achieve project goals and objectives (as stated by the client)</i>	

## 2.5 Client Influence Upon Construction Time Performance

Putting aside the issue of how well the builder coped with the challenges of client influences - how do you respond to the following statements.

where: 1 = very weak, 2 = weak, 3 = slightly weak, 4 = average  
5 = slightly strong, 6 = strong, 7 = very strong.

2.5.1 The general perception was that the client (or client representative) exercised a ☐ influence on the construction time performance of this project.

where: 1 = very complex, 2 = complex, 3 = slightly complex,  
4 = neutral 5 = slightly simple 6 = simple, 7 = very simple.

2.5.2 The client's influence resulted in a general perception that this was a ☐ project to construct.

### ***Reason For This Impact:***

Your answers to the following questions should help to explain your assessment of the client representative's impact upon the project's level of success. From now on the client or client's representative on the project will be referred to simply as the 'client'.

Broadly speaking, contribution to project team performance is segregated into measures of client sophistication and the effectiveness of the relationship between the client and other project team members to work together as a team. These measure are sought regardless of contractual arrangements entered into.

## 2.6 Client Sophistication Measures

where: 1 = very low, 2 = low, 3 = slightly low, 4 = average  
5 = slightly high, 6 = high, 7 = very high.

Rate the response that best describes your opinion of the following client sophistication measures.

<i>Client Sophistication Characteristics</i>	<i>Rating</i>	<i>Client Sophistication Characteristics</i>	<i>Rating</i>
2.6.1 understanding the project's constraints		2.6.2 ability to quickly make authoritative decisions	
2.6.3 ability to effectively brief the design team		2.6.4 stability of decisions	
2.6.5 ability to contribute ideas to the design process		2.6.6 ability to contribute ideas to the construction process	

## 2.7 Client-Project Team Relationships

where: 1 = very low, 2 = low, 3 = slightly low, 4 = average  
5 = slightly high, 6 = high, 7 = very high.

Rate the response that best describes your opinion of the following client-construction team relationship characteristics that resulted in the level of construction time performance attained on the project.

<i>Client-Project Team Relationships</i>	<i>Rating</i>	<i>Client-Project Team Relationships</i>	<i>Rating</i>
2.7.1 project design team's confidence in the client's contribution		2.7.2 client's confidence in the project's design team	
2.7.3 construction team's confidence in the client's contribution		2.7.4 client's confidence in the construction team	
2.7.5 client's ability to mould shared project goals and aspirations		2.7.6 client's willingness to accept effective and positive ideas	
2.7.7 client's willingness to contribute effective and positive ideas		2.7.8 overall client contribution to project team harmony	



### Q3 - PROJECT COMPLEXITY DETAILS

#### INHERENT SITE CONDITIONS

Putting aside the issue of how well the builder coped with the challenges of inherent site conditions - how do you respond to the following statement.

where: 1 = very complex, 2 = complex, 3 = slightly complex,  
4 = neutral 5 = slightly simple 6 = simple, 7 = very simple.

3.1	Inherent site conditions generally contributed to the perception that this was a <input type="checkbox"/> project to construct.
-----	--

#### 3.2 Specific Aspects Of Inherent Site Conditions

What was the perceived degree of complexity contributed by the following to the impression that this was, or was not, a complex project:

	<i>Aspect of Inherent Site Conditions</i>	<i>Rating</i>	<i>Comments</i>
3.2.1	<i>nature of demolition work</i>		
3.2.2	<i>nature of restoration work</i>		
3.2.3	<i>structural stability of ground</i>		
3.2.4	<i>extent of ground contamination</i>		
3.2.5	<i>extent of archaeological finds</i>		
3.2.6	<i>impact of water table</i>		
3.2.7	<i>impact of underground services</i>		
3.2.8	<i>impact of underpinning existing structures</i>		

## Q4 - PROJECT COMPLEXITY DETAILS

### BUILDABILITY

Putting aside the issue of how well the builder coped with the challenges of the project design - how do you respond to the following statement.

where:            1 = *very complex*, 2 = *complex*, 3 = *slightly complex*,  
                       4 = *neutral* 5 = *slightly simple* 6 = *simple*, 7 = *very simple*.

4.1      The level of design buildability generally contributed to the perception that this was a ☐ project to construct.

#### 4.2      *General Facets of Design Buildability*

What was the perceived degree of complexity contributed by the following to the impression that this was, or was not, a complex project:

	<i>General Facets of Design Buildability</i>	<i>Rating</i>	<i>Comments</i>
4.2.1	<i>scope of off-site fabrication</i>		
4.2.2	<i>complexity of off-site fabricated components</i>		
4.2.3	<i>appropriateness of design tolerances</i>		
4.2.4	<i>appropriateness of working space</i>		
4.2.5	<i>implication upon trade coordination</i>		
4.2.6	<i>impact of materials storage and movement</i>		
4.2.7	<i>impact on smooth activity workflow and activity sequencing</i>		

## Q5 - PROJECT COMPLEXITY DETAILS

### QUALITY OF DESIGN COORDINATION

Putting aside the issue of how well the builder coped with the challenges of the project design coordination - how do you respond to the following statement.

where: 1 = very complex, 2 = complex, 3 = slightly complex,  
4 = neutral 5 = slightly simple 6 = simple, 7 = very simple.

5.1 The level of design coordination generally contributed to the perception that this was a ☐ project to construct.

#### 5.2 General Facets of Design Coordination

What was the perceived degree of complexity contributed by the following to the impression that this was, or was not, a complex project:

	<i>Major Elements of Design Coordination Affecting The Smooth Flow Of Work</i>	<i>Rating</i>	<i>Comments</i>
5.2.1	<i>conflicting design information</i>		
5.2.2	<i>timeliness of revised drawings issue</i>		
5.2.3	<i>missing information</i>		
5.2.4	<i>dimensional inaccuracies</i>		
5.2.5	<i>provision &amp; location of penetrations</i>		
5.2.6	<i>expediting shop drawings</i>		

## Q6 - PROJECT COMPLEXITY DETAILS

### QUALITY MANAGEMENT PROCEDURES

Putting aside the issue of how well the builder coped with the challenges of the project quality management coordination - how do you respond to the following statement.

where:            1 = *very complex*, 2 = *complex*, 3 = *slightly complex*,  
                       4 = *neutral* 5 = *slightly simple* 6 = *simple*, 7 = *very simple*.

6.1      The level of quality management procedures generally contributed to the perception that this was a ☐ project to construct.

#### 6.2      *General Facets of Quality Management Procedures*

What was the perceived degree of complexity contributed by the following to the impression that this was, or was not, a complex project:

	<i>Major Elements of Quality Management (QM) Affecting The Smooth Flow Of Work</i>	<i>Rating</i>	<i>Comments</i>
6.2.1	<i>timely inspection procedures</i>		
6.2.2	<i>adequate QM inspection resources</i>		
6.2.3	<i>QM information processing requirements</i>		
6.2.4	<i>materials/work rejection rate</i>		
6.2.5	<i>clean/dry working environment requirements</i>		

## Q7 - PROJECT COMPLEXITY DETAILS

### SITE ACCESS CONSIDERATIONS

Putting aside the issue of how well the builder coped with the challenges of site access to or within the project design - how do you respond to the following statement.

where: 1 = very complex, 2 = complex, 3 = slightly complex,  
4 = neutral 5 = slightly simple 6 = simple, 7 = very simple.

7.1 Access to or within site generally contributed to the perception that this was a ☐ project to construct.

#### 7.2 General Facets of Site Access

What was the perceived degree of complexity contributed by the following to the impression that this was, or was not, a complex project:

	Major Elements of Access to Site and Within Site Affecting Smooth Workflow	Rating	Comments
7.2.1	proximity to required resources		
7.2.2	access to site entry/exit points		
7.2.3	congestion at site entry/exit points		
7.2.4	building footprint to site area ratio		
7.2.5	storage space at or near ground level		
7.2.6	storage space at upper levels		
7.2.7	requirement for restrictive working hours		

## OVERALL PROJECT COMPLEXITY INDICATOR

Putting aside the issue of how well the builder coped with the challenges of client influence, inherent site conditions, buildability, quality of design coordination, quality management procedures, and site access - how do you respond to the following statement.

where:            1 = *very complex*, 2 = *complex*, 3 = *slightly complex*,  
                      4 = *neutral* 5 = *slightly simple* 6 = *simple*, 7 = *very simple*.

7.3      The overall characteristics of this particular project generally contributed to the perception that this was a <input type="checkbox"/> project to construct.
--

## Q8 - PROJECT ENVIRONMENT DETAILS

### PHYSICAL ENVIRONMENT CONSIDERATIONS

Putting aside the issue of how well the builder coped with the challenges of the physical environment - how do you respond to the following statement.

where: 1 = very complex, 2 = complex, 3 = slightly complex,  
4 = neutral 5 = slightly simple 6 = simple, 7 = very simple.

8.1 The physical environment generally contributed to the perception that this was  
a ☐ environment within which to construct a project.

#### 8.2 General Facets of The Physical Environment

What was the perceived degree of complexity contributed by the following to the impression that this was, or was not, a complex environment:

	Major Elements of The Physical Environment Affecting Smooth Workflow	Rating	Comments
8.2.1	impact of natural hazards (fire, floods etc.)		
8.2.2	general climatic conditions		
8.2.3	local weather patterns on site		
8.2.4	ambient noise conditions		
8.2.5	ambient light conditions		

## Q9 - PROJECT ENVIRONMENT DETAILS

## ECONOMIC ENVIRONMENT CONSIDERATIONS

Putting aside the issue of how well the builder coped with the challenges of the prevailing economic environment - how do you respond to the following statement.

where: 1 = very complex, 2 = complex, 3 = slightly complex,  
4 = neutral 5 = slightly simple 6 = simple, 7 = very simple.

9.1	The prevailing economic environment generally contributed to the perception that this was a <input type="checkbox"/> environment within which to construct a project.
-----	---

### 9.2 General Facets of the Economic Environment

What was the perceived degree of complexity contributed by the following to the impression that this was, or was not, a complex environment:

	Major Elements of The Economic Environment Affecting Smooth Workflow	Rating	Comments
9.2.1	materials availability		
9.2.2	equipment availability		
9.2.3	trades/operatives availability		
9.2.4	supervision/management staff availability		
9.2.5	indirect impact of interest rates/inflation		
9.2.6	insolvencies and bankruptcies		



## Q10 - PROJECT ENVIRONMENT DETAILS

### SOCIO-POLITICAL ENVIRONMENT CONSIDERATIONS

Putting aside the issue of how well the builder coped with the challenges of the socio-political environment (legislative, legal, political and local government) - how do you respond to the following statement.

where:            1 = very complex, 2 = complex, 3 = slightly complex,  
                       4 = neutral 5 = slightly simple 6 = simple, 7 = very simple.

10.1    The socio-political environment generally contributed to the perception that this was a ☐ environment within which to construct a project.

#### 10.2    *General Facets of the Socio-Political Environment*

What was the perceived degree of complexity contributed by the following to the impression that this was, or was not, a complex environment:

10.2	<i>Major Elements of The Socio-Political Environment Affecting Smooth Workflow</i>	<i>Rating</i>	<i>Comments</i>
10.2.1	<i>civil strife or riots</i>		
10.2.2	<i>influence of protest action-groups</i>		
10.2.3	<i>political intimidation (national or local)</i>		
10.2.4	<i>disruption due to environmental concerns</i>		
10.2.5	<i>affects of changes in legislation</i>		
10.2.6	<i>affects of changes to occupational health and safety legislation</i>		

### 10.3 General Facets of the Local Government and Statutory Authorities Environment

where: 1 = very complex, 2 = complex, 3 = slightly complex,  
4 = neutral 5 = slightly simple 6 = simple, 7 = very simple.

What was the perceived degree of complexity contributed by the following to the impression that this was, or was not, a complex environment:

10.3	Major Elements of Influence of Interaction with Statutory Authorities and Local Government Affecting Smooth Workflow	Rating	Comments
10.3.1	staged permit approval processing		
10.3.2	programmed building inspections		
10.3.3	interpretation of building codes and standards		
10.3.4	non-building approval process (fire authorities, liquor licensing etc.)		
10.3.5	connection of utilities		
10.3.6	coordination by government departments where several groups within these bodies have the capacity to expedite or delay processing of permits or approvals.		

## Q11 - PROJECT ENVIRONMENT DETAILS

### INDUSTRIAL RELATIONS ENVIRONMENT CONSIDERATIONS

Putting aside the issue of how well the builder coped with the challenges of the industrial relations environment - how do you respond to the following statement.

where:            1 = *very complex*, 2 = *complex*, 3 = *slightly complex*,  
                       4 = *neutral* 5 = *slightly simple* 6 = *simple*, 7 = *very simple*.

11.1    The industrial relations environment (in general and/or on-site) contributed to the perception that this was a ☐ environment within which to construct a project.

#### 11.2    *General Facets of the Industrial Relations Environment*

What was the perceived degree of complexity contributed by the following to the impression that this was, or was not, a complex environment:

11.2	Major Impact of the Industrial Relations Environment Affecting Smooth Workflow	Rating	Comments
11.2.1	<i>national/state IR campaigns</i>		
11.2.2	<i>local IR campaigns/issues</i>		
11.2.3	<i>level of demarcation disputes</i>		
11.2.4	<i>OHS related issues</i>		
11.2.5	<i>secondary boycott or picketing</i>		
11.2.6	<i>flow on from business insolvency</i>		
11.2.7	<i>affects of the impact of workplace reform</i>		

## OVERALL ENVIRONMENTAL COMPLEXITY INDICATOR

where:            1 = *very complex*, 2 = *complex*, 3 = *slightly complex*,  
                      4 = *neutral* 5 = *slightly simple* 6 = *simple*, 7 = *very simple*.

Putting aside the issue of how well the builder coped with the challenges of the physical, economic, socio-political, and industrial relations environment - how do you respond to the following statement.

11.3    This project was perceived to be constructed under <input type="checkbox"/> environmental conditions.
---

**Q12 - MANAGEMENT RESPONSE DETAILS**  
**CLIENT MANAGEMENT CONSIDERATIONS**

Putting aside the issue of what constraints were placed upon the project by the goals and characteristics of the client - how do you respond to the following statement.

where:            1 = *strongly diminished*, 2 = *diminished*, 3 = *slightly diminished*,  
                      4 = *neither diminished nor enhanced*, 5 = *slightly enhanced*, 6 = *enhanced*,  
                      7 = *strongly enhanced*.

12.1    Speed of construction was ☐ by the working relationship developed between the client (or client representative) and the construction management team.

where:            1 = *very ineffective*, 2 = *ineffective*, 3 = *slightly ineffective*,  
                      4 = *neither ineffective nor effective*, 5 = *slightly effective*, 6 = *effective*,  
                      7 = *very effective*.

12.2    The construction team management was ☐ in managing the client as a member of the project team to gain influence over the client's decision making process and response from the client regarding decisions made and requests for information affecting construction time performance.

**Q13 - MANAGEMENT RESPONSE DETAILS**  
**CONSTRUCTION MANAGEMENT PROCEDURES**

Putting aside the issue of what constraints were placed upon the project by the goals and characteristics of the client - how do you respond to the following statement.

where:           1 = *strongly diminished*, 2 = *diminished*, 3 = *slightly diminished*,  
                    4 = *neither diminished nor enhanced*, 5 = *slightly enhanced*, 6 = *enhanced*,  
                    7 = *strongly enhanced*.

13.1   Speed of construction was ☐ by the construction management team's  
          established and maintained management systems and procedures to manage  
          the construction of the project.

### 13.2 Management Techniques Used for Planning and Control

Management techniques used during the construction phase for planning, monitoring and controlling.

Please indicate **usage** - yes/no; **frequency** of monitoring - N = never, O = once only, WU = weekly updates, MU = monthly updates, VP = variable periodical updates, CC = constantly updated for identified critical path activities.

	<i>Technique</i>	<i>Used</i>	<i>Frequency</i>	<i>Comments on Effectiveness</i>
13.2.1	<i>critical path methods</i>			
13.2.2	<i>workflow methods (LOB)</i>			
13.2.3	<i>simulation or queuing theory</i>			

### 13.3 General Facets of Construction Management Procedures & Systems

where: 1 = very ineffective, 2 = ineffective, 3 = slightly ineffective,  
4 = neither ineffective nor effective, 5 = slightly effective, 6 = effective,  
7 = very effective.

What was the perceived impact upon speed of construction through the level of performance attained by the construction management team on the following:

	<i>Achieved Effectiveness of Construction Management Actions:</i>	<i>Rating</i>
13.3.1	<i>forecasted planning data e.g. activity duration, resource quantities required etc.</i>	
13.3.2	<i>analysing construction methods</i>	
13.3.3	<i>analysing resource movement to and within site</i>	
13.3.4	<i>analysing work sequencing to achieve and maintain workflow</i>	
13.3.5	<i>monitoring and updating plans to appropriately reflect work status</i>	
13.3.6	<i>responding to recover from problems or taking advantage of opportunities presented</i>	
13.3.7	<i>effectively coordinating resources</i>	
13.3.8	<i>developing an appropriate organisational structure to maintain workflow</i>	

### Q14 - MANAGEMENT RESPONSE DETAILS



## DEVELOPING ORGANISATIONAL STRUCTURES TO MANAGE RISK

Putting aside the issue of what constraints were placed upon the project by the goals and characteristics of the client - how do you respond to the following statement.

where:            1 = *strongly diminished*, 2 = *diminished*, 3 = *slightly diminished*,  
                      4 = *neither diminished nor enhanced*, 5 = *slightly enhanced*, 6 = *enhanced*,  
                      7 = *strongly enhanced*.

14.1    Speed of construction was ☐ by the appropriateness of the construction management team's organisational structure to manage risk associated with the project.

Risk refers to contractual obligations and legal liability to complete work to the level and quality agreed.

14.2    Speed of construction was ☐ by the level of risk accepted by the design team on the project.

14.3    Speed of construction was ☐ by the level of risk accepted by the client on the project.

14.4    Speed of construction was ☐ by the level of risk accepted by key sub-contractors on the project.

**Q15 - MANAGEMENT RESPONSE DETAILS**  
**MANAGING HUMAN RESOURCES AND TEAM CONFLICT**

Putting aside the issue of what constraints were placed upon the project by the goals and characteristics of the client - how do you respond to the following statement.

where:            1 = *strongly diminished*, 2 = *diminished*, 3 = *slightly diminished*,  
                      4 = *neither diminished nor enhanced*, 5 = *slightly enhanced*, 6 = *enhanced*,  
                      7 = *strongly enhanced*.

15.1    Speed of construction was <input type="checkbox"/> by the construction management team's effectiveness in managing team effort to optimise inter and intra group synergism and creatively manage conflict.
--

## 15.2 Key Team Members Organisational Style Characteristics

where: 1 = very low, 2 = low, 3 = slightly low, 4 = average,  
5 = slightly high, 6 = high, 7 = very high.

Rate the response that best describes your opinion of the way in which key team members reacted during your interactions with them on this project.

Statement - What in your judgement was the level of:	Client Rep.	Design Arch.	Design Services	Builder	Key Sub-contractors
15.2.1 comfort with a fixed hierarchical framework through rules and procedures.					
15.2.2 need to confer with organisational superiors before making commitments.					
15.2.3 influence by those with project related expertise rather than formal organisational authority.					
15.2.4 readiness to explore options outside the immediately obvious.					
15.2.5 reliance on formal channels of communication.					
15.2.6 focus on problems to be solved rather than the procedural mechanisms of problem solving.					

### 15.3 Management Style

where: 1 = very low, 2 = low, 3 = slightly low, 4 = average,  
5 = slightly high, 6 = high, 7 = very high.

Rate the response that best describes your opinion of the way in which team leaders from the following groups focussed upon tasks they were responsible for supervising.

<i>Statement - give your general impressions of the extent to which team leaders:</i>	<i>Client/Representative</i>	<i>Design Team Manager</i>	<i>Construction Team Manager</i>	<i>Generally - Foreman/Supervisors</i>
15.3.1 Specified goals people are to accomplish.				
15.3.2 Organised the work situation for people.				
15.3.3 Set time lines.				
15.3.4 Provided specific direction.				
15.3.5 Required regular reporting on progress.				
15.3.6 Provided support and encouragement.				
15.3.7 Involved team members through discussion of work.				
15.3.8 Facilitated group interaction.				
15.3.9 Sought people's opinions & concerns.				
15.3.10 Provided feedback on accomplishments.				

### 15.4 Management of Power

where: 1 = very low, 2 = low, 3 = slightly low, 4 = average,  
5 = slightly high, 6 = high, 7 = very high.

Rate the response that best describes your opinion of the sources of power used by team leaders in managing personnel they supervised.

Statement - give your general impressions of the level of power used based on:	Client/ Represent -ative	Design Team Manager	Construction Team Manager	Generally - Foreman/ Supervisors
15.4.1 POWER - fear of punishment.				
15.4.2 POWER - the legal or traditional position held.				
15.4.3 POWER - respect of expert knowledge.				
15.4.4 POWER - ability to provide rewards.				
15.4.5 POWER - personal qualities, being liked.				
15.4.6 POWER - access to valuable information.				
15.4.7 POWER - leader's connections with influential persons inside or outside the organisation.				

### 15.5 Motivation of Teams

where: 1 = very low, 2 = low, 3 = slightly low, 4 = average,  
5 = slightly high, 6 = high, 7 = very high.

Rate the response that best describes your opinion of the extent to which the following factors motivated teams involved with the project.

	<i>Client/ Rep.</i>	<i>Design Team</i>	<i>Construction Mngmt Team</i>	<i>On-site Workforce</i>
15.5.1 Pay and allowances.				
15.5.2 Achievement from meeting complex challenges				
15.5.3 Job security.				
15.5.4 A sense of belonging & identification with the project team.				
15.5.5 Recognition (monitory or kudos) of contribution made.				
15.5.6 Opportunity to extend skills and experience - i.e. learning.				
15.5.7 Equitable rewards relative to other's input to the project.				
15.5.8 Exercise of power				
15.5.9 Opportunity for career advancement - i.e. for future benefit.				

## 15.6 De-Motivation of Teams

where: 1 = very low, 2 = low, 3 = slightly low, 4 = average,  
5 = slightly high, 6 = high, 7 = very high.

Rate the response that best describes your opinion of the extent to which the following factors de-motivated members of teams involved with the project.

<i>de-motivation of teams —&gt;</i>	<i>Client Rep.</i>	<i>Design Team</i>	<i>Construction Mngmt Team</i>	<i>On-site Workforce</i>
15.6.1 Pay and conditions				
15.6.2 Physical working environment (safety discomfort etc.).				
15.6.3 Being accountable for unclear or conflicting objectives.				
15.6.4 Sense of isolation or marginalisation.				
15.6.5 Lack of recognition of contribution made.				
15.6.6 Having to re-do work				
15.6.7 Having to work to unreasonable time frames.				
15.6.8 Having insufficient authority to meet contractual or ethical obligations.				
15.6.9 Inter-team conflict or petty point scoring between groups.				

**Q16 - MANAGEMENT RESPONSE DETAILS**  
**COMMUNICATION MANAGEMENT FOR DECISION MAKING**

Putting aside the issue of what constraints were placed upon the project by the goals and characteristics of the client - how do you respond to the following statement.

where:           1 = *strongly diminished*, 2 = *diminished*, 3 = *slightly diminished*,  
                  4 = *neither diminished nor enhanced*, 5 = *slightly enhanced*, 6 = *enhanced*,  
                  7 = *strongly enhanced*.

Communications includes visual image, verbal, written, and electronic media used when transferring, processing, or presenting information (between individuals or groups in meetings) to facilitate decision making.

16.1   Speed of construction was <input type="checkbox"/> by the construction management team's effectiveness in managing communications to facilitate appropriate speed and responsible decision making of the construction team.
--



## 16.2 Effective Communication Management BETWEEN Teams

where: 1 = very low, 2 = low, 3 = slightly low, 4 = average  
5 = slightly high, 6 = high, 7 = very high.

Rate the effectiveness (in terms of decision making and decision implementation) of communications *between* project teams, during the pre-contract phase (PC-PH), during the first half of the construction phase (H1-PH), and during the second half of the construction phase (H2-PH).

16.2 Effectiveness of Communication BETWEEN Team Groups for decision making	PC-PH	H1-PH	H2-PH
16.2.1 Client/Construction Team			
16.2.2 Client/Design Team Leader			
16.2.3 Design Team Leader/Construction Team			

## 16.3 Effective Communication Management WITHIN Teams

Rate the effectiveness (in terms of decision making and decision implementation) of communications *within* project teams, during the pre-contract phase (PC-PH), during the first half of the construction phase (H1-PH), and during the second half of the construction phase (H2-PH).

16.3 Effectiveness of Relationship WITHIN Team Groups	PC-PH	H1-PH	H2-PH
16.3.1 Client Team			
16.3.2 Design Team			
16.3.3 Construction Team			

### 16.4 Management Organisational Structures for Decision Making

where: 1 = very low, 2 = low, 3 = slightly low, 4 = average  
5 = slightly high, 6 = high, 7 = very high.

Rate the response that best describes your opinion of the **organisational structure effectiveness** (both formal and informal) of the following entities established or as evolved, to facilitate action on decisions made, communicated, and coordinated. The question relates to the effectiveness of the organisations as a whole and not to individuals or key personnel.

<i>Decision Making Organisations</i>	<i>Decision Making</i>	<i>Decision Communication</i>	<i>Coordination of Team Members To Take Action On Decisions</i>
<i>16.4.1 Client team</i>			
<i>16.4.2 Design team</i>			
<i>16.4.3 Construction team</i>			
<i>16.4.4 overall impact on</i>			

## 16.5 Computerisation of Management Techniques Used for Planning and Control

Information technology tools used for planning for control may include (SCH) scheduling, (SPSH) spreadsheets, (DBS) data base systems, (WP) word processing, (GR) graphics tools and other off-the-shelf or customised systems developed and used on this project.

<i>Description</i>	<i>IT tools used</i>	<i>Comments</i>
<i>IT tools used by the client's representative:</i>		
<i>IT tools used by the design team:</i>		
<i>IT tools used by the construction team:</i>		

### 16.6 Effectiveness of Techniques & Tools Used for Planning and Control

Rate the response that best describes your opinion of the effectiveness of techniques used (computerised or manual systems) on this project for planning, monitoring and communicating plans to achieve control of construction time performance. State reason where appropriate.

where: 1 = very low, 2 = low, 3 = slightly low, 4 = average  
5 = slightly high, 6 = high, 7 = very high.

Description	Rating	Comments
IT tools used by the client's representative:		
IT tools used by the design team:		
IT tools used by the construction team:		

## OVERALL MANAGEMENT CONTROL PERFORMANCE INDICATOR

Bearing in mind the issue of project and environmental conditions complexity and its impact upon managerial action - how do you respond to the following statement.

where:            1 = *strongly diminished*, 2 = *diminished*, 3 = *slightly diminished*,  
                      4 = *neither diminished nor enhanced*, 5 = *slightly enhanced*, 6 = *enhanced*,  
                      7 = *strongly enhanced*.

17.1    Speed of construction was <input type="checkbox"/> by the construction management team's effectiveness in managing the construction process and overcoming difficulties imposed by project characteristics or environmental complexity.
---

## APPENDIX 2

### RESULTS FROM SUB-HYPOTHESIS TESTING

#### NOTES:

The ANOVA results provide both statistical results and a graph of the results of the tested variable (on the X axis) and the construction time performance (CTP) index value (on the Y axis). Table 2.2 in chapter two outlines case study number and CTP index value, 19 cases exceed the trend-line CTP and 14 are below trend-line CTP, moreover, 13 cases performed at less than 95% of trend-line CTP, 7 cases performed within 5% plus or minus trend-line CTP, and 13 performed at better than 5% above trend-line CTP. These performance measures should be kept in mind when considering the graphs and the clusters of projects in the categories illustrated in graphs.

When referring to correlation analysis results with a correlation of greater than 0.449 were considered. Hinkle *et al.* (1988, p118) recommend as a rule of thumb that a correlation of 0.70 to 0.90 be considered a high correlation and 0.50 to 0.70 as moderate.

Correlation value throughout this thesis are referred as  $C_p = ?$  for Pearson Product Moment Correlation and  $C_s = ?$  for Spearman Rank Correlation. Significance level found for correlation are referred to as 'sig. = ?' indicating the degree of chance associated with an incorrect correlation result, thus 'sig.' needs to be less than 0.05 to be considered reliable. Text is formatted in *italics* when describing and discussing a variable with moderate correlation and **bold** for variables with high correlation.

## SUB-HYPOTHESIS NUMBER 1

## QUESTIONNAIRE NUMBER Q1.1

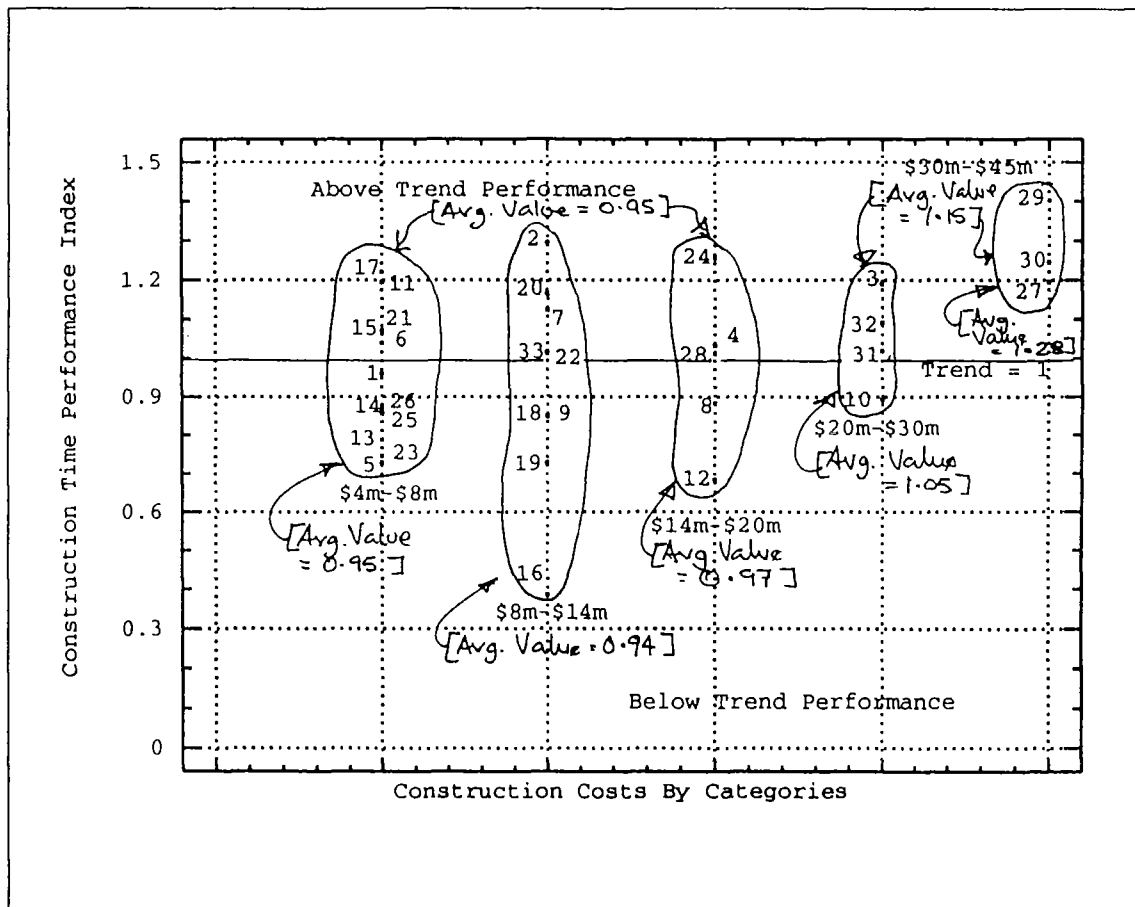
$H_0$  Construction time performance is **NOT** dependent upon construction cost being greater than A\$20 million (January 1990).

$H_1$  Construction time performance **IS** dependent upon construction cost being greater than A\$20 million (January 1990).

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
5.375	0.0272	<b><math>H_0</math> REJECTED <math>H_1</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 1**

**DATA ITEM: CONSTRUCTION COST (CATEGORISED INTO 5 GROUPS)**

[1] \$4 million up to \$8 million; [2] \$8+ million to \$14 million;  
[3] \$14+ million to \$20 million; [4] 4 cases of \$20+ million to \$30 million;  
[5] over \$30

**Spearman Rank Correlation results for factors affecting CTP:**

☐ no significant correlation.

**Spearman Rank Correlation results for factors NOT affecting CTP:**

☐ the CR's confidence in the construction team ( $C_s = 0.4759$ ; sig. = 0.0081);



## SUB-HYPOTHESIS NUMBER 2

## QUESTIONNAIRE NUMBER Q1.3

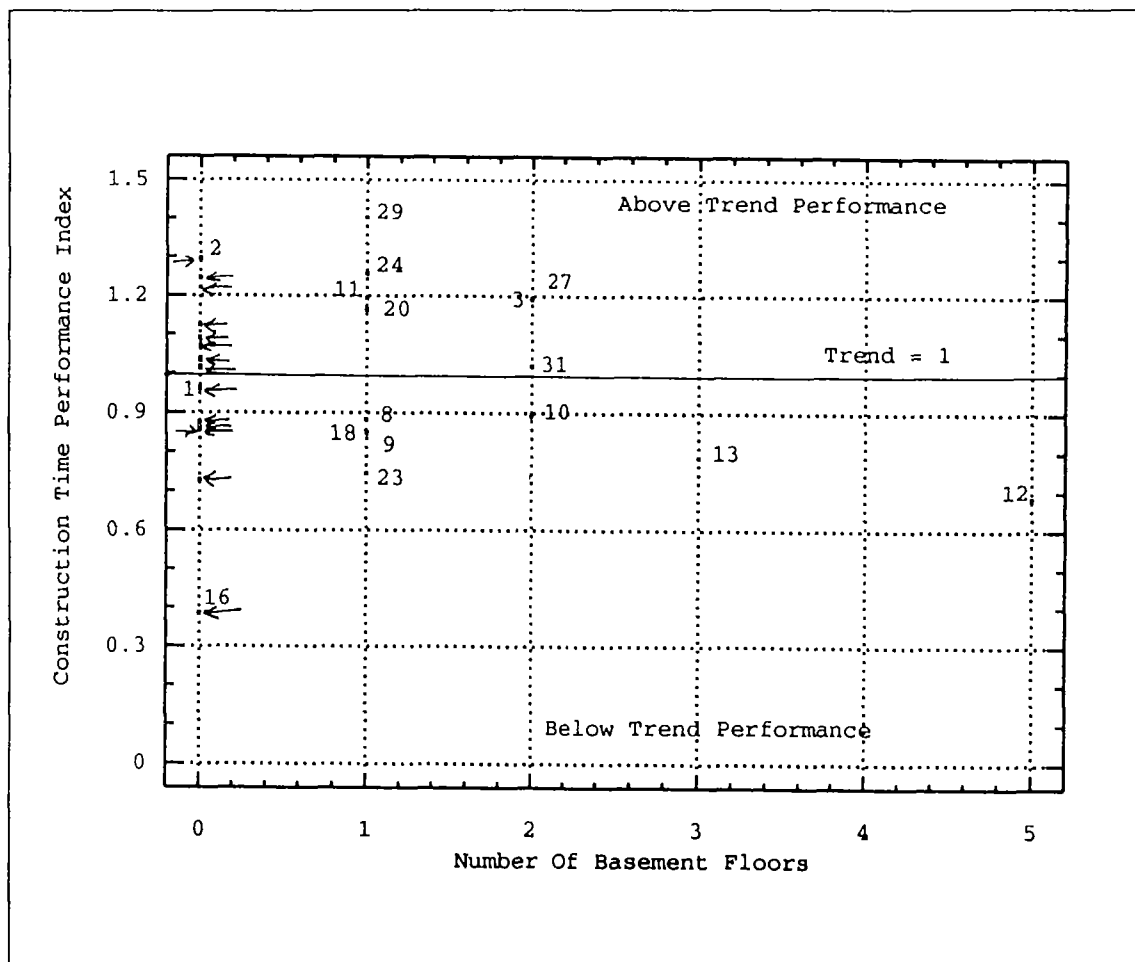
$H_0$  Construction time performance is **NOT** dependent upon number of basement levels

$H_1$  Construction time performance **IS** dependent upon number of basement levels

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
1.126	0.4111	<b><math>H_0</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 2**  
**DATA ITEM: NUMBER OF BASEMENT LEVELS**

**Spearman Rank Correlation results for factors affecting CTP:**

☐ no significant correlation.

**Spearman Rank Correlation results for factors NOT affecting CTP:**

☐ *design team's organisational structure to manage risk ( $C_s = 0.6462$ ; sig. = 0.0003);*

## SUB-HYPOTHESIS NUMBER 3

## QUESTIONNAIRE NUMBER Q1.4

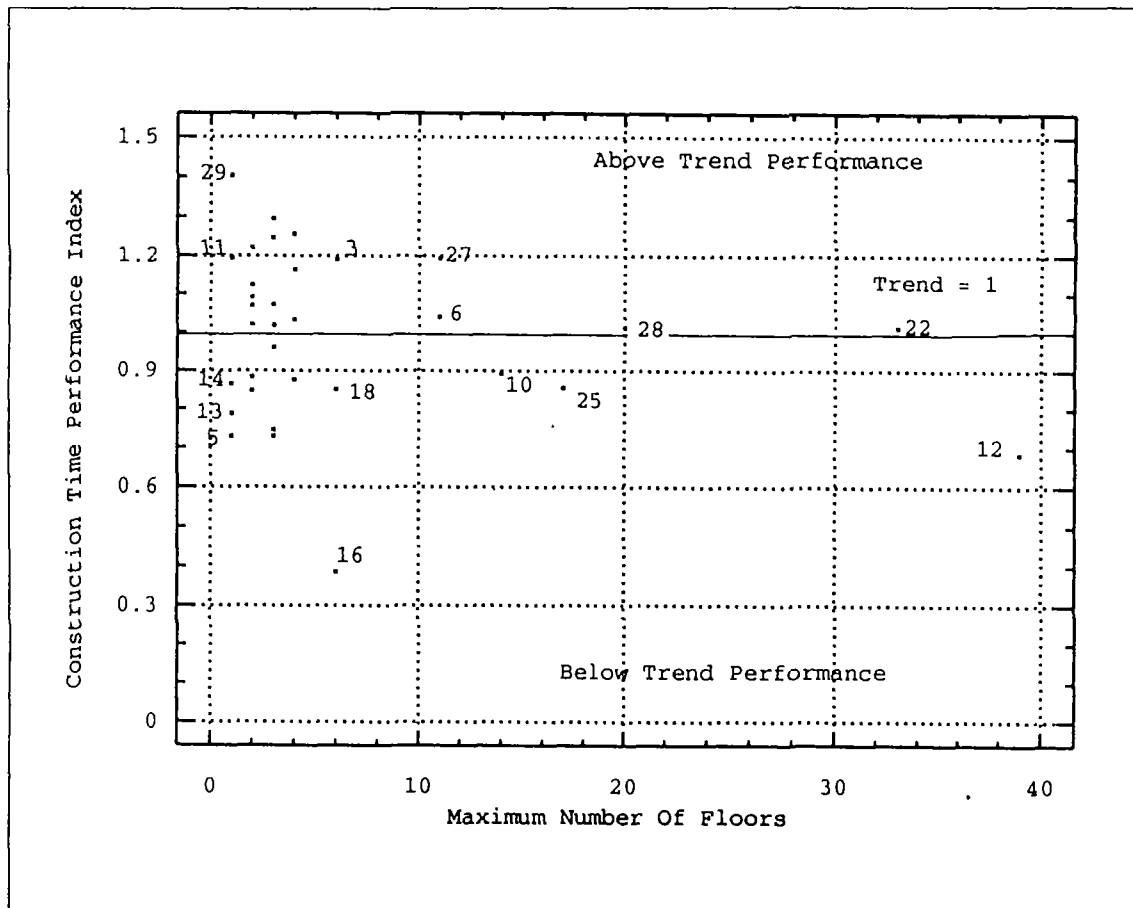
$H_0$  Construction time performance is **NOT** dependent upon numbers of floors being greater than two.

$H_1$  Construction time performance **IS** dependent upon numbers of floors being greater than two.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of *less than* 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.299	0.5939	<b><math>H_0</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 3**  
**DATA ITEM: NUMBER OF FLOORS**

**Spearman Rank Correlation results for factors affecting CTP:**

☐ no significant correlation.

**Spearman Rank Correlation results for factors NOT affecting CTP:**

☐ no significant correlation.

## SUB-HYPOTHESIS NUMBER 4

## QUESTIONNAIRE NUMBER Q1.6

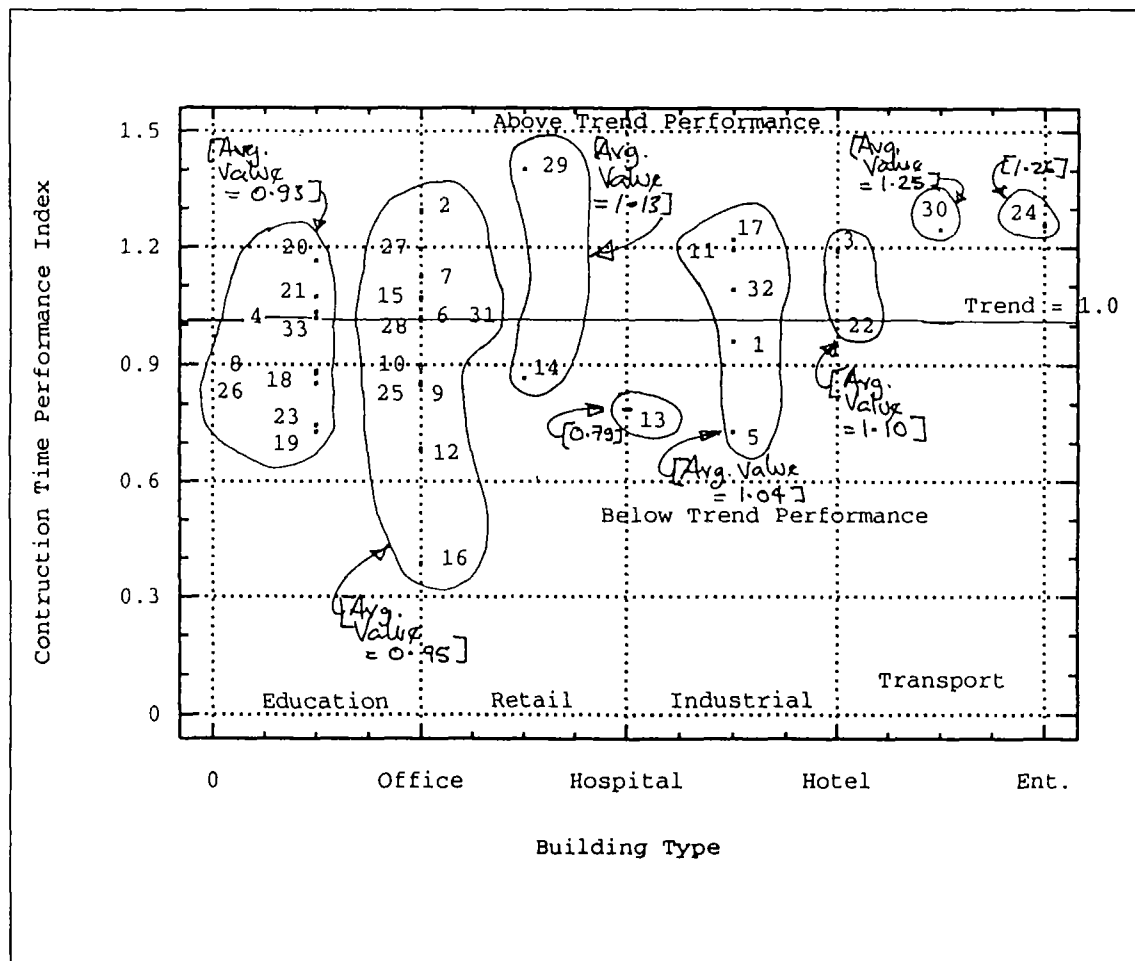
$H_0$  Construction time performance is **NOT** dependent upon the building's end use.

$H_1$  Construction time performance **IS** dependent upon the building's end use.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.949	0.4882	<b><math>H_0</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 4**

**DATA ITEM: BUILDING'S END-USE (CATEGORISED INTO 8 GROUPS)**

[1] education, [2] office, [3] retail, [4] hospital, [5] industrial, [6] hotel, [7] transport, [8] entertainment.

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *ability of the CR to contribute ideas to the design process ( $C_s = 0.5196$ ; sig. = 0.0038);*
- ☐ *impact of CR/CM working relationship ( $C_s = 0.6230$ ; sig. = 0.0004);*
- ☐ *CM's communication management to facilitate decision making ( $C_s = 0.5332$ ; sig. = 0.0026).*

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *client representation form ( $C_s = -0.5827$ ; sig. = 0.0010);*
- ☐ *client company size ( $C_s = -0.4915$ ; sig. = 0.0062);*
- ☐ *the overall CR contribution to project team harmony ( $C_s = 0.4585$ ; sig. = 0.0095);*
- ☐ *direct use of power in the design team's management style ( $C_s = -0.4878$ ; sig. = 0.0169).*

## SUB-HYPOTHESIS NUMBER 5

## QUESTIONNAIRE NUMBER Q1.6

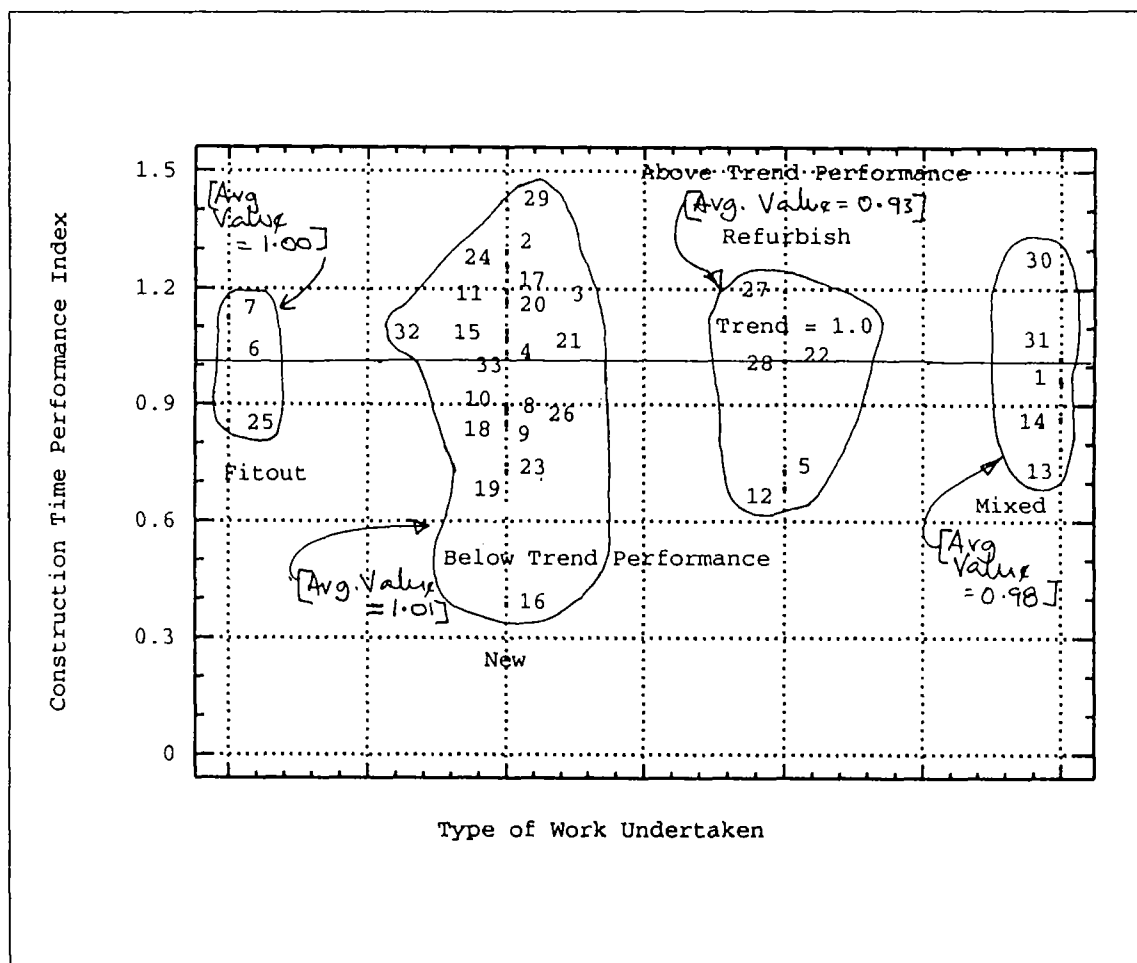
$H_0$  Construction time performance is **NOT** dependent upon the type of work undertaken (fit-out, refurbishment, new or a mixture of these).

$H_1$  Construction time performance **IS** dependent upon the type of work undertaken (fit-out, refurbishment, new or a mixture of these).

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.208	0.8903	<b><math>H_0</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 5**

**DATA ITEM: TYPE OF WORK UNDERTAKEN (CATEGORISED INTO 4 GROUPS)**

[1] fit-out work, [2] new work, [3] refurbishment, [4] mixture of 1-3.

**Spearman Rank Correlation results for factors affecting CTP:**

☐ no significant correlation.

**Spearman Rank Correlation results for factors NOT affecting CTP:**

☐ direct use of power in the CM's management style ( $C_s = -0.4579$ ; sig. = 0.0096).



## SUB-HYPOTHESIS NUMBER 6

## QUESTIONNAIRE NUMBER Q1.7.1

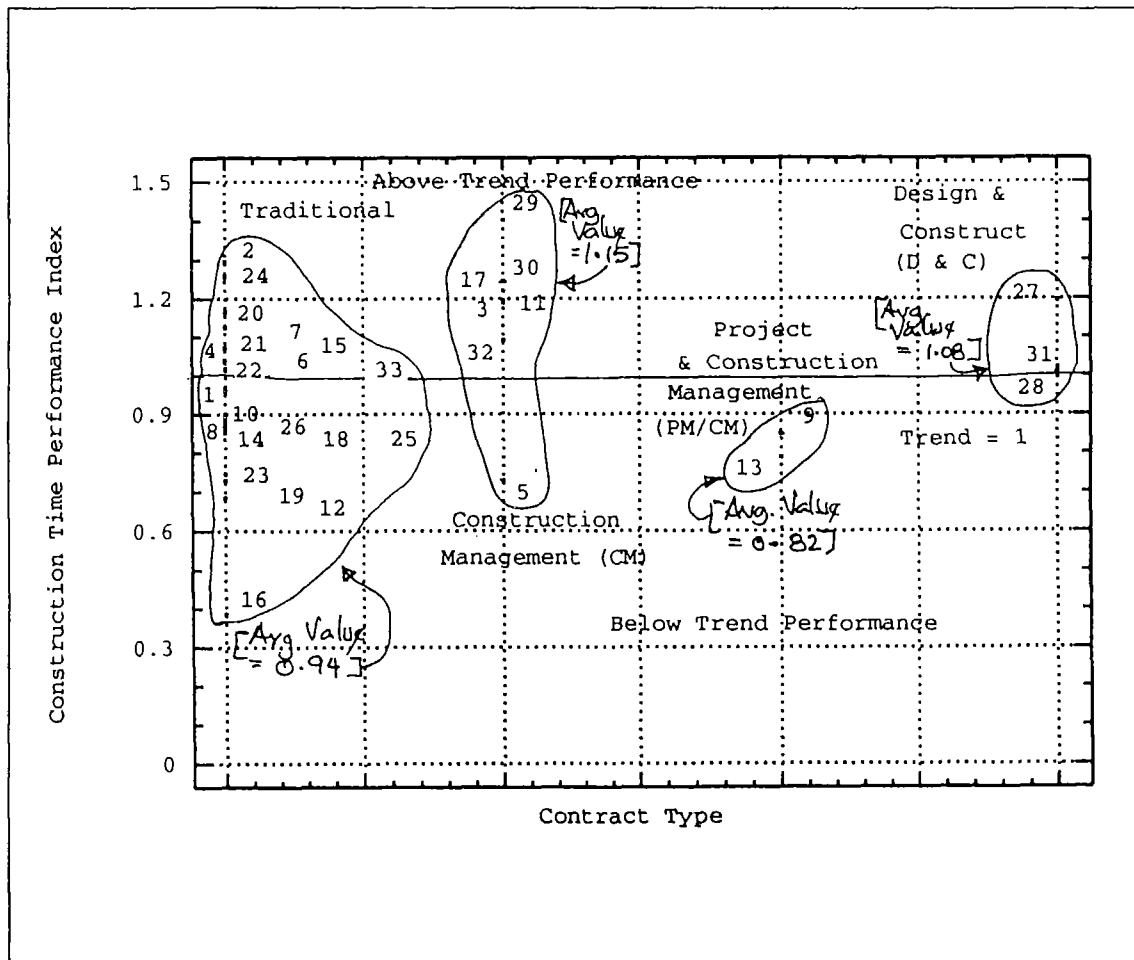
$H_0$  Construction time performance is **NOT** dependent upon procurement method.

$H_1$  Construction time performance **IS** dependent upon procurement method.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set.  $F$ -ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
2.642	0.0681	<b><math>H_0</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 6**

**DATA ITEM: PROCUREMENT METHOD (CATEGORISED INTO 4 GROUPS)**

[1] traditional contract, [2] construction management,  
[3] project and construction management, [4] design and construct.

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ the project design team's confidence in the CR contribution ( $C_s = 0.5581$ ; sig. = 0.0022).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ task-orientation of the CR's management style ( $C_s = 0.4912$ ; sig. = 0.0062);
- ☐ direct use of power in the CR's management style ( $C_s = -0.4967$ ; sig. = 0.0057);
- ☐ direct use of power in the CM's management style ( $C_s = -0.5707$ ; sig. = 0.0012);
- ☐ direct use of power in key sub-contractor's management style ( $C_s = -0.5189$ ; sig. = 0.0033);
- ☐ CR's effective use of information technologies ( $C_s = 0.5350$ ; sig. = 0.0324).

## SUB-HYPOTHESIS NUMBER 7

## QUESTIONNAIRE NUMBER Q1.7.2

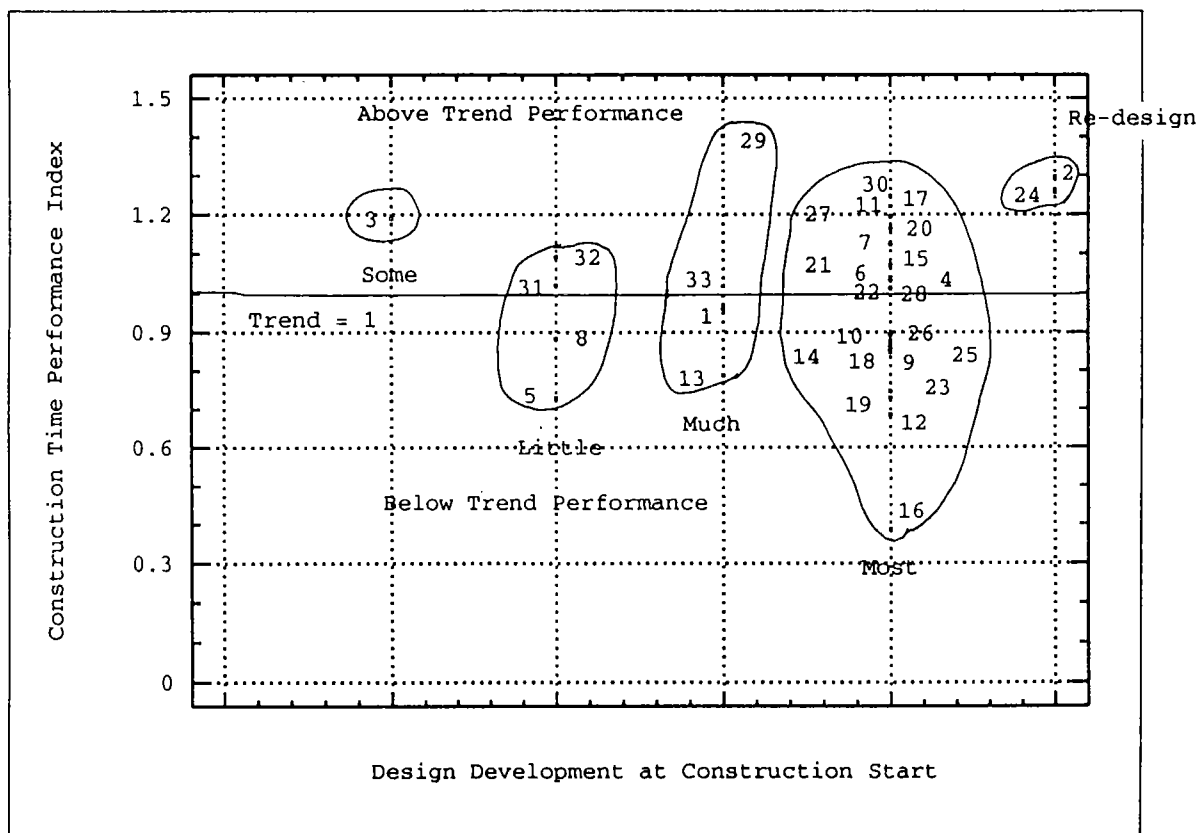
$H_0$  Construction time performance is **NOT** dependent upon design development stage at start of construction.

$H_1$  Construction time performance **IS** dependent upon design development stage at start of construction.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
1.440	0.2469	<b><math>H_0</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 7**

**DATA ITEM: DESIGN DEVELOPMENT STAGE AT CONSTRUCTION START  
(CATEGORISED INTO 5 GROUPS)**

[1] some (under 25%), little (25% to 50%), [2] much (50% to 75%),  
[3] most (more than 75%), [4] re-designed.

**Spearman Rank Correlation results for factors affecting CTP:**

☐ no significant correlation.

**Spearman Rank Correlation results for factors NOT affecting CTP:**

☐ socio-political environmental complexity ( $C_s = 0.4633$ ; sig. = 0.0088).

## SUB-HYPOTHESIS NUMBER 8

## QUESTIONNAIRE NUMBER Q1.9-Q1.10

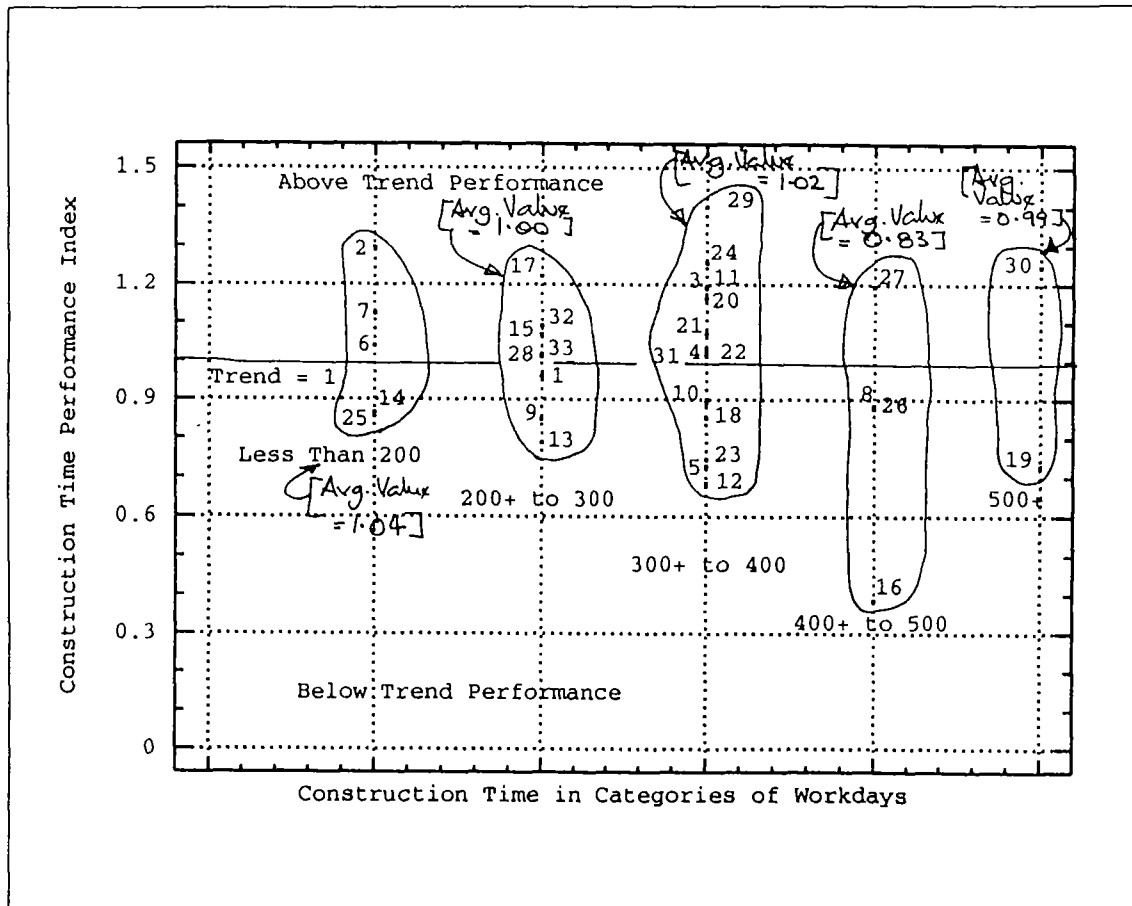
$H_0$  Construction time performance is **NOT** dependent upon construction time period.

$H_1$  Construction time performance **IS** dependent upon construction time period.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.620	0.6520	$H_0$ ACCEPTED

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 8**

**DATA ITEM: CONSTRUCTION TIME PERIOD (CATEGORISED INTO 5 GROUPS)**

[1] less than 200 workdays, [2] 200+ to 300 workdays,  
[3] 300+ to 400 workdays, [4] 400+ to 500 workdays, [5] 500+ workdays.

**Spearman Rank Correlation results for factors affecting CTP:**

☐ no significant correlation.

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ clarity of communication of client/CR objectives ( $C_s = -0.4828$ ; sig. = 0.0063);
- ☐ flexibility of the CR's management style ( $C_s = -0.5011$ ; sig. = 0.0046).

## SUB-HYPOTHESIS NUMBER 9

## QUESTIONNAIRE NUMBER Q1.11

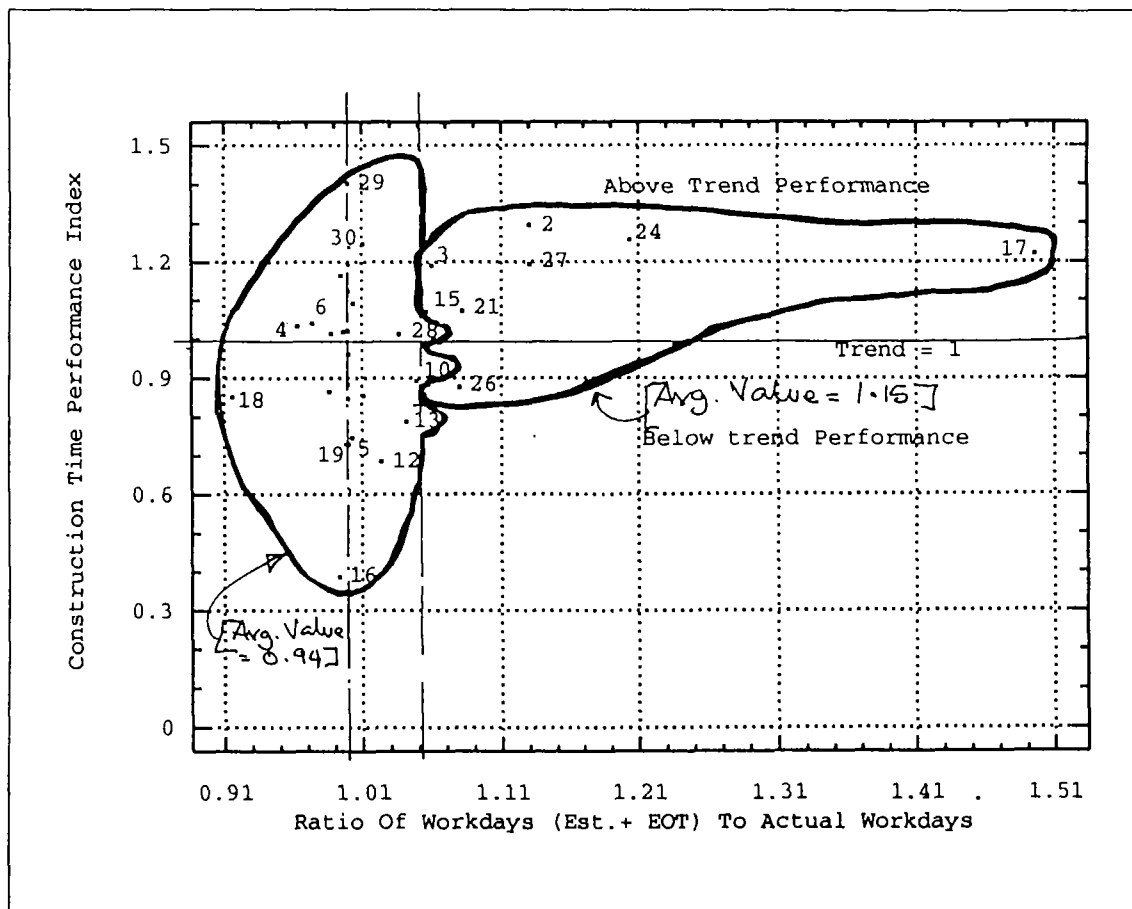
$H_0$  Construction time performance is **NOT** dependent upon building construction duration being within 5% of estimated duration adjusted for EOT.

$H_1$  Construction time performance **IS** dependent upon building construction duration being within 5% of estimated duration adjusted for EOT.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
6.476	0.0161	<b><math>H_0</math> REJECTED <math>H_1</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 9**

**DATA ITEM: ADJUSTED ESTIMATE:ACTUAL CONSTRUCTION TIME PERIOD  
(CATEGORISED INTO 4 GROUPS)**

(estimated at tender time + granted EOT = adjusted estimate the ratio is  
then the adjusted estimate to actual construction time)

[1] 0.90 to 0.95, [2] 0.95+ to 1.05, [3] 1.05+ to 1.15, [4] 1.15+

**Spearman Rank Correlation results for factors affecting CTP:**

☐ *impact of CR/CM working relationship ( $C_s = 0.5032$ ;  $sig. = 0.0044$ ).*

**Spearman Rank Correlation results for factors NOT affecting CTP:**

☐ no significant correlation.



SUB-HYPOTHESIS NUMBER 10

QUESTIONNAIRE NUMBER Q1.12

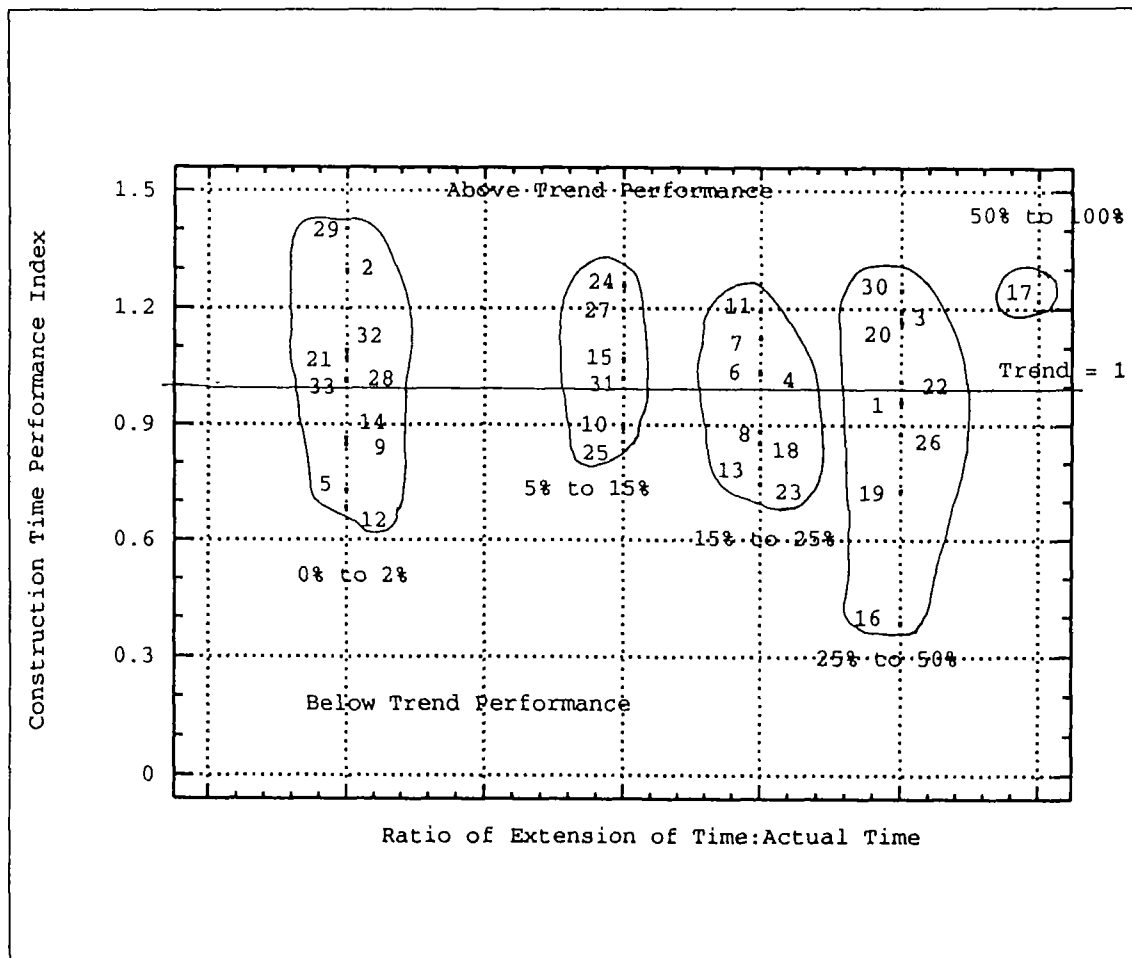
$H_0$  Construction time performance is **NOT** dependent upon the ratio of extension of time claims granted to actual construction time.

$H_1$  Construction time performance **IS** dependent upon the ratio of extension of time claims granted to actual construction time.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.512	0.7275	<b><math>H_0</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 10**

**DATA ITEM: RATIO OF EOT: ACTUAL CONSTRUCTION TIME PERIOD  
(CATEGORISED INTO 5 GROUPS)**

[1] 0 to 2%, [2] 5% to 15%, [3] 15% to 25%, [4] 25% to 50%,  
[5] over 50%

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *CM's effectively coordinating resources* ( $C_s = -0.5017$ ; sig. = 0.0045);
- ☐ *CM's developing an organisational structure to maintain workflow* ( $C_s = -0.4475$ ; sig. = 0.0114);
- ☐ *effectiveness of the construction team's monitoring and control* ( $C_s = -0.4639$ ; sig. = 0.0087);
- ☐ *key sub-contractor's task-oriented management style* ( $C_s = -0.4706$ ; sig. = 0.0078);
- ☐ *effectiveness of the CM team in managing the construction process* ( $C_s = -0.4941$ ; sig. = 0.0052).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *the CR's confidence in the construction team* ( $C_s = -0.4940$ ; sig. = 0.0059);
- ☐ *CM management systems and procedures* ( $C_s = -0.5339$ ; sig. = 0.0025);
- ☐ *CM's effectiveness in team management to achieve synergy* ( $C_s = -0.6219$ ; sig. = 0.0004);
- ☐ *flexibility of design team's management style* ( $C_s = -0.4665$ ; sig. = 0.0094);
- ☐ *CM's people-oriented management style* ( $C_s = -0.5051$ ; sig. = 0.0043);
- ☐ *key sub-contractor's people-oriented management style* ( $C_s = -0.5049$ ; sig. = 0.0043).

## SUB-HYPOTHESIS NUMBER 11

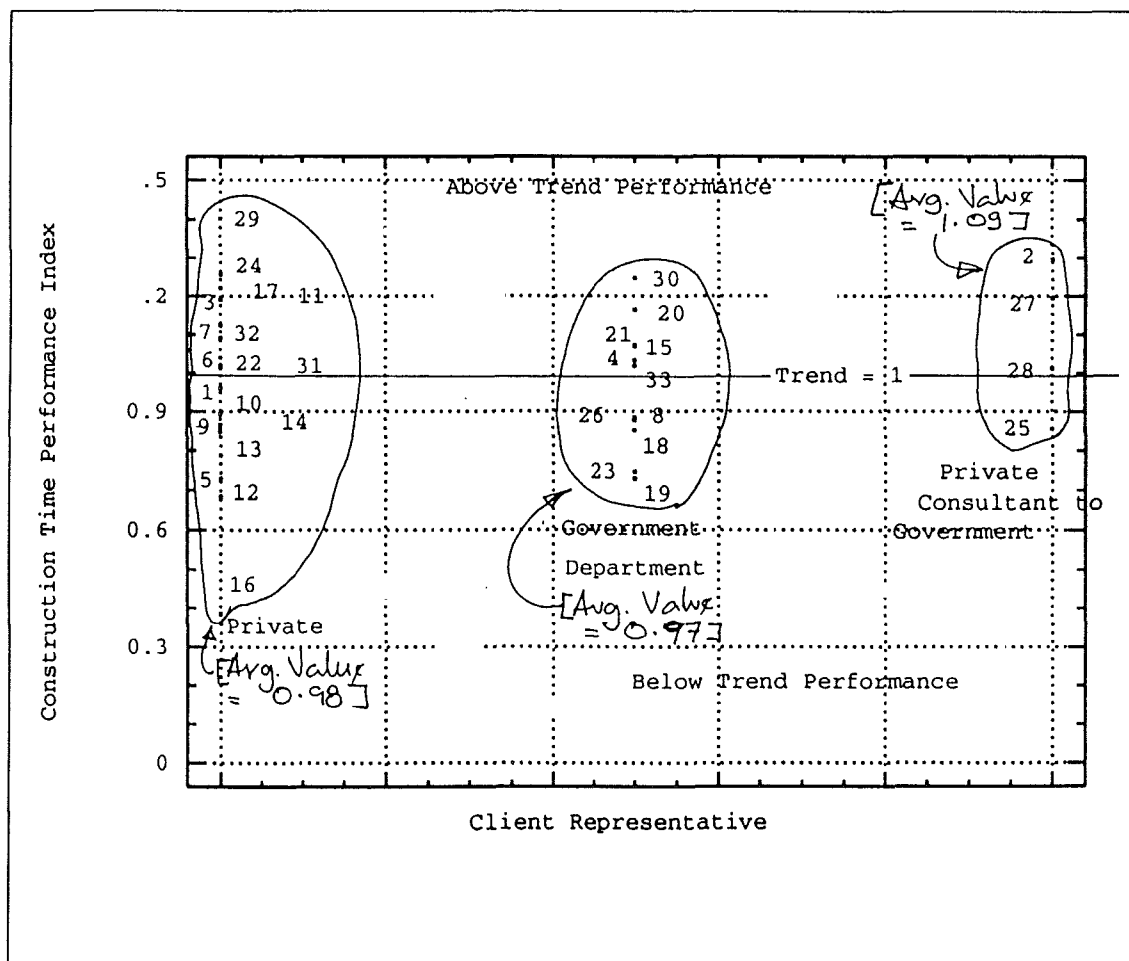
## QUESTIONNAIRE NUMBER Q2.2.1

- $H_0$  Construction time performance is **NOT** dependent upon client representation form.  
 $H_1$  Construction time performance **IS** dependent upon client representation form.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.462	0.6344	<b><math>H_0</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 11**

**DATA ITEM: TYPE OF CLIENT (CATEGORISED INTO 3 GROUPS)**

[1] private, [2] government, [3] private consultant (acting on behalf of a government department).

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ no significant correlation.

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *type of building end-use* ( $C_s = -0.5827$ ;  $\text{sig.} = 0.0010$ );
- ☐ *client company size* ( $C_s = 0.5163$ ;  $\text{sig.} = 0.0040$ );
- ☐ *physical environmental complexity* ( $C_s = 0.4606$ ;  $\text{sig.} = 0.0092$ ).

## SUB-HYPOTHESIS NUMBER 12

## QUESTIONNAIRE NUMBER Q2.2.2

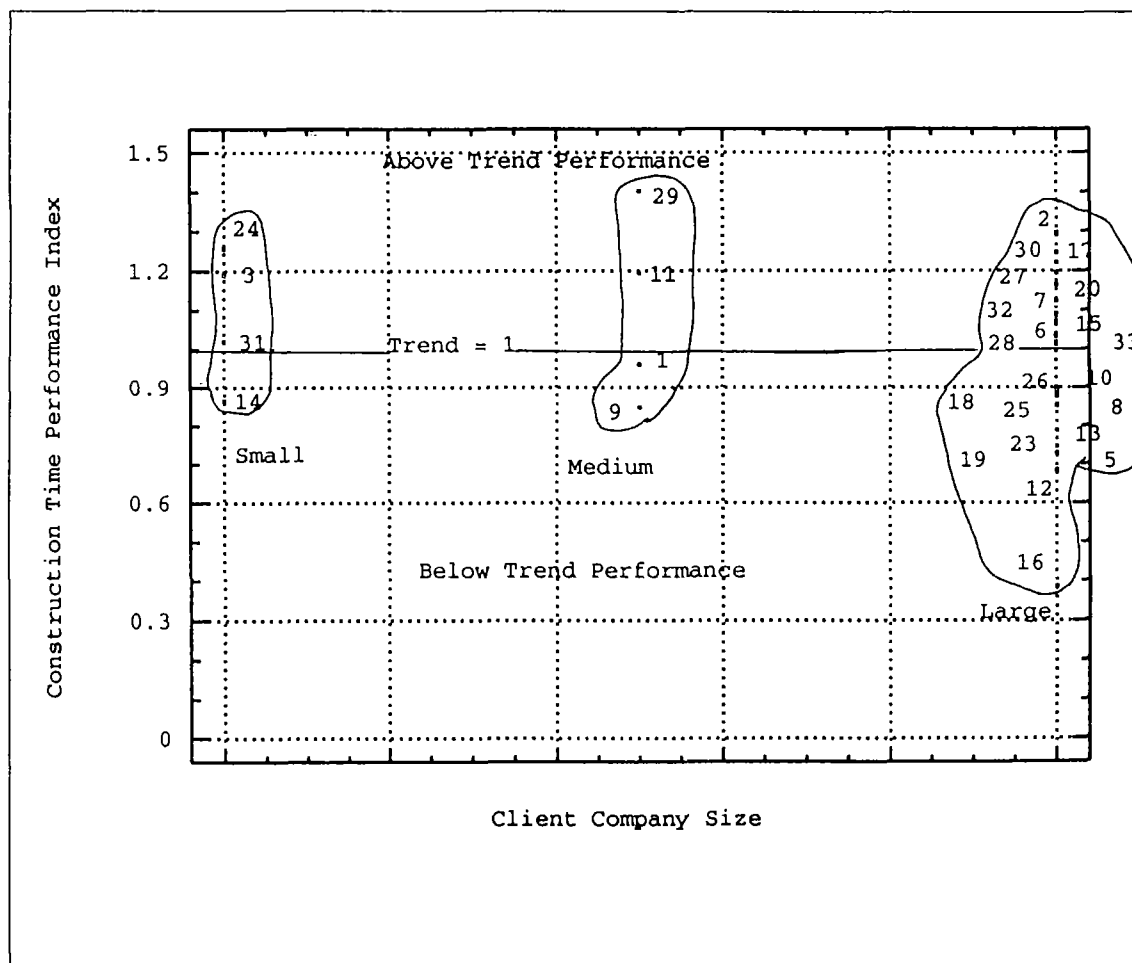
$H_0$  Construction time performance is **NOT** dependent upon client company size.

$H_1$  Construction time performance **IS** dependent upon client company size.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of *less than* 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
1.160	0.3275	<b><math>H_0</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 12**

**DATA ITEM: CLIENT COMPANY SIZE (CATEGORISED INTO 3 GROUPS)**

[1] small, [2] medium, [3] large.

**Spearman Rank Correlation results for factors affecting CTP:**

☐ no significant correlation.

**Spearman Rank Correlation results for factors NOT affecting CTP:**

☐ type of building end-use ( $C_s = -0.4915$ ; sig. = 0.0062);

☐ *client representation form* ( $C_s = 0.5163$ ; sig. = 0.0040).

## SUB-HYPOTHESIS NUMBER 13

## QUESTIONNAIRE NUMBER Q2.3.1

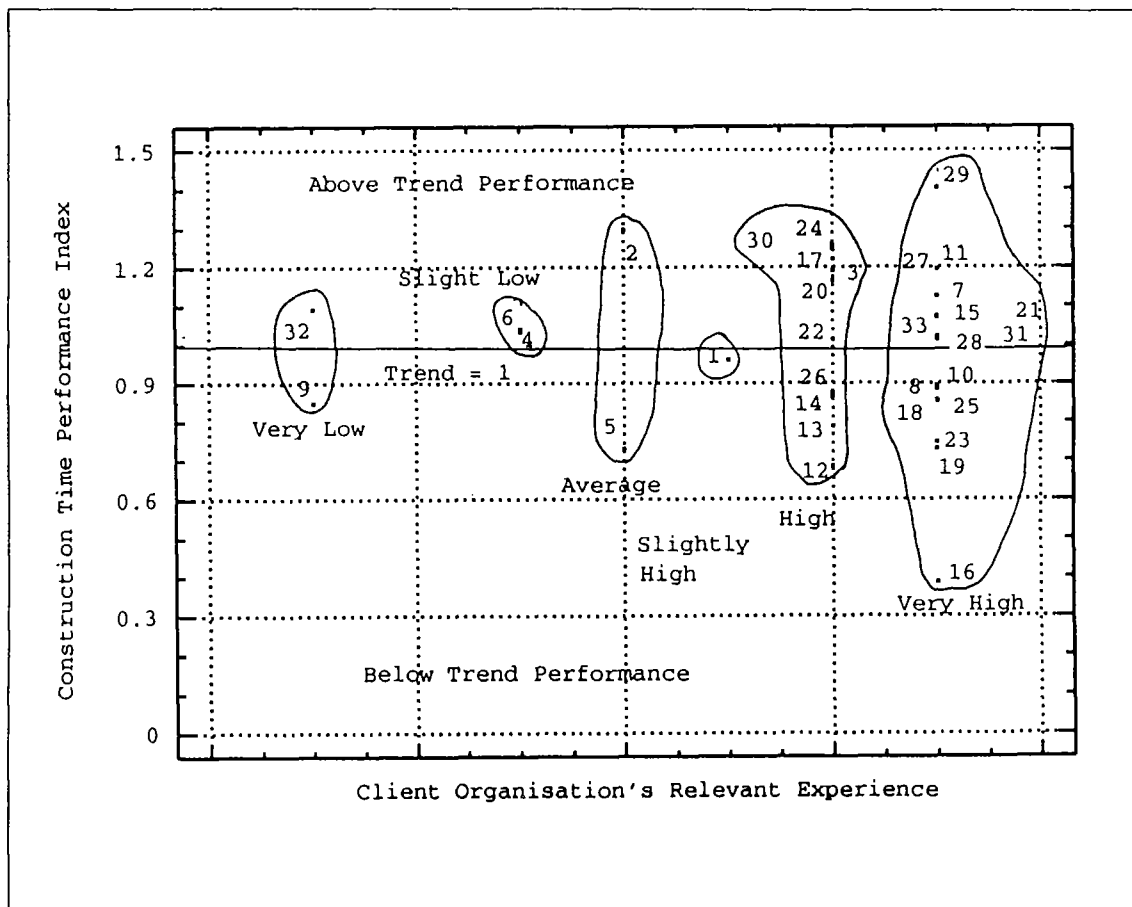
$H_0$  Construction time performance is **NOT** dependent upon client organisation's relevant experience.

$H_1$  Construction time performance **IS** dependent upon client organisation's relevant experience.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.124	0.9858	<b><math>H_0</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 13**

**DATA ITEM: CLIENT ORGANISATION'S EXPERIENCE**

**Spearman Rank Correlation results for factors affecting CTP:**

☐ no significant correlation.

**Spearman Rank Correlation results for factors NOT affecting CTP:**

☐ *design team's effective use of information technologies ( $C_s = 0.5011$ ; sig. = 0.0217).*



## SUB-HYPOTHESIS NUMBER 14

## QUESTIONNAIRE NUMBER Q2.3.2

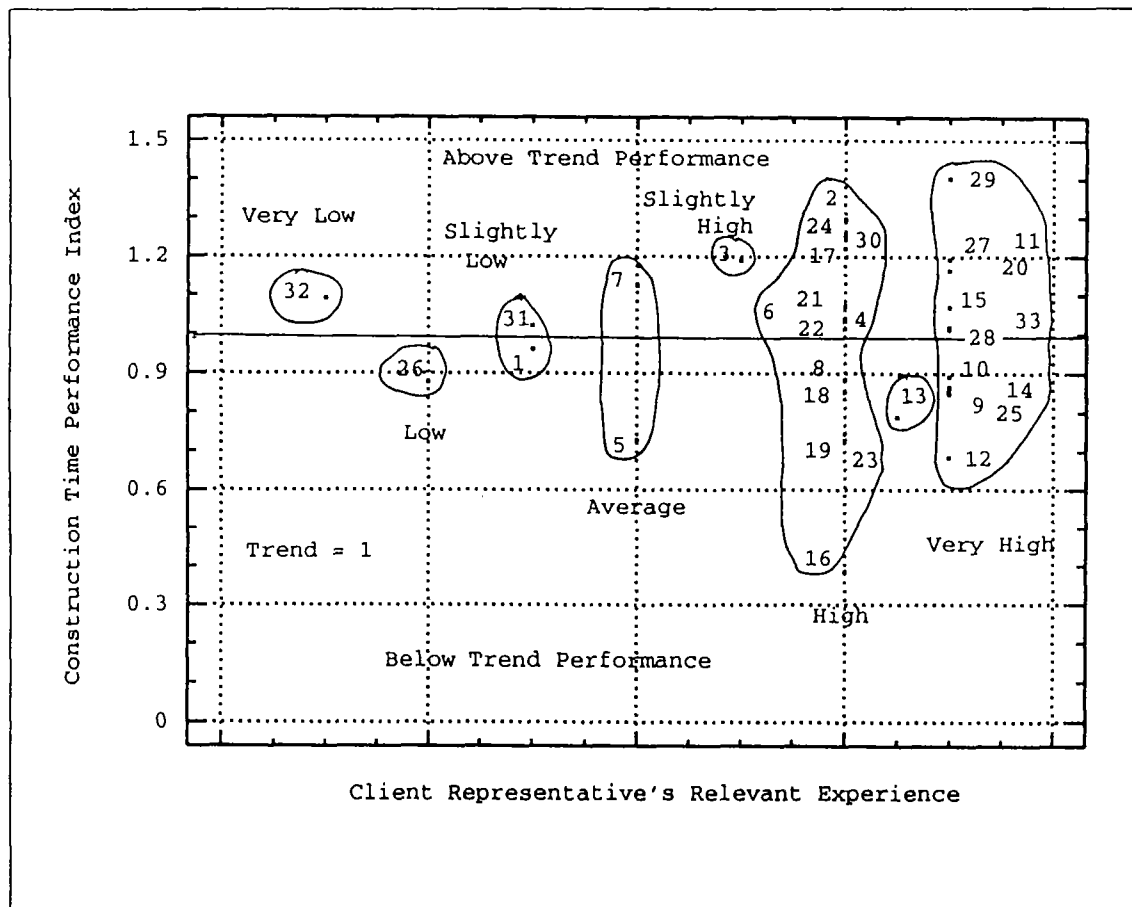
$H_0$  Construction time performance is NOT dependent upon client representative's relevant experience.

$H_1$  Construction time performance IS dependent upon client representative's relevant experience.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.324	0.9356	<b><math>H_0</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



### SUB-HYPOTHESIS NUMBER 14

#### DATA ITEM: CLIENT REPRESENTATIVE'S (CR'S) EXPERIENCE

##### **Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *ability of the CR to contribute ideas to the construction process ( $C_s = 0.5048$ ; sig. = 0.0043);*
- ☐ *the construction team's confidence in the CR's contribution ( $C_s = 0.4915$ ; sig. = 0.0054);*
- ☐ *economic environmental complexity ( $C_s = 0.5170$ ; sig. = 0.0035);*
- ☐ *CM's analysing construction methods ( $C_s = 0.4947$ ; sig. = 0.0051);*
- ☐ *CM's organisational structure to manage risk ( $C_s = 0.4475$ ; sig. = 0.0114);*
- ☐ *key sub-contractor's task-oriented management style ( $C_s = 0.4704$ ; sig. = 0.0078);*
- ☐ *CR and CM team communication effectiveness for decision making ( $C_s = 0.5098$ ; sig. = 0.0052);*
- ☐ *decision making communication within the CM team ( $C_s = 0.6224$ ; sig. = 0.0004);*
- ☐ *effectiveness of the CM team in managing the construction process sig. = 0.4948; sig. = 0.0051).*

##### **Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *client organisation's confidence in the CR ( $C_s = 0.5874$ ; sig. = 0.0011);*
- ☐ *stability of client/CR objectives ( $C_s = 0.5848$ ; sig. = 0.0009);*
- ☐ *CR's understanding the project's constraints ( $C_s = 0.5694$ ; sig. = 0.0013);*
- ☐ *CR's ability to quickly make authoritative decisions ( $C_s = 0.4783$ ; sig. = 0.0068);*
- ☐ *CR's ability to effectively brief the design team ( $C_s = 0.5217$ ; sig. = 0.0043);*
- ☐ *socio-political environmental complexity ( $C_s = 0.5723$ ; sig. = 0.0012);*
- ☐ *impact of general environmental factors ( $C_s = 0.4575$ ; sig. = 0.0097);*
- ☐ *analysing work sequencing to achieve and maintain workflow ( $C_s = 0.5139$ ; sig. = 0.0036);*
- ☐ *CR's organisational structure to manage risk ( $C_s = 0.4691$ ; sig. = 0.0080);*
- ☐ *task-orientation of the CR's management style ( $C_s = 0.5248$ ; sig. = 0.0035);*
- ☐ *flexibility of the CM's management style ( $C_s = 0.4833$ ; sig. = 0.0063);*
- ☐ *decision making communication within the CR team ( $C_s = 0.4587$ ; sig. = 0.0152);*
- ☐ *decision making communication within the design team ( $C_s = 0.4472$ ; sig. = 0.0160);*
- ☐ *CR decision making, communicating and actioning ( $C_s = 0.4989$ ; sig. = 0.0048);*
- ☐ *CR's effective use of information technologies ( $C_s = 0.5950$ ; sig. = 0.0173).*

## SUB-HYPOTHESIS NUMBER 15

## QUESTIONNAIRE NUMBER Q2.3.3

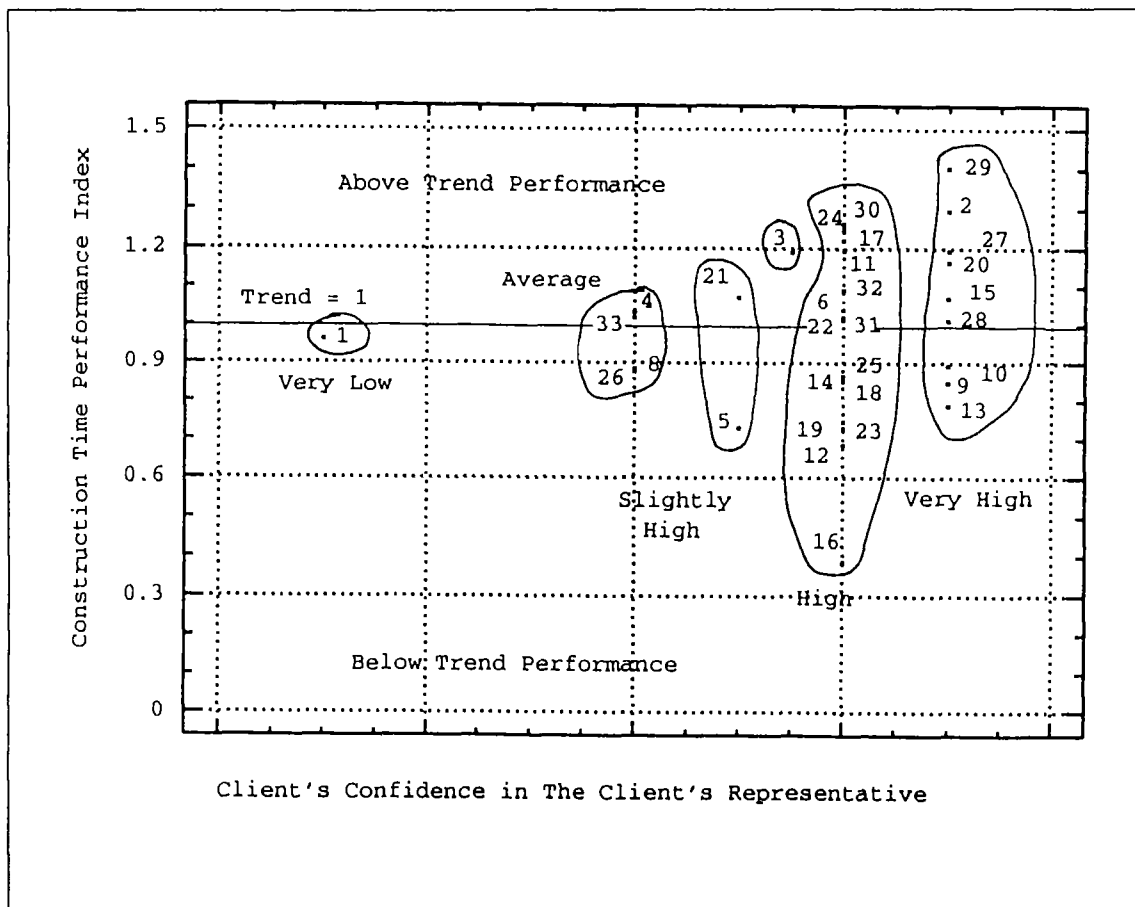
$H_0$  Construction time performance is NOT dependent upon the client's confidence in the client representative.

$H_1$  Construction time performance IS dependent upon the client's confidence in the client representative.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.623	0.6838	$H_0$ ACCEPTED

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 15**  
**DATA ITEM: CLIENT CONFIDENCE IN THE CR**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *ability of the CR to contribute ideas to the construction process ( $C_s = 0.5368$ ; sig. = 0.0028);*
- ☐ *the project design team's confidence in the CR contribution ( $C_s = 0.4761$ ; sig. = 0.0104);*
- ☐ *the construction team's confidence in the CR's contribution ( $C_s = 0.5349$ ; sig. = 0.0029);*
- ☐ *impact of CR/CM working relationship ( $C_s = 0.4882$ ; sig. = 0.0066);*
- ☐ *effectiveness of the construction team's planning ( $C_s = 0.4445$ ; sig. = 0.0133);*
- ☐ *effectiveness of the construction team's monitoring and control ( $C_s = 0.4561$ ; sig. = 0.0111);*
- ☐ *CR and design team communication effectiveness for decision making ( $C_s = 0.4601$ ; sig. = 0.0132);*
- ☐ *decision making communication within the CM team ( $C_s = 0.5502$ ; sig. = 0.0022).*

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *CR's experience with the building procurement process ( $C_s = 0.5874$ ; sig. = 0.0011);*
- ☐ *stability of client/CR objectives ( $C_s = 0.5460$ ; sig. = 0.0024);*
- ☐ *complexity from the CR's influence upon the project's management ( $C_s = 0.4751$ ; sig. = 0.0082);*
- ☐ *the CR understanding the project's constraints ( $C_s = 0.4791$ ; sig. = 0.0076);*
- ☐ *CR's ability to quickly make authoritative decisions ( $C_s = 0.5660$ ; sig. = 0.0016);*
- ☐ *CR's ability to effectively brief the design team ( $C_s = 0.5720$ ; sig. = 0.0021);*
- ☐ *stability of CR decisions ( $C_s = 0.5360$ ; sig. = 0.0028);*
- ☐ *the overall CR contribution to project team harmony ( $C_s = 0.4853$ ; sig. = 0.0069);*
- ☐ *design buildability complexity ( $C_s = 0.4576$ ; sig. = 0.0108);*
- ☐ *design coordination complexity ( $C_s = 0.4630$ ; sig. = 0.0099);*
- ☐ *CM's effectiveness in influencing the CR decision making process ( $C_s = 0.5280$ ; sig. = 0.0033);*
- ☐ *design team's organisational structure to manage risk ( $C_s = 0.4982$ ; sig. = 0.0055);*
- ☐ *CR's organisational structure to manage risk ( $C_s = 0.5822$ ; sig. = 0.0012);*
- ☐ *task-orientation of the CR's management style ( $C_s = 0.4920$ ; sig. = 0.0070);*
- ☐ *decision making communication within the CR team ( $C_s = 0.6562$ ; sig. = 0.0007);*
- ☐ *CR's effective use of information technologies ( $C_s = 0.4876$ ; sig. = 0.0590).*

## SUB-HYPOTHESIS NUMBER 16

## QUESTIONNAIRE NUMBER Q2.4.1

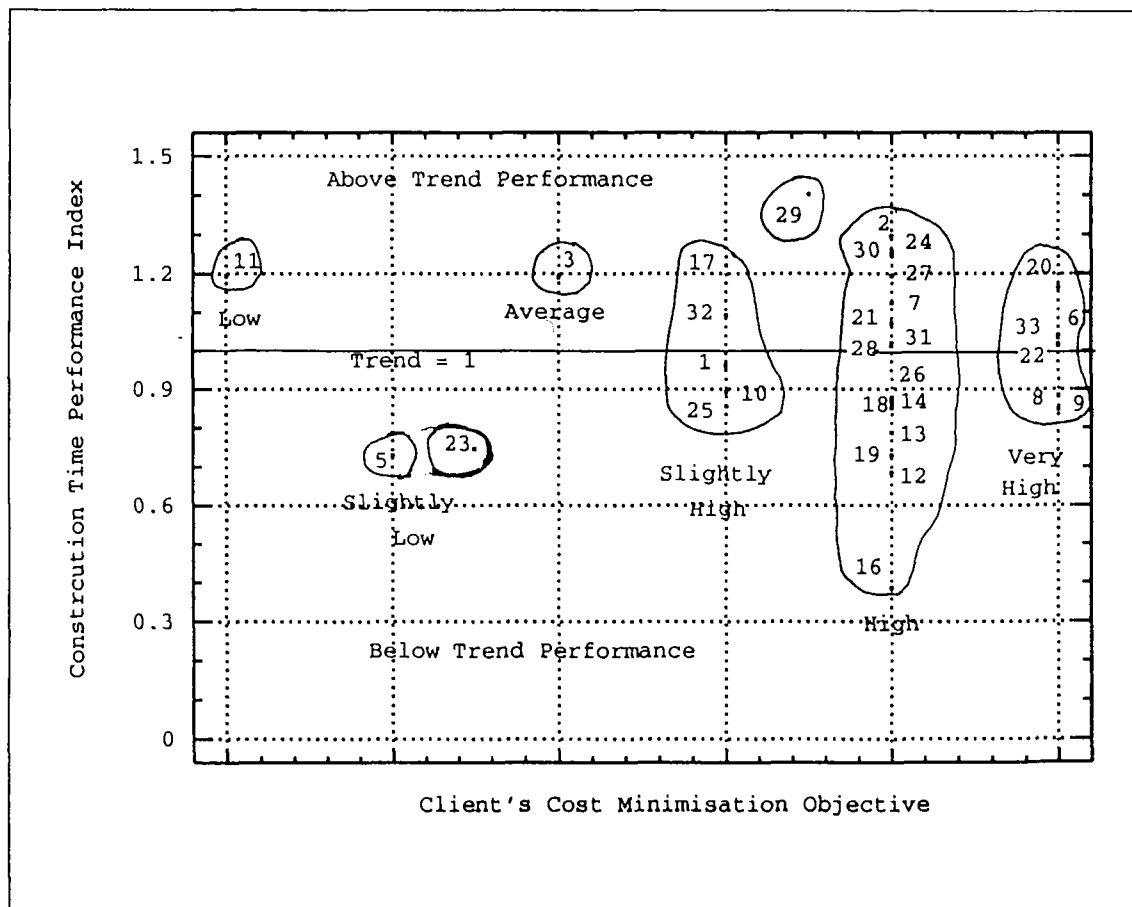
$H_0$  Construction time performance is NOT dependent upon the client's construction cost minimisation objective.

$H_1$  Construction time performance IS dependent upon the client's construction cost minimisation objective.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of *less than* 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
1.300	0.2907	$H_0$ ACCEPTED

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 16**

**DATA ITEM: CLIENT'S COST MINIMISATION OBJECTIVE**

**Spearman Rank Correlation results for factors affecting CTP:**

☐ no significant correlation.

**Spearman Rank Correlation results for factors NOT affecting CTP:**

☐ no significant correlation.

## SUB-HYPOTHESIS NUMBER 17

## QUESTIONNAIRE NUMBER Q2.4.2

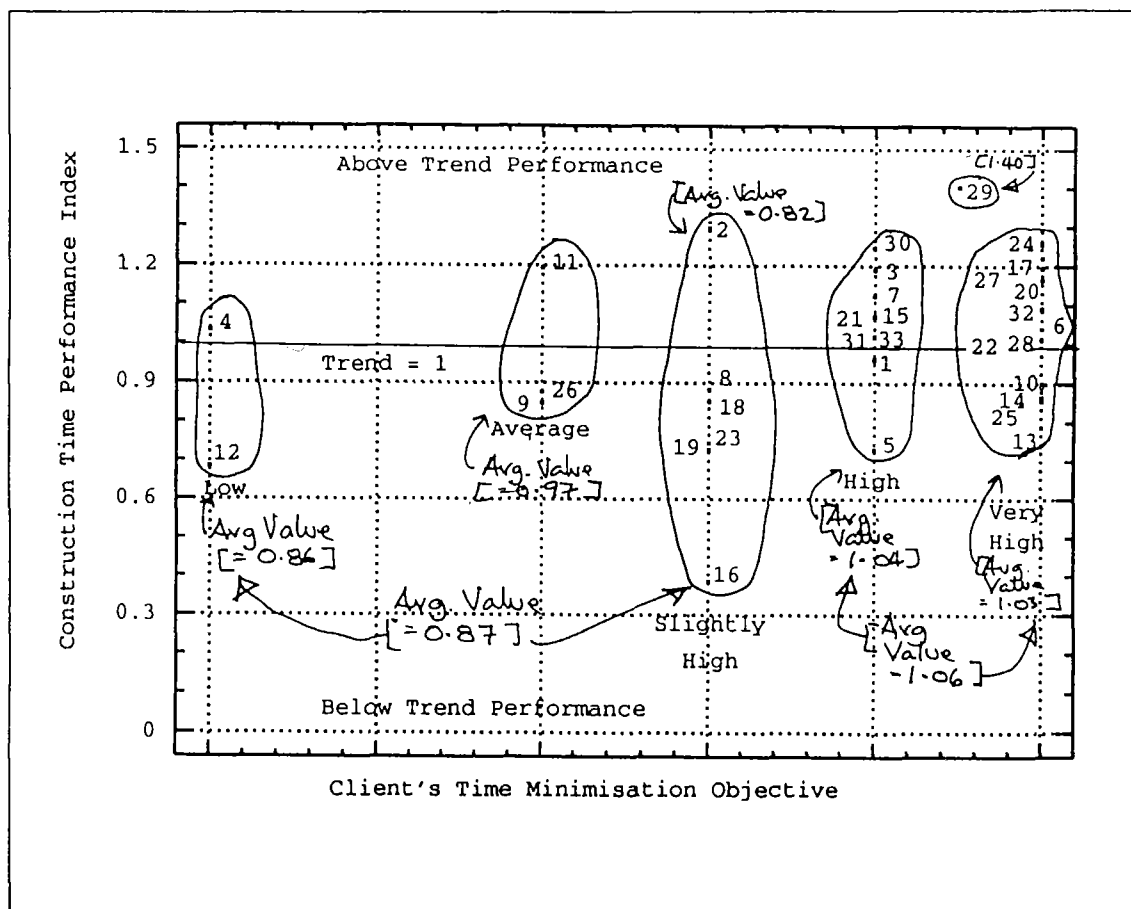
$H_0$  Construction time performance is **NOT** dependent upon the client's high level of construction time minimisation objective.

$H_1$  Construction time performance **IS** dependent upon the client's high level of construction time minimisation objective.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
6.851	0.0136	<b><math>H_0</math> REJECTED: <math>H_1</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 17**

**DATA ITEM: CLIENT'S TIME MINIMISATION OBJECTIVE**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *impact of CR/CM working relationship ( $C_s = 0.5537$ ; sig. = 0.0017);*
- ☐ *CM's forecasting planning data ( $C_s = 0.4835$ ; sig. = 0.0071);*
- ☐ *effectiveness of the construction team's planning ( $C_s = 0.4710$ ; sig. = 0.0077);*
- ☐ *CM's planning - responding to problems or opportunities ( $C_s = 0.6042$ ; sig. = 0.0006);*
- ☐ *effectively coordinating resources ( $C_s = 0.4716$ ; sig. = 0.0076);*
- ☐ *effectiveness of the construction team's monitoring and control ( $C_s = 0.4981$ ; sig. = 0.0048);*
- ☐ *CM's communication management to facilitate decision making ( $C_s = 0.5592$ ; sig. = 0.0016);*
- ☐ *CR and CM team communication effectiveness for decision making ( $C_s = 0.4568$ ; sig. = 0.0098);*
- ☐ *CM decision making, communicating and actioning ( $C_s = 0.4959$ ; sig. = 0.0050).*

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *clarity of communication of client/CR objectives ( $C_s = 0.4736$ ; sig. = 0.0074);*
- ☐ *complexity from the CR's influence upon the project's management ( $C_s = 0.5003$ ; sig. = 0.0047);*
- ☐ *the overall CR contribution to project team harmony ( $C_s = 0.4497$ ; sig. = 0.0110);*
- ☐ *CM's effectiveness in influencing the CR decision making process ( $C_s = 0.5522$ ; sig. = 0.0018);*
- ☐ *CM management systems and procedures ( $C_s = 0.4748$ ; sig. = 0.0072);*
- ☐ *forecasting planning data ( $C_s = 0.4835$ ; sig. = 0.0071);*
- ☐ *CM's analysing resource movement ( $C_s = 0.5693$ ; sig. = 0.0015);*
- ☐ *CM's analysing work sequencing to achieve and maintain workflow ( $C_s = 0.5098$ ; sig. = 0.0040);*
- ☐ *CR's organisational structure to manage risk ( $C_s = 0.5338$ ; sig. = 0.0025);*
- ☐ *decision making communication within the CR team ( $C_s = 0.4621$ ; sig. = 0.0145).*



H<sub>1</sub> Construction time performance IS dependent upon client construction quality objective.

F-Ratio	Significance Level	Interpretation
3.717	0.0151	<b>H<sub>0</sub> REJECTED: H<sub>1</sub> ACCEPTED</b>

**SUB-HYPOTHESIS NUMBER 18**

**DATA ITEM: CLIENT'S QUALITY STANDARDS OBJECTIVE**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *CM's forecasting planning data ( $C_s = 0.6029$ ; sig. = 0.0008);*
- ☐ *CM's analysing construction methods ( $C_s = 0.4641$ ; sig. = 0.0087);*
- ☐ *effectiveness of the construction team's planning ( $C_s = 0.4820$ ; sig. = 0.0064);*
- ☐ *CM's monitoring and updating plans to reflect work status ( $C_s = 0.5279$ ; sig. = 0.0028);*
- ☐ *effectiveness of the CM team in managing the construction process ( $C_s = 0.6020$ ; sig. = 0.0007).*

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *stability of client/CR objectives ( $C_s = 0.4780$ ; sig. = 0.0068);*
- ☐ *CM's analysing work sequencing to achieve and maintain workflow ( $C_s = 0.5134$ ; sig. = 0.0037).*

## SUB-HYPOTHESIS NUMBER 19

## QUESTIONNAIRE NUMBER Q2.4.4

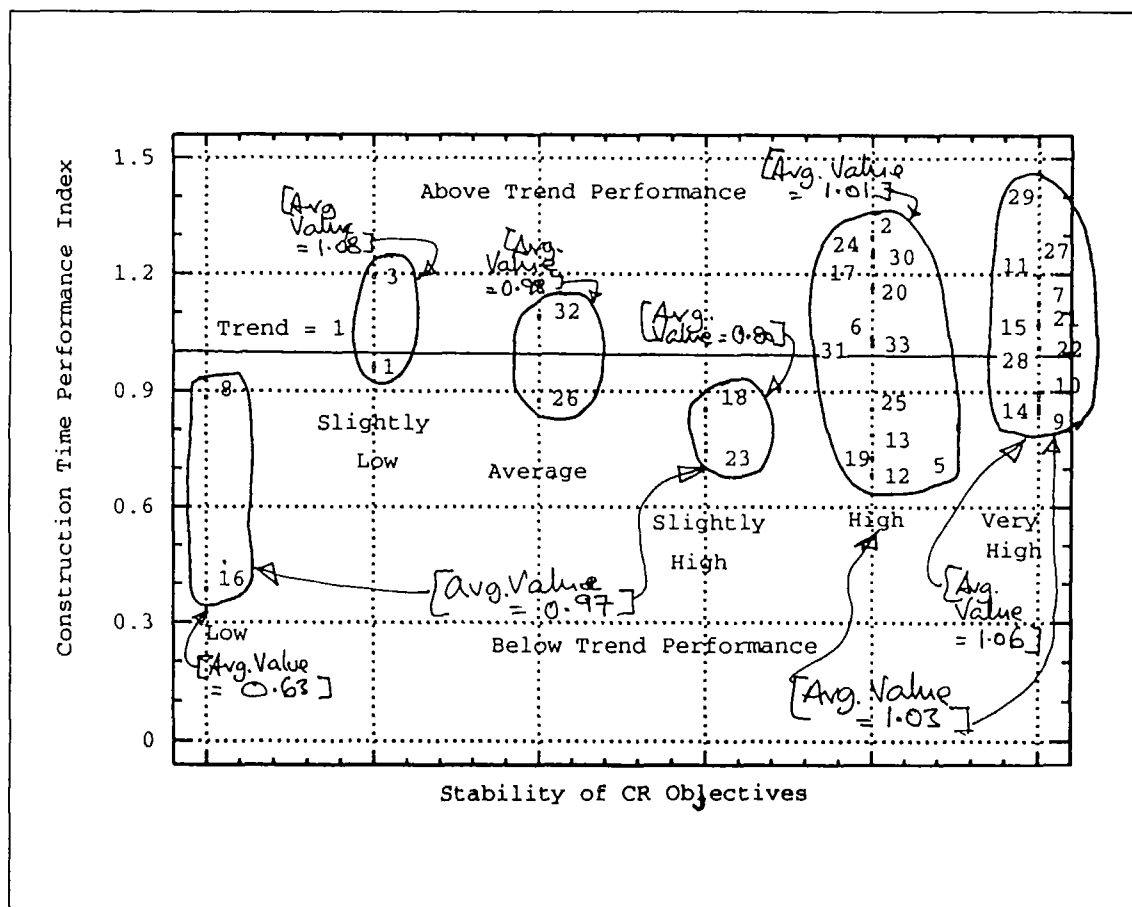
$H_0$  Construction time performance is **NOT** dependent upon stability of client's objectives.

$H_1$  Construction time performance **IS** dependent upon stability of client's objectives.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
2.050	0.1033	$H_0$ ACCEPTED

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 19**

**DATA ITEM: STABILITY OF CLIENT/CR OBJECTIVES**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ client/CR's quality performance objective ( $C_s = 0.4780$ ; sig. = 0.0068);
- ☐ ability of the CR to contribute ideas to the construction process ( $C_s = 0.5006$ ; sig. = 0.0046);
- ☐ the construction team's confidence in the CR's contribution ( $C_s = 0.5912$ ; sig. = 0.0008);
- ☐ impact of CR/CM working relationship ( $C_s = 0.5141$ ; sig. = 0.0036);
- ☐ CM's forecasting planning data ( $C_s = 0.5054$ ; sig. = 0.0049);
- ☐ CM's analysing construction methods ( $C_s = 0.4786$ ; sig. = 0.0068);
- ☐ effectiveness of the construction team's planning ( $C_s = 0.5179$ ; sig. = 0.0034);
- ☐ CM's effectively coordinating resources ( $C_s = 0.5037$ ; sig. = 0.0044);
- ☐ CM's developing an organisational structure to maintain workflow ( $C_s = 0.6456$ ; sig. = 0.0003);
- ☐ effectiveness of the construction team's monitoring and control ( $C_s = 0.6058$ ; sig. = 0.0006);
- ☐ CM's organisational structure to manage risk ( $C_s = 0.6308$ ; sig. = 0.0004);
- ☐ key sub-contractor's task-oriented management style ( $C_s = 0.5367$ ; sig. = 0.0024);
- ☐ decision making communication within the CM team ( $C_s = 0.5312$ ; sig. = 0.0027);
- ☐ CM decision making, communicating and actioning ( $C_s = 0.5193$ ; sig. = 0.0033);
- ☐ effectiveness of the CM team in managing the construction process ( $C_s = 0.6808$ ; sig. = 0.0001).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ CR's experience with the building procurement process ( $C_s = 0.5848$ ; sig. = 0.0009);
- ☐ client organisation's confidence in the CR ( $C_s = 0.5460$ ; sig. = 0.0024);
- ☐ clarity of communication of client/CR objectives ( $C_s = 0.6202$ ; sig. = 0.0005);
- ☐ complexity from the CR's influence upon the project's management ( $C_s = 0.5313$ ; sig. = 0.0027);
- ☐ CR's ability to quickly make authoritative decisions ( $C_s = 0.5425$ ; sig. = 0.0021);
- ☐ CM management systems and procedures ( $C_s = 0.6221$ ; sig. = 0.0004);
- ☐ CM's analysing work sequencing to achieve and maintain workflow ( $C_s = 0.4458$ ; sig. = 0.0117);
- ☐ CR's organisational structure to manage risk ( $C_s = 0.5811$ ; sig. = 0.0010);
- ☐ CM's effectiveness in team management to achieve synergy ( $C_s = 0.5537$ ; sig. = 0.0017);
- ☐ flexibility of the CR's management style ( $C_s = 0.4667$ ; sig. = 0.0083);
- ☐ task-orientation of the CR's management style ( $C_s = 0.4908$ ; sig. = 0.0063);
- ☐ flexibility of the CM's management style ( $C_s = 0.6004$ ; sig. = 0.0007);
- ☐ CM's people-oriented management style ( $C_s = 0.5860$ ; sig. = 0.0009);
- ☐ key sub-contractor's people-oriented management style ( $C_s = 0.5493$ ; sig. = 0.0019);
- ☐ direct use of power in key sub-contractor's management style ( $C_s = -0.4906$ ; sig. = 0.0055);
- ☐ decision making communication within the CR team ( $C_s = 0.4509$ ; sig. = 0.0170);
- ☐ CR decision making, communicating and actioning ( $C_s = 0.6008$ ; sig. = 0.0007);
- ☐ CR's effective use of information technologies ( $C_s = 0.4689$ ; sig. = 0.0609).

## SUB-HYPOTHESIS NUMBER 20

## QUESTIONNAIRE NUMBER Q2.4.5

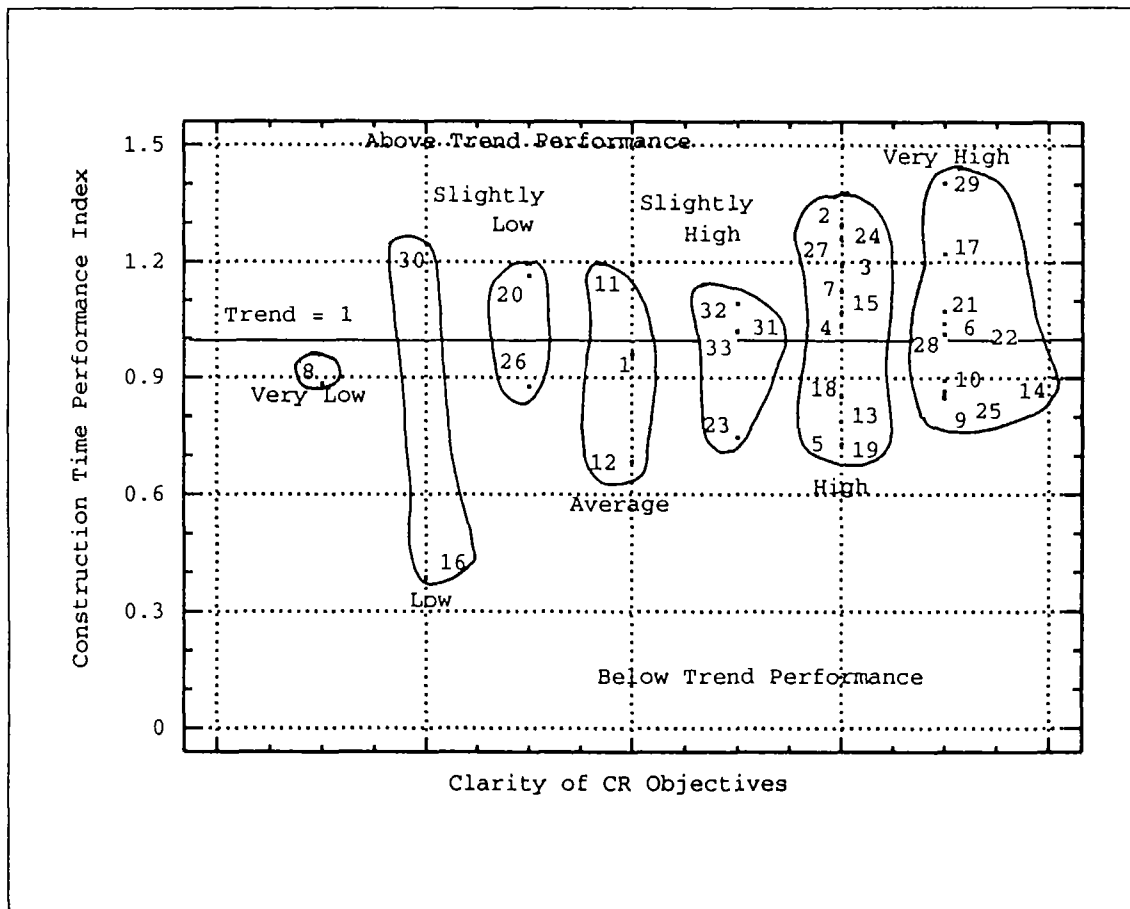
$H_0$  Construction time performance is **NOT** dependent upon clarity of client's objectives.

$H_1$  Construction time performance **IS** dependent upon clarity of client's objectives.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.331	0.9145	$H_0$ ACCEPTED

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 20**

**DATA ITEM: CLARITY OF COMMUNICATION OF CLIENT/CR OBJECTIVES**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ client/CR's time minimisation objective ( $C_s = 0.4736$ ; sig. = 0.0074);
- ☐ *ability of the CR to contribute ideas to the design process* ( $C_s = 0.5579$ ; sig. = 0.0019);
- ☐ the project design team's confidence in the CR contribution ( $C_s = 0.4849$ ; sig. = 0.0079);
- ☐ **the construction team's confidence in the CR's contribution** ( $C_s = 0.7690$ ; sig. = 0.0000);
- ☐ *CR's willingness to contribute effective and positive ideas* ( $C_s = 0.5994$ ; sig. = 0.0007);
- ☐ *impact of CR/CM working relationship* ( $C_s = 0.6395$ ; sig. = 0.0003);
- ☐ *CM's forecasting planning data* ( $C_s = 0.5656$ ; sig. = 0.0016);
- ☐ *CM's analysing construction methods* ( $C_s = 0.4555$ ; sig. = 0.0100);
- ☐ effectiveness of the construction team's planning ( $C_s = 0.4678$ ; sig. = 0.0081);
- ☐ *CM's effectively coordinating resources* ( $C_s = 0.5187$ ; sig. = 0.0033);
- ☐ *CM's developing an organisational structure to maintain workflow* ( $C_s = 0.5702$ ; sig. = 0.0013);
- ☐ *effectiveness of the construction team's monitoring and control* ( $C_s = 0.5509$ ; sig. = 0.0018);
- ☐ *CM's organisational structure to manage risk* ( $C_s = 0.6130$ ; sig. = 0.0005);
- ☐ *CM communication management to facilitate decision making* ( $C_s = 0.5273$ ; sig. = 0.0029);
- ☐ *CR and CM team communication effectiveness for decision making* ( $C_s = 0.4986$ ; sig. = 0.0048);
- ☐ *CM decision making, communicating and actioning* ( $C_s = 0.5344$ ; sig. = 0.0025);
- ☐ effectiveness of the CM team in managing the construction process ( $C_s = 0.4866$ ; sig. = 0.0059).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ total construction period ( $C_s = 0.4828$ ; sig. = 0.0063);
- ☐ *stability of client/CR objectives* ( $C_s = 0.6202$ ; sig. = 0.0005);
- ☐ **complexity from the CR's influence upon the project's management** ( $C_s = 0.7742$ ; sig. = 0.0000);
- ☐ *CR's ability to quickly make authoritative decisions* ( $C_s = 0.6588$ ; sig. = 0.0002);
- ☐ *CR's ability to effectively brief the design team* ( $C_s = 0.5218$ ; sig. = 0.0043);
- ☐ *stability of CR decisions* ( $C_s = 0.6457$ ; sig. = 0.0003);
- ☐ *the CR's ability to mould shared project goals and aspirations* ( $C_s = 0.6640$ ; sig. = 0.0002);
- ☐ *the CR's willingness to accept effective and positive ideas* ( $C_s = 0.6341$ ; sig. = 0.0003);
- ☐ *the overall CR contribution to project team harmony* ( $C_s = 0.5577$ ; sig. = 0.0016);
- ☐ *CM's effectiveness in influencing the CR decision making process* ( $C_s = 0.5591$ ; sig. = 0.0016);
- ☐ *CM management systems and procedures* ( $C_s = 0.6218$ ; sig. = 0.0004);
- ☐ *CR's organisational structure to manage risk* ( $C_s = 0.6924$ ; sig. = 0.0001);
- ☐ key sub-contractor's organisational structure to manage risk ( $C_s = 0.4712$ ; sig. = 0.0087);
- ☐ *CM's effectiveness in team management to achieve synergy* ( $C_s = 0.4466$ ; sig. = 0.0115);
- ☐ **flexibility of the CR's management style** ( $C_s = 0.7326$ ; sig. = 0.0000);
- ☐ *CR's people-oriented management style* ( $C_s = 0.4524$ ; sig. = 0.0118);
- ☐ direct use of power in the CR's management style ( $C_s = -0.4639$ ; sig. = 0.0098);
- ☐ *flexibility of design team's management style* ( $C_s = 0.5075$ ; sig. = 0.0047);
- ☐ flexibility of the CM's management style ( $C_s = 0.4554$ ; sig. = 0.0100);
- ☐ *CR decision making, communicating and actioning* ( $C_s = 0.6296$ ; sig. = 0.0004).

## SUB-HYPOTHESIS NUMBER 21

## QUESTIONNAIRE NUMBER Q2.4.6

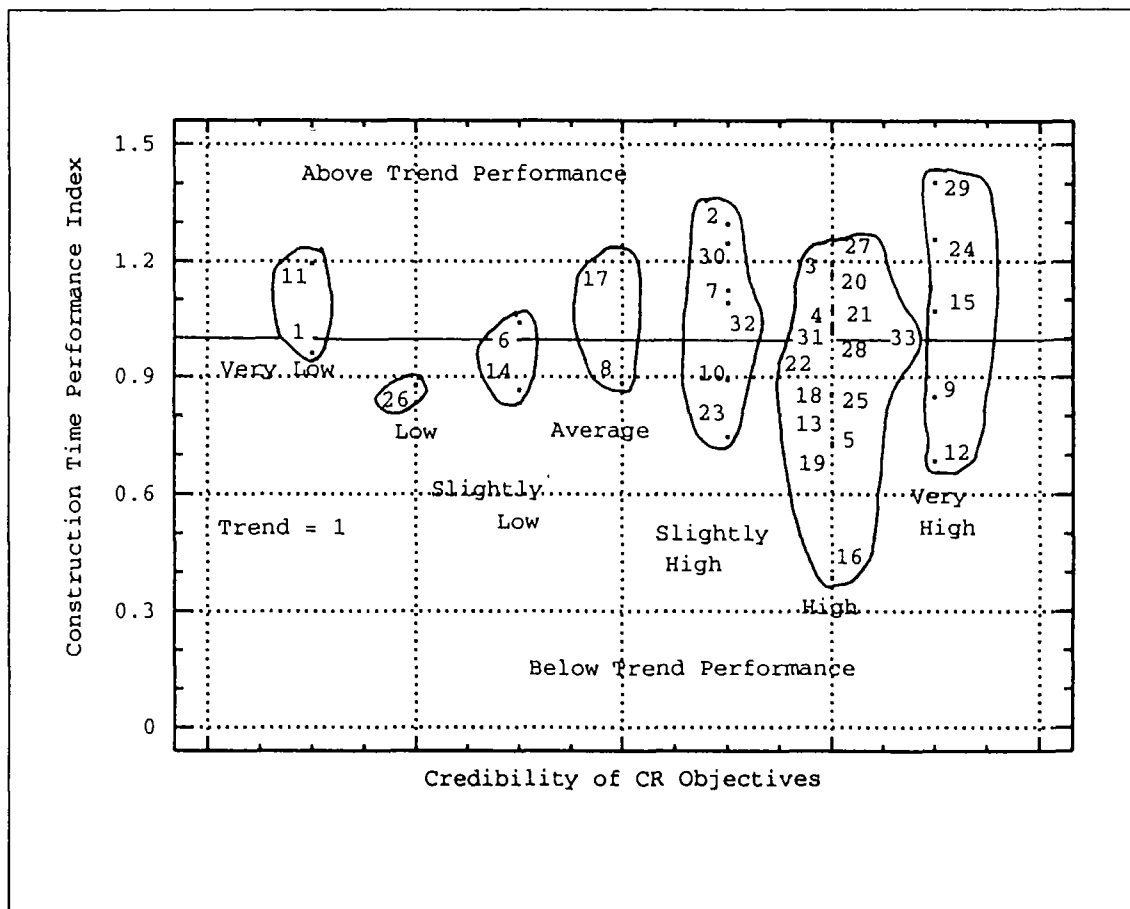
$H_0$  Construction time performance is **NOT** dependent upon credibility of client's objectives.

$H_1$  Construction time performance **IS** dependent upon credibility of client's objectives.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of *less than* 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.442	0.8440	<b><math>H_0</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 21**

**DATA ITEM: CREDIBILITY OF ACHIEVING GOALS ESTABLISHED BY THE CR/CLIENT**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *CR and design team communication effectiveness for decision making ( $C_s = 0.5289$ ; sig. = 0.0038).*

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *CR's confidence in the project design team ( $C_s = 0.4795$ ; sig. = 0.0076);*
- ☐ *the CR's willingness to accept effective and positive ideas ( $C_s = 0.5317$ ; sig. = 0.0026);*
- ☐ *the CR's ability to mould shared project goals and aspirations ( $C_s = 0.4571$ ; sig. = 0.0109);*
- ☐ *flexibility of design team's management style ( $C_s = 0.5338$ ; sig. = 0.0030);*
- ☐ *design team's people-oriented management style ( $C_s = 0.5031$ ; sig. = 0.0089);*
- ☐ *direct use of power in the design team's management style ( $C_s = -0.5138$ ; sig. = 0.0118);*
- ☐ *task-orientation of the CM's management style ( $C_s = 0.4938$ ; sig. = 0.0052).*



## SUB-HYPOTHESIS NUMBER 22

## QUESTIONNAIRE NUMBER Q2.5.1

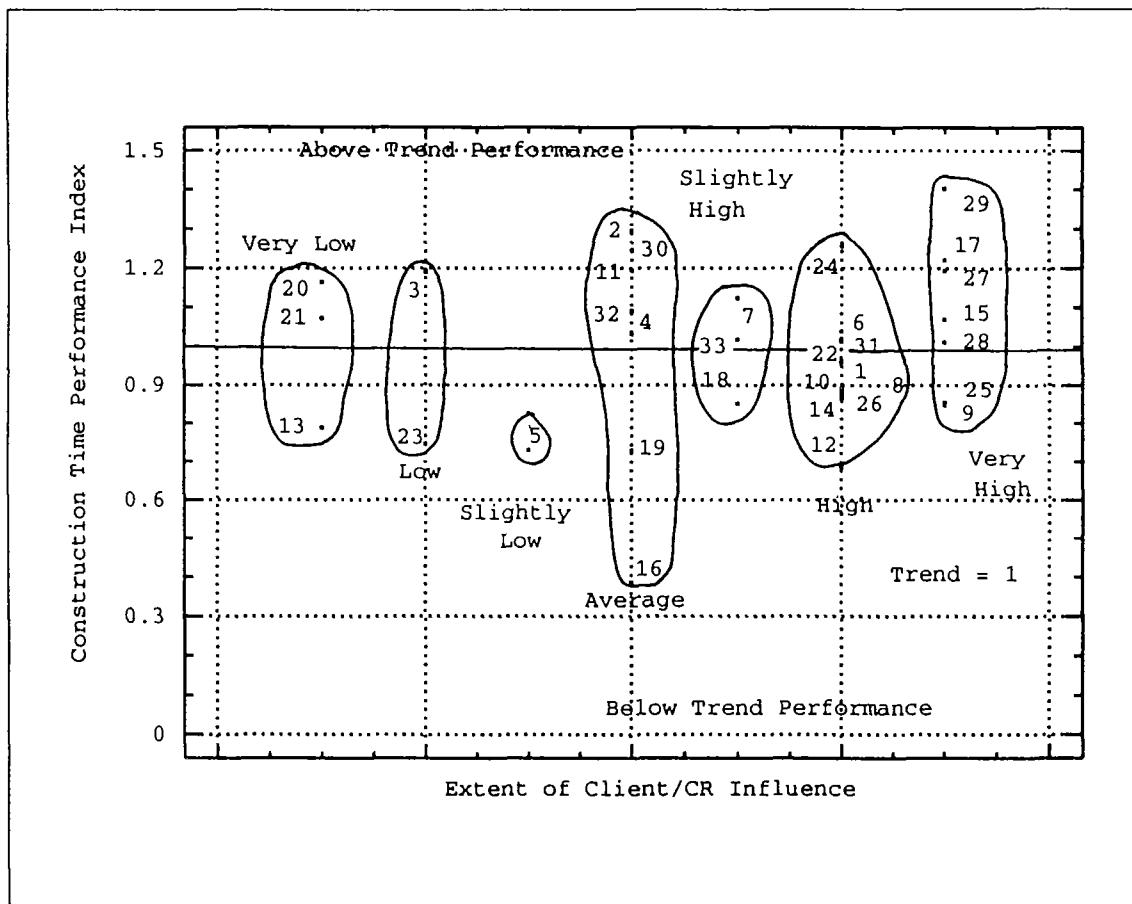
$H_0$  Construction time performance is **NOT** dependent upon the extent of CR influence upon the project's management.

$H_1$  Construction time performance **IS** dependent upon the extent of CR influence upon the project's management.

One-way ANOVA test results *measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.*

F-Ratio	Significance Level	Interpretation
0.503	0.8001	<b><math>H_0</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 22**

**DATA ITEM: THE EXTENT OF INFLUENCE EXERCISED ON CTP BY THE CR**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ ability of the CR to contribute ideas to the design process ( $C_s = 0.4556$ ; sig. = 0.0112);
- ☐ CR's willingness to contribute effective and positive ideas ( $C_s = 0.4509$ ; sig. = 0.0108);
- ☐ *CM's analysing construction methods* ( $C_s = 0.5358$ ; sig. = 0.0024);
- ☐ CM's effectively coordinating resources ( $C_s = 0.4800$ ; sig. = 0.0066);
- ☐ CM decision making, communicating and actioning ( $C_s = 0.4532$ ; sig. = 0.0104).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ CR's understanding the project's constraints ( $C_s = 0.4586$ ; sig. = 0.0095);
- ☐ *CR's ability to effectively brief the design team* ( $C_s = 0.5715$ ; sig. = 0.0017)
- ☐ CM's effectiveness in team management to achieve synergy ( $C_s = 0.4635$ ; sig. = 0.0087);
- ☐ *flexibility of the CR's management style* ( $C_s = 0.5044$ ; sig. = 0.0043);
- ☐ CR's people-oriented management style ( $C_s = 0.4535$ ; sig. = 0.0116);
- ☐ task-orientation of the CM's management style ( $C_s = 0.4683$ ; sig. = 0.0081);
- ☐ CR decision making, communicating and actioning ( $C_s = 0.4706$ ; sig. = 0.0078).

## SUB-HYPOTHESIS NUMBER 23

## QUESTIONNAIRE NUMBER Q2.5.2

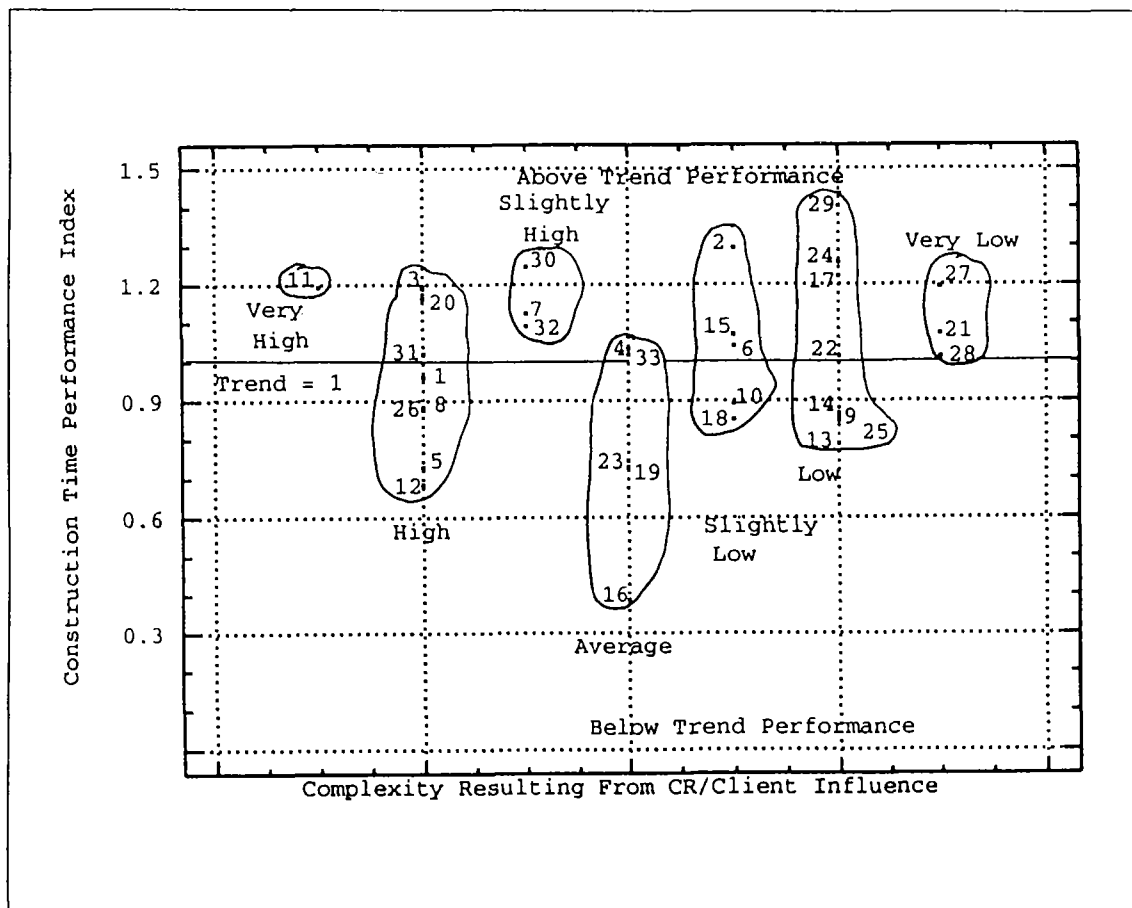
$H_0$  Construction time performance is **NOT** dependent upon complexity resulting from CR influence upon management of the project.

$H_1$  Construction time performance **IS** dependent upon complexity resulting from CR influence upon management of the project.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
1.705	0.1596	<b><math>H_0</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 23**

**DATA ITEM: COMPLEXITY OF CR'S INFLUENCE UPON THE PROJECT'S MANAGEMENT**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *client/CR's time minimisation objective* ( $C_s = 0.5003$ ; sig. = 0.0047);
- ☐ *ability of the CR to contribute ideas to the design process* ( $C_s = 0.4694$ ; sig. = 0.0090);
- ☐ *ability of the CR to contribute ideas to the construction process* ( $C_s = 0.4530$ ; sig. = 0.0104);
- ☐ *the project design team's confidence in the CR contribution* ( $C_s = 0.5965$ ; sig. = 0.0011);
- ☐ **the construction team's confidence in the CR's contribution** ( $C_s = 0.7068$ ; sig. = 0.0001);
- ☐ *impact of CR/CM working relationship* ( $C_s = 0.6018$ ; sig. = 0.0007);
- ☐ *CM's forecasting planning data* ( $C_s = 0.5086$ ; sig. = 0.0046);
- ☐ *CM's analysing construction methods* ( $C_s = 0.4645$ ; sig. = 0.0086);
- ☐ *effectiveness of the construction team's planning* ( $C_s = 0.4756$ ; sig. = 0.0071);
- ☐ *CM's developing an organisational structure to maintain workflow* ( $C_s = 0.5238$ ; sig. = 0.0030);
- ☐ *CM's organisational structure to manage risk* ( $C_s = 0.4917$ ; sig. = 0.0054);
- ☐ *CM's communication management to facilitate decision making* ( $C_s = 0.4479$ ; sig. = 0.0113);
- ☐ *CR and CM team communication effectiveness for decision making* ( $C_s = 0.4639$ ; sig. = 0.0087);
- ☐ *CM decision making, communicating and actioning* ( $C_s = 0.5293$ ; sig. = 0.0028).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *client organisation's confidence in the CR* ( $C_s = 0.4751$ ; sig. = 0.0082);
- ☐ *stability of client/CR objectives* ( $C_s = 0.5313$ ; sig. = 0.0027);
- ☐ **clarity of communication of client/CR objectives** ( $C_s = 0.7742$ ; sig. = 0.0027);
- ☐ *CR's understanding the project's constraints* ( $C_s = 0.5274$ ; sig. = 0.0029);
- ☐ **CR's ability to quickly make authoritative decisions** ( $C_s = 0.7202$ ; sig. = 0.0000)
- ☐ *CR's ability to effectively brief the design team* ( $C_s = 0.5858$ ; sig. = 0.0013);
- ☐ *stability of CR decisions* ( $C_s = 0.6887$ ; sig. = 0.0001);
- ☐ *the CR's confidence in the construction team* ( $C_s = 0.5208$ ; sig. = 0.0037);
- ☐ *the CR's willingness to accept effective and positive ideas* ( $C_s = 0.5514$ ; sig. = 0.0018);
- ☐ *the CR's ability to mould shared project goals and aspirations* ( $C_s = 0.6429$ ; sig. = 0.0003);
- ☐ *the overall CR contribution to project team harmony* ( $C_s = 0.6236$ ; sig. = 0.0004);
- ☐ *design buildability complexity* ( $C_s = 0.4481$ ; sig. = 0.0113);
- ☐ *CM's effectiveness in influencing the CR decision making process* ( $C_s = 0.5322$ ; sig. = 0.0026);
- ☐ *CM management systems and procedures* ( $C_s = 0.5340$ ; sig. = 0.0025);
- ☐ *CR's organisational structure to manage risk* ( $C_s = 0.6233$ ; sig. = 0.0004);
- ☐ *key sub-contractor's organisational structure to manage risk* ( $C_s = 0.4944$ ; sig. = 0.0059);
- ☐ *flexibility of the CR's management style* ( $C_s = 0.5483$ ; sig. = 0.0019);
- ☐ *CR's people-oriented management style* ( $C_s = 0.4712$ ; sig. = 0.0087);
- ☐ *direct use of power in the CR's management style*; sig. = -0.5389; sig. = 0.0027);
- ☐ *flexibility of design team's management style* ( $C_s = 0.5114$ ; sig. = 0.0044);
- ☐ *CR decision making, communicating and actioning* ( $C_s = 0.4987$ ; sig. = 0.0048).

## SUB-HYPOTHESIS NUMBER 24

## QUESTIONNAIRE NUMBER Q2.6.1

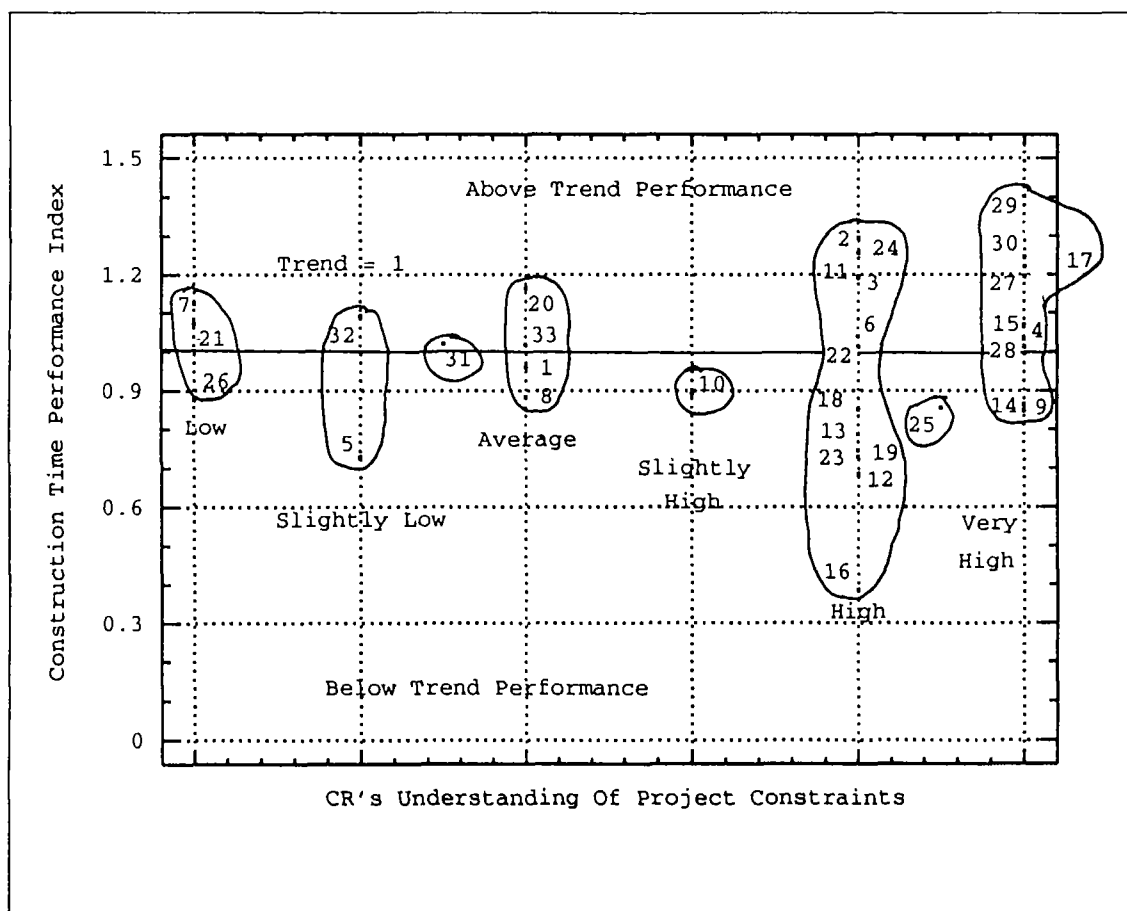
$H_0$  Construction time performance is NOT dependent upon the CR's understanding of the project's constraints.

$H_1$  Construction time performance IS dependent upon the CR's understanding of the project's constraints.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.550	0.7887	<b><math>H_0</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 24**

**DATA ITEM: CR'S UNDERSTANDING THE PROJECT'S CONSTRAINTS**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *ability of the CR to contribute ideas to the design process ( $C_s = 0.5831$ ; sig. = 0.0012);*
- ☐ *CR's willingness to contribute effective and positive ideas ( $C_s = 0.4604$ ; sig. = 0.0092);*
- ☐ ***ability of the CR to contribute ideas to the construction process ( $C_s = 0.7044$ ; sig. = 0.0001);***
- ☐ *the project design team's confidence in the CR contribution ( $C_s = 0.6628$ ; sig. = 0.0003);*
- ☐ *the construction team's confidence in the CR's contribution ( $C_s = 0.6135$ ; sig. = 0.0005);*
- ☐ *impact of CR/CM working relationship ( $C_s = 0.4580$ ; sig. = 0.0096);*
- ☐ *CM's organisational structure to manage risk ( $C_s = 0.4721$ ; sig. = 0.0076);*
- ☐ *CR and design team communication effectiveness for decision making ( $C_s = 0.5448$ ; sig. = 0.0028).*

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *CR's experience with the building procurement process ( $C_s = 0.5694$ ; sig. = 0.0013);*
- ☐ *client organisation's confidence in the CR ( $C_s = 0.4791$ ; sig. = 0.0076);*
- ☐ *the level of influence exercised on CTP by the CR ( $C_s = 0.4586$ ; sig. = 0.0095);*
- ☐ *complexity of CR's influence upon the project's management ( $C_s = 0.5274$ ; sig. = 0.0029);*
- ☐ ***CR's ability to effectively brief the design team ( $C_s = 0.7507$ ; sig. = 0.0000);***
- ☐ *stability of CR decisions ( $C_s = 0.4856$ ; sig. = 0.0060);*
- ☐ *the CR's confidence in the construction team ( $C_s = 0.4857$ ; sig. = 0.0068);*
- ☐ *the CR's ability to mould shared project goals and aspirations ( $C_s = 0.5591$ ; sig. = 0.0019);*
- ☐ *the overall CR contribution to project team harmony ( $C_s = 0.5764$ ; sig. = 0.0011);*
- ☐ *CM's effectiveness in influencing the CR decision making process ( $C_s = 0.5215$ ; sig. = 0.0032);*
- ☐ *flexibility of the CR's management style ( $C_s = 0.4905$ ; sig. = 0.0055);*
- ☐ *task-orientation of the CR's management style ( $C_s = 0.6693$ ; sig. = 0.0002);*
- ☐ *CR's people-oriented management style ( $C_s = 0.5773$ ; sig. = 0.0013);*
- ☐ *direct use of power in the CR's management style ( $C_s = -0.5744$ ; sig. = 0.0014);*
- ☐ *flexibility of the CM's management style ( $C_s = 0.5265$ ; sig. = 0.0029).*

## SUB-HYPOTHESIS NUMBER 25

## QUESTIONNAIRE NUMBER Q2.6.2

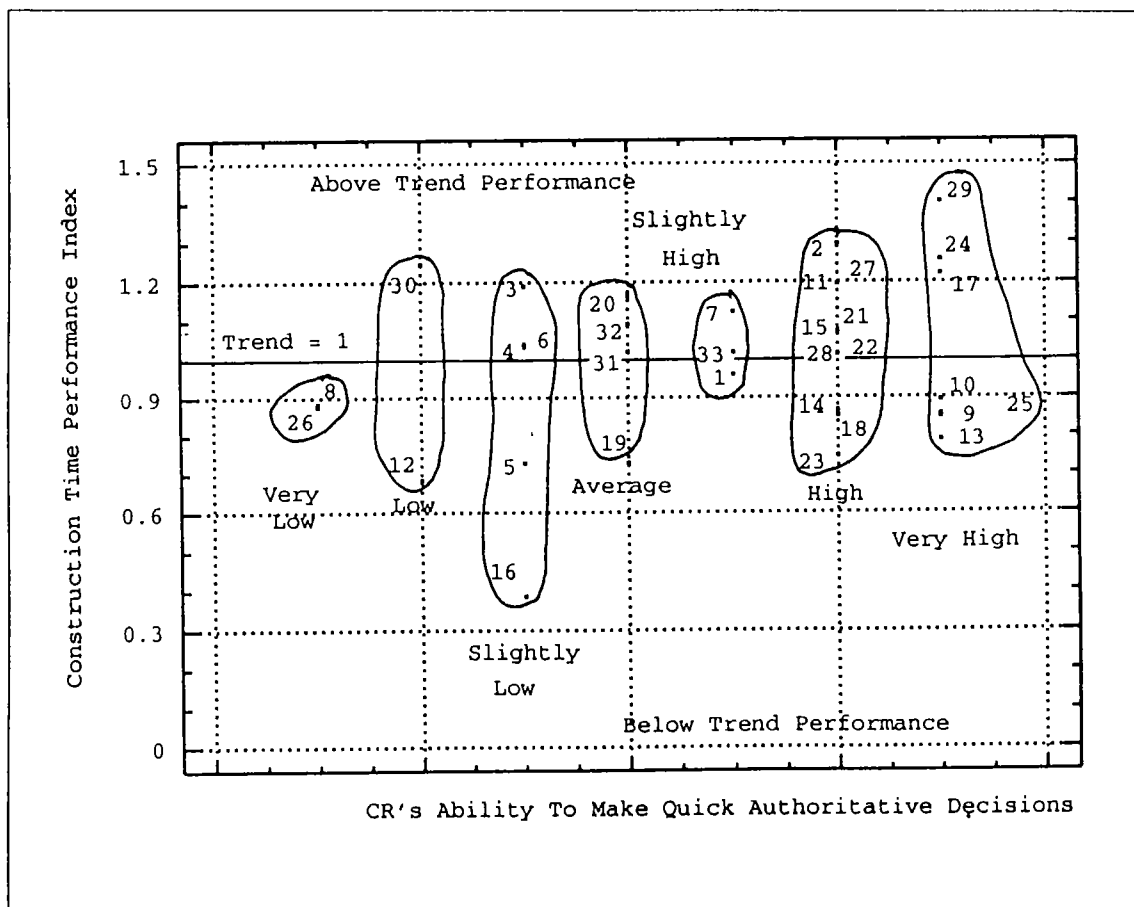
$H_0$  Construction time performance is **NOT** dependent upon the CR's ability to make quick authoritative decisions.

$H_1$  Construction time performance **IS** dependent upon the CR's ability to make quick authoritative decisions.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.425	0.8553	<b><math>H_0</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 25**

**DATA ITEM: CR'S ABILITY TO QUICKLY MAKE AUTHORITATIVE DECISIONS**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *ability of the CR to contribute ideas to the construction process* ( $C_s = 0.5256$ ; sig. = 0.0029);
- ☐ CR's willingness to contribute effective and positive ideas ( $C_s = 0.4458$ ; sig. = 0.0117);
- ☐ *the project design team's confidence in the CR contribution* ( $C_s = 0.5689$ ; sig. = 0.0818);
- ☐ **the construction team's confidence in the CR's contribution** ( $C_s = 0.7379$ ; sig. = 0.0000);
- ☐ **impact of CR/CM working relationship** ( $C_s = 0.7399$ ; sig. = 0.0000);
- ☐ CM's forecasting planning data ( $C_s = 0.4796$ ; sig. = 0.0076);
- ☐ CM's analysing construction methods ( $C_s = 0.4731$ ; sig. = 0.0074);
- ☐ effectiveness of the construction team's planning ( $C_s = 0.4562$ ; sig. = 0.0099);
- ☐ *CM's organisational structure to manage risk* ( $C_s = 0.5310$ ; sig. = 0.0027);
- ☐ *CM's communication management to facilitate decision making* ( $C_s = 0.4959$ ; sig. = 0.0050);
- ☐ CR and design team communication effectiveness for decision making ( $C_s = 0.4722$ ; sig. = 0.0097);
- ☐ CM decision making, communicating and actioning ( $C_s = 0.4776$ ; sig. = 0.0069);
- ☐ CM's effective use of information technologies ( $C_s = 0.4602$ ; sig. = 0.0092).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ CR's experience with the building procurement process ( $C_s = 0.4783$ ; sig. = 0.0068);
- ☐ *client organisation's confidence in the CR* ( $C_s = 0.5660$ ; sig. = 0.0016);
- ☐ *stability of client/CR objectives* ( $C_s = 0.5425$ ; sig. = 0.0021);
- ☐ *clarity of communication of client/CR objectives* ( $C_s = 0.6588$ ; sig. = 0.0002);
- ☐ **complexity of CR's influence upon the project's management** ( $C_s = 0.7202$ ; sig. = 0.0000);
- ☐ *CR's ability to effectively brief the design team* ( $C_s = 0.6534$ ; sig. = 0.0003);
- ☐ **stability of CR decisions** ( $C_s = 0.6956$ ; sig. = 0.0001);
- ☐ *the CR's ability to mould shared project goals and aspirations* ( $C_s = 0.5613$ ; sig. = 0.0018);
- ☐ *the overall CR contribution to project team harmony* ( $C_s = 0.5675$ ; sig. = 0.0013);
- ☐ *socio-political environmental complexity* ( $C_s = 0.5103$ ; sig. = 0.0039);
- ☐ CM's effectiveness in influencing the CR decision making process ( $C_s = 0.4611$ ; sig. = 0.0091);
- ☐ *CM management systems and procedures* ( $C_s = 0.5051$ ; sig. = 0.0843);
- ☐ **CR's organisational structure to manage risk** ( $C_s = 0.7931$ ; sig. = 0.0000);
- ☐ CM's effectiveness in team management to achieve synergy ( $C_s = 0.4849$ ; sig. = 0.0061);
- ☐ *flexibility of the CR's management style* ( $C_s = 0.5362$ ; sig. = 0.0024);
- ☐ flexibility of the CM's management style ( $C_s = 0.4666$ ; sig. = 0.0083);
- ☐ decision making communication within the CR team ( $C_s = 0.4856$ ; sig. = 0.0102);
- ☐ *CR decision making, communicating and actioning* ( $C_s = 0.5680$ ; sig. = 0.0013);
- ☐ CR's effective use of information technologies ( $C_s = 0.4895$ ; sig. = 0.0502).



## SUB-HYPOTHESIS NUMBER 26

## QUESTIONNAIRE NUMBER Q2.6.3

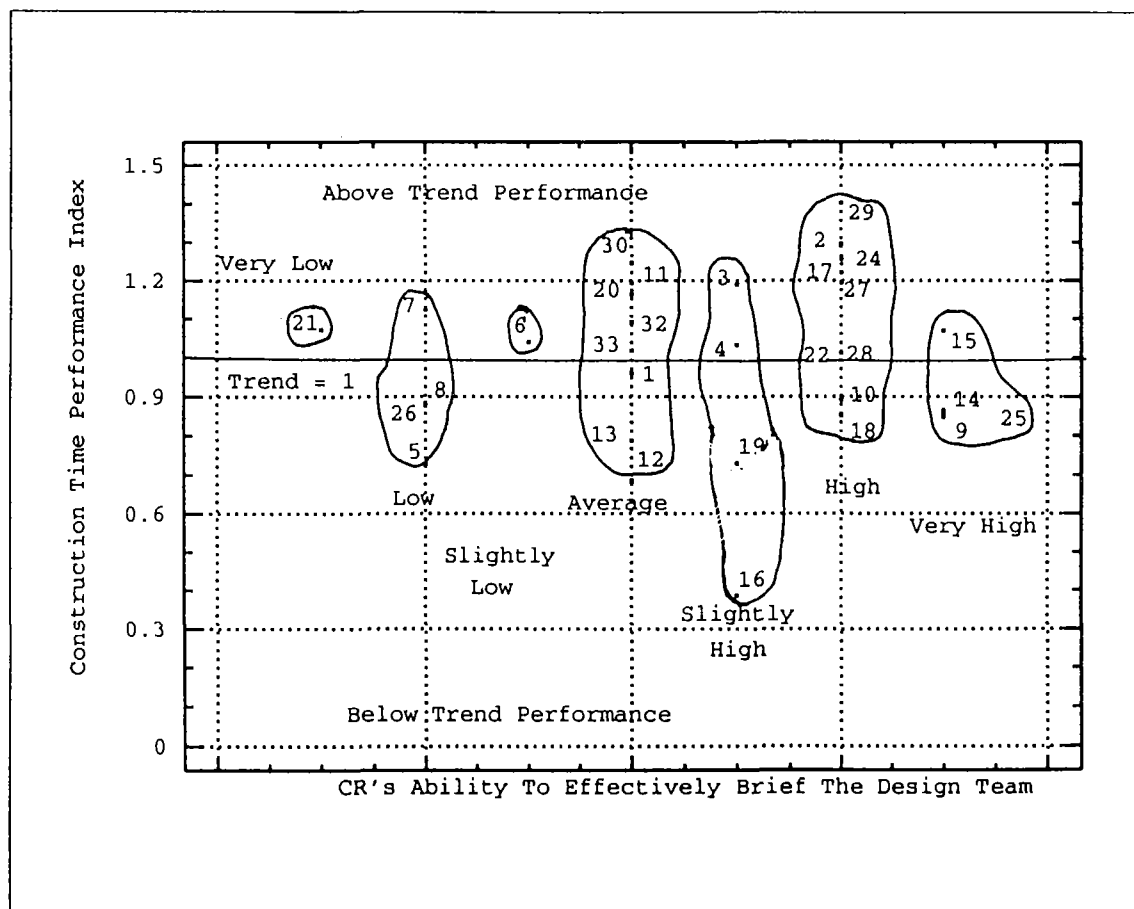
$H_0$  Construction time performance is **NOT** dependent upon the CR's ability to effectively brief the design team.

$H_1$  Construction time performance **IS** dependent upon the CR's ability to effectively brief the design team.

One-way ANOVA test results *measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.*

F-Ratio	Significance Level	Interpretation
1.256	0.3140	<b><math>H_0</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 26**

**DATA ITEM: CR'S ABILITY TO EFFECTIVELY BRIEF THE DESIGN TEAM**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *ability of the CR to contribute ideas to the design process* ( $C_s = 0.6543$ ; sig. = 0.0004);
- ☐ *CR's willingness to contribute effective and positive ideas* ( $C_s = 0.5061$ ; sig. = 0.0056);
- ☐ *ability of the CR to contribute ideas to the construction process* ( $C_s = 0.6740$ ; sig. = 0.0002);
- ☐ *the project design team's confidence in the CR contribution* ( $C_s = 0.5406$ ; sig. = 0.0036);
- ☐ *the construction team's confidence in the CR's contribution* ( $C_s = 0.6610$ ; sig. = 0.0003);
- ☐ *impact of CR/CM working relationship* ( $C_s = 0.5837$ ; sig. = 0.0014);
- ☐ *CM's analysing construction methods* ( $C_s = 0.4717$ ; sig. = 0.0098);
- ☐ *effectiveness of the construction team's planning* ( $C_s = 0.4461$ ; sig. = 0.0146);
- ☐ *CM's effectively coordinating resources* ( $C_s = 0.4849$ ; sig. = 0.0079);
- ☐ *effectiveness of the construction team's monitoring and control* ( $C_s = 0.4781$ ; sig. = 0.0088);
- ☐ *CM's organisational structure to manage risk* ( $C_s = 0.5649$ ; sig. = 0.0020);
- ☐ *CM's communication management to facilitate decision making* ( $C_s = 0.5023$ ; sig. = 0.0059);
- ☐ *CR and design team communication effectiveness for decision making* ( $C_s = 0.6487$ ; sig. = 0.0006);
- ☐ *CM decision making, communicating and actioning* ( $C_s = 0.5116$ ; sig. = 0.0051);

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *CR's experience with the building procurement process* ( $C_s = 0.5217$ ; sig. = 0.0043);
- ☐ *client organisation's confidence in the CR* ( $C_s = 0.5720$ ; sig. = 0.0021);
- ☐ *clarity of communication of client/CR objectives* ( $C_s = 0.5218$ ; sig. = 0.0043);
- ☐ *the level of influence exercised on CTP by the CR* ( $C_s = 0.5715$ ; sig. = 0.0017);
- ☐ *complexity of CR's influence upon the project's management* ( $C_s = 0.5858$ ; sig. = 0.0013);
- ☐ **CR's understanding the project's constraints** ( $C_s = 0.7507$ ; sig. = 0.0000);
- ☐ *CR's ability to quickly make authoritative decisions* ( $C_s = 0.6534$ ; sig. = 0.0003);
- ☐ **stability of CR decisions** ( $C_s = 0.7964$ ; sig. = 0.000);
- ☐ *the CR's ability to mould shared project goals and aspirations* ( $C_s = 0.5013$ ; sig. = 0.0069);
- ☐ *the overall CR contribution to project team harmony* ( $C_s = 0.5607$ ; sig. = 0.0021);
- ☐ *design buildability complexity* ( $C_s = 0.5104$ ; sig. = 0.0052);
- ☐ *design coordination complexity* ( $C_s = 0.4830$ ; sig. = 0.0082);
- ☐ *CM's effectiveness in influencing the CR decision making process* ( $C_s = 0.6200$ ; sig. = 0.0007);
- ☐ *CR's organisational structure to manage risk* ( $C_s = 0.5767$ ; sig. = 0.0016);
- ☐ *CM's effectiveness in team management to achieve synergy* ( $C_s = 0.4887$ ; sig. = 0.0074);
- ☐ *level of CR mechanistic-oriented management style* ( $C_s = -0.4650$ ; sig. = 0.0109);
- ☐ *flexibility of the CR's management style* ( $C_s = 0.6180$ ; sig. = 0.0007);
- ☐ *CR's people-oriented management style* ( $C_s = 0.4793$ ; sig. = 0.0099);
- ☐ *flexibility of the CM's management style* ( $C_s = 0.5344$ ; sig. = 0.0034);
- ☐ *CR decision making, communicating and actioning* ( $C_s = 0.5783$ ; sig. = 0.0015).

## SUB-HYPOTHESIS NUMBER 27

## QUESTIONNAIRE NUMBER Q2.6.4

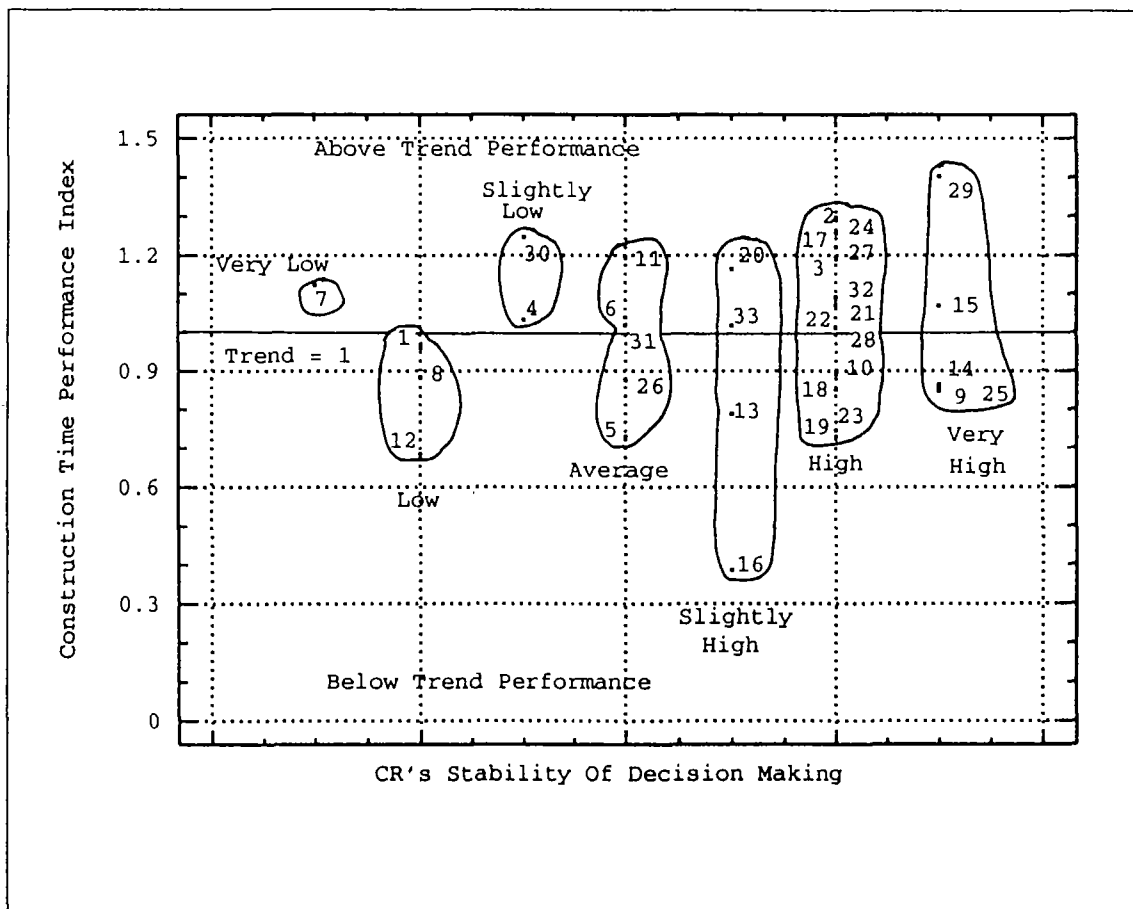
$H_0$  Construction time performance is **NOT** dependent upon the CR's stability of decision making.

$H_1$  Construction time performance **IS** dependent upon the CR's stability of decision making.

One-way ANOVA test results *measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.*

F-Ratio	Significance Level	Interpretation
0.936	0.4863	<b><math>H_0</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 27**  
**DATA ITEM: STABILITY OF CR DECISIONS**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ ability of the CR to contribute ideas to the design process ( $C_s = 0.5319$ ; sig. = 0.0031);
- ☐ ability of the CR to contribute ideas to the construction process ( $C_s = 0.4681$ ; sig. = 0.0081);
- ☐ the project design team's confidence in the CR contribution ( $C_s = 0.6243$ ; sig. = 0.0006);
- ☐ stability of CR decisions ( $C_s = 0.6444$ ; sig. = 0.0003);
- ☐ impact of CR/CM working relationship ( $C_s = 0.6081$ ; sig. = 0.0006);
- ☐ CM's forecasting planning data ( $C_s = 0.5275$ ; sig. = 0.0033);
- ☐ CM's analysing construction methods ( $C_s = 0.5782$ ; sig. = 0.0011);
- ☐ effectiveness of the construction team's planning ( $C_s = 0.6034$ ; sig. = 0.0006);
- ☐ CM's monitoring and updating plans to reflect work status ( $C_s = 0.4790$ ; sig. = 0.0067);
- ☐ CM's effectively coordinating resources ( $C_s = 0.5506$ ; sig. = 0.0018);
- ☐ CM's developing an organisational structure to maintain workflow ( $C_s = 0.5868$ ; sig. = 0.0009);
- ☐ effectiveness of the construction team's monitoring and control ( $C_s = 0.5325$ ; sig. = 0.0026);
- ☐ CM's organisational structure to manage risk ( $C_s = 0.6123$ ; sig. = 0.0005);
- ☐ CM's communication management to facilitate decision making ( $C_s = 0.5337$ ; sig. = 0.0025);
- ☐ CR and CM team communication effectiveness for decision making ( $C_s = 0.4467$ ; sig. = 0.0115);
- ☐ CR and design team communication effectiveness for decision making ( $C_s = 0.5315$ ; sig. = 0.0036);
- ☐ CM decision making, communicating and actioning ( $C_s = 0.5517$ ; sig. = 0.0018).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ client organisation's confidence in the CR ( $C_s = 0.5360$ ; sig. = 0.0028);
- ☐ clarity of communication of client/CR objectives ( $C_s = 0.6457$ ; sig. = 0.0003);
- ☐ complexity of CR's influence upon the project's management ( $C_s = 0.6887$ ; sig. = 0.0001);
- ☐ CR's understanding the project's constraints ( $C_s = 0.4856$ ; sig. = 0.0060);
- ☐ CR's ability to quickly make authoritative decisions ( $C_s = 0.6956$ ; sig. = 0.0001);
- ☐ CR's ability to effectively brief the design team ( $C_s = 0.7964$ ; sig. = 0.000);
- ☐ the CR's confidence in the construction team ( $C_s = 0.5119$ ; sig. = 0.0044);
- ☐ the CR's ability to mould shared project goals and aspirations ( $C_s = 0.5948$ ; sig. = 0.0009);
- ☐ the overall CR contribution to project team harmony ( $C_s = 0.5052$ ; sig. = 0.0043);
- ☐ general project complexity ( $C_s = 0.4749$ ; sig. = 0.0072);
- ☐ CM's effectiveness in influencing the CR decision making process ( $C_s = 0.6130$ ; sig. = 0.0005);
- ☐ CM management systems and procedures ( $C_s = 0.5275$ ; sig. = 0.0028);
- ☐ CR's organisational structure to manage risk ( $C_s = 0.6035$ ; sig. = 0.0006);
- ☐ CM's effectiveness in team management to achieve synergy ( $C_s = 0.5287$ ; sig. = 0.0028);
- ☐ decision making communication within the CR team ( $C_s = 0.4773$ ; sig. = 0.0115);
- ☐ CR decision making, communicating and actioning ( $C_s = 0.5797$ ; sig. = 0.0010).

## SUB-HYPOTHESIS NUMBER 28

## QUESTIONNAIRE NUMBER Q2.6.5

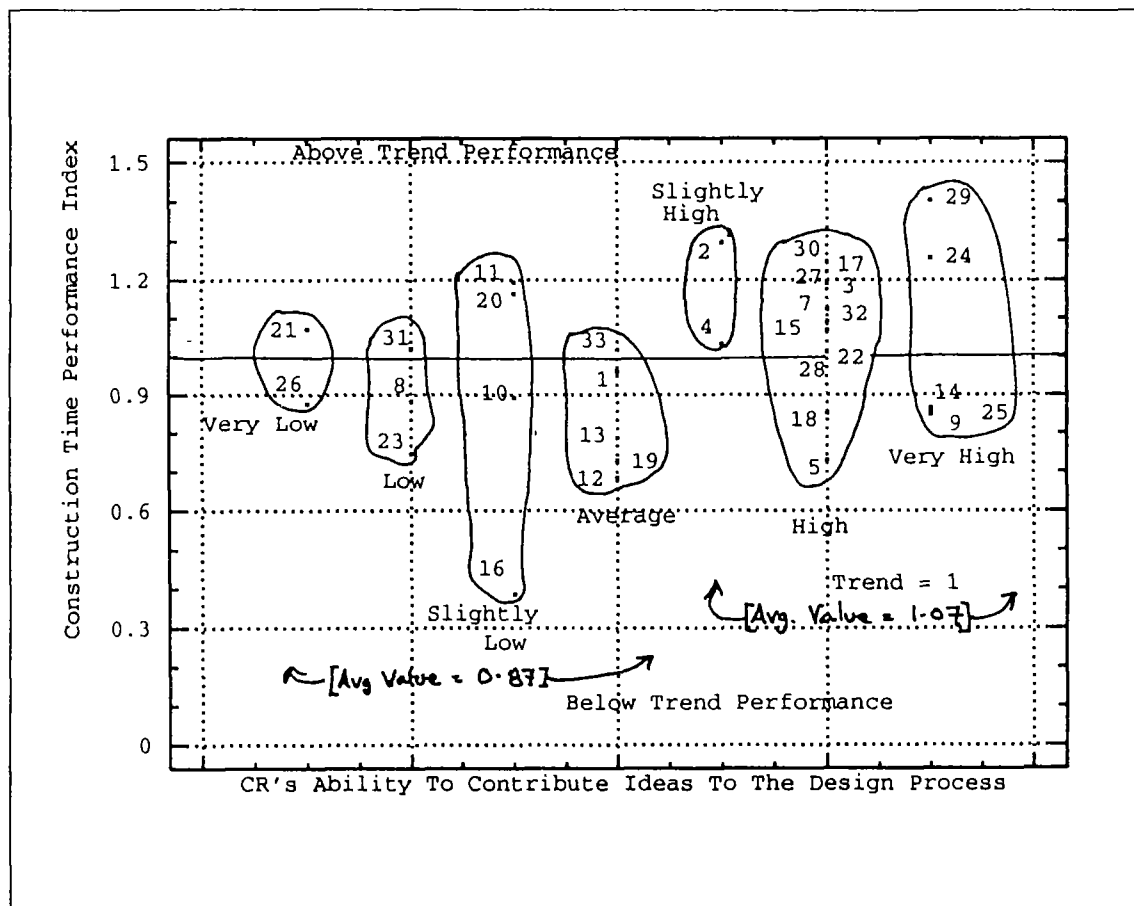
$H_0$  Construction time performance is **NOT** dependent upon a higher than average ability of the CR to contribute ideas to the design process.

$H_1$  Construction time performance **IS** dependent upon a higher than average ability of the CR to contribute ideas to the design process.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of *less than* 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
6.860	0.0137	<b><math>H_0</math> REJECTED: <math>H_1</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



## SUB-HYPOTHESIS NUMBER 28

### DATA ITEM: ABILITY OF THE CR TO CONTRIBUTE IDEAS TO THE DESIGN PROCESS

#### Spearman Rank Correlation results for factors affecting CTP:

- ☐ ability of the CR to contribute ideas to the construction process ( $C_s = 0.6552$ ; sig. = 0.0003);
- ☐ CR's willingness to contribute effective and positive ideas ( $C_s = 0.6670$ ; sig. = 0.0002);
- ☐ the project design team's confidence in the CR contribution ( $C_s = 0.5363$ ; sig. = 0.0039);
- ☐ the construction team's confidence in the CR's contribution ( $C_s = 0.5770$ ; sig. = 0.0013);
- ☐ impact of CR/CM working relationship ( $C_s = 0.6273$ ; sig. = 0.0005);
- ☐ CM's forecasting planning data ( $C_s = 0.6283$ ; sig. = 0.0006);
- ☐ effectiveness of the construction team's planning ( $C_s = 0.4666$ ; sig. = 0.0094);
- ☐ CM's effectively coordinating resources ( $C_s = 0.4910$ ; sig. = 0.0063);
- ☐ CM's developing an organisational structure to maintain workflow ( $C_s = 0.5378$ ; sig. = 0.0028);
- ☐ effectiveness of the construction team's monitoring and control ( $C_s = 0.5762$ ; sig. = 0.0013);
- ☐ CM's organisational structure to manage risk ( $C_s = 0.5728$ ; sig. = 0.0014);
- ☐ key sub-contractor's task-oriented management style ( $C_s = 0.4782$ ; sig. = 0.0078);
- ☐ CM's communication management to facilitate decision making ( $C_s = 0.5059$ ; sig. = 0.0049);
- ☐ CR and CM team communication effectiveness for decision making ( $C_s = 0.4814$ ; sig. = 0.0074);
- ☐ CR and design team communication effectiveness for decision making ( $C_s = 0.4892$ ; sig. = 0.0084);
- ☐ CM decision making, communicating and actioning ( $C_s = 0.6066$ ; sig. = 0.0007);
- ☐ effectiveness of the CM team in managing the construction process ( $C_s = 0.5729$ ; sig. = 0.0014);

#### Spearman Rank Correlation results for factors NOT affecting CTP:

- ☐ building end use ( $C_s = 0.5196$ ; sig. = 0.0038);
- ☐ clarity of communication of client/CR objectives ( $C_s = 0.5579$ ; sig. = 0.0019);
- ☐ the level of influence exercised on CTP by the CR ( $C_s = 0.4556$ ; sig. = 0.0112);
- ☐ complexity of CR's influence upon the project's management ( $C_s = 0.4694$ ; sig. = 0.0090);
- ☐ CR's understanding the project's constraints ( $C_s = 0.5831$ ; sig. = 0.0012);
- ☐ CR's ability to effectively brief the design team ( $C_s = 0.6543$ ; sig. = 0.0004);
- ☐ stability of CR decisions ( $C_s = 0.5319$ ; sig. = 0.0031);
- ☐ the CR's confidence in the construction team ( $C_s = 0.5329$ ; sig. = 0.0035);
- ☐ the CR's ability to mould shared project goals and aspirations ( $C_s = 0.5486$ ; sig. = 0.0027);
- ☐ the overall CR contribution to project team harmony ( $C_s = 0.6036$ ; sig. = 0.0008);
- ☐ CM's effectiveness in influencing the CR decision making process ( $C_s = 0.6266$ ; sig. = 0.0005);
- ☐ CR's organisational structure to manage risk ( $C_s = 0.5113$ ; sig. = 0.0044);
- ☐ CM's effectiveness in team management to achieve synergy ( $C_s = 0.4481$ ; sig. = 0.0126);
- ☐ flexibility of the CR's management style ( $C_s = 0.5618$ ; sig. = 0.0018);
- ☐ direct use of power in the CR's management style ( $C_s = -0.4508$ ; sig. = 0.0135);
- ☐ direct use of power in the design team's management style ( $C_s = -0.4812$ ; sig. = 0.0210);
- ☐ task-orientation of the CM's management style ( $C_s = 0.4700$ ; sig. = 0.0089).

## SUB-HYPOTHESIS NUMBER 29

## QUESTIONNAIRE NUMBER Q2.6.6

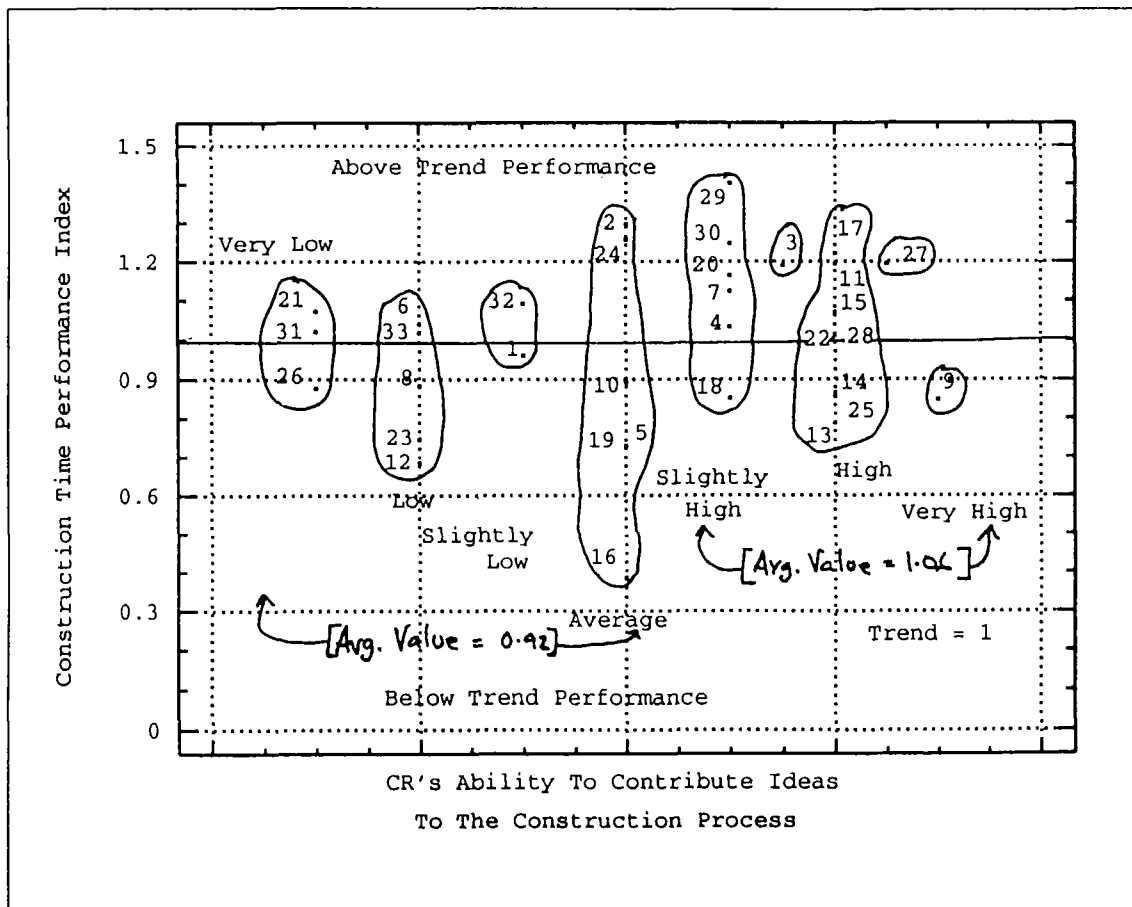
$H_0$  Construction time performance is **NOT** dependent upon a slightly high or higher ability of the CR to contribute ideas to the construction process.

$H_1$  Construction time performance **IS** dependent upon a slightly high or higher ability of the CR to contribute ideas to the construction process.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
4.204	0.0489	<b><math>H_0</math> REJECTED: <math>H_1</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 29**

**DATA ITEM: CR'S ABILITY TO CONTRIBUTE IDEAS TO THE CONSTRUCTION PROCESS**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *ability of the CR to contribute ideas to the design process ( $C_s = 0.6552$ ; sig. = 0.0003);*
- ☐ *CR's willingness to contribute effective and positive ideas ( $C_s = 0.5586$ ; sig. = 0.0016);*
- ☐ *the project design team's confidence in the CR contribution ( $C_s = 0.5426$ ; sig. = 0.0030);*
- ☐ *the construction team's confidence in the CR's contribution ( $C_s = 0.6632$ ; sig. = 0.0002);*
- ☐ *impact of CR/CM working relationship ( $C_s = 0.5551$ ; sig. = 0.0017);*
- ☐ *CM's organisational structure to manage risk ( $C_s = 0.5502$ ; sig. = 0.0019);*
- ☐ *CM's communication management to facilitate decision making ( $C_s = 0.4581$ ; sig. = 0.0096);*
- ☐ *CR and CM team communication effectiveness for decision making ( $C_s = 0.5125$ ; sig. = 0.0037);*
- ☐ *CR and design team communication effectiveness for decision making ( $C_s = 0.4865$ ; sig. = 0.0077).*

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *CR's experience with the building procurement process ( $C_s = 0.5048$ ; sig. = 0.0043);*
- ☐ *client organisation's confidence in the CR ( $C_s = 0.5368$ ; sig. = 0.0028);*
- ☐ *stability of client/CR objectives ( $C_s = 0.5006$ ; sig. = 0.0046);*
- ☐ *complexity of CR's influence upon the project's management ( $C_s = 0.4530$ ; sig. = 0.0104);*
- ☐ **CR's understanding the project's constraints ( $C_s = 0.7044$ ; sig. = 0.0001);**
- ☐ *CR's ability to quickly make authoritative decisions ( $C_s = 0.5256$ ; sig. = 0.0029);*
- ☐ *CR's ability to effectively brief the design team ( $C_s = 0.6740$ ; sig. = 0.0002);*
- ☐ *stability of CR decisions ( $C_s = 0.4681$ ; sig. = 0.0081);*
- ☐ *the CR's ability to mould shared project goals and aspirations ( $C_s = 0.4840$ ; sig. = 0.0070);*
- ☐ *the overall CR contribution to project team harmony ( $C_s = 0.6635$ ; sig. = 0.0002);*
- ☐ *CM's effectiveness in influencing the CR decision making process ( $C_s = 0.5172$ ; sig. = 0.0034);*
- ☐ *CR's organisational structure to manage risk ( $C_s = 0.6531$ ; sig. = 0.0002);*
- ☐ *flexibility of the CR's management style ( $C_s = 0.5030$ ; sig. = 0.0044);*
- ☐ *task-orientation of the CR's management style ( $C_s = 0.4822$ ; sig. = 0.0073);*
- ☐ *CR's people-oriented management style ( $C_s = 0.4569$ ; sig. = 0.0110);*
- ☐ *direct use of power in the CR's management style ( $C_s = -0.4963$ ; sig. = 0.0057);*
- ☐ *flexibility of the CM's management style ( $C_s = 0.4604$ ; sig. = 0.0092);*
- ☐ *decision making communication within the CR team ( $C_s = 0.5461$ ; sig. = 0.0020).*



## SUB-HYPOTHESIS NUMBER 30

## QUESTIONNAIRE NUMBER Q2.7.1

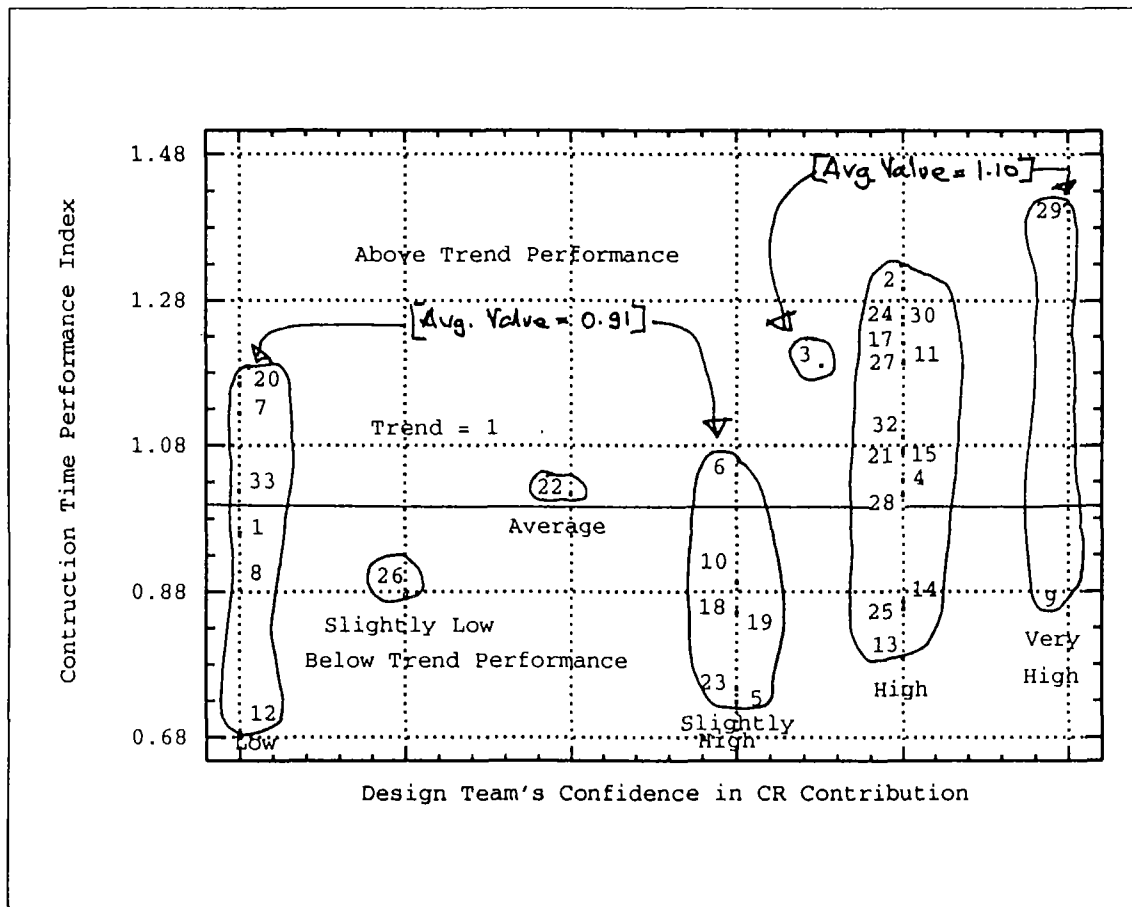
$H_0$  Construction time performance is NOT dependent upon a higher than slightly high confidence of design team in the CR's contribution to the project.

$H_1$  Construction time performance IS dependent upon a higher than slightly high confidence of design team in the CR's contribution to the project.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
9.792	0.0040	<b><math>H_0</math> REJECTED: <math>H_1</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



### SUB-HYPOTHESIS NUMBER 30

#### DATA ITEM: THE PROJECT DESIGN TEAM'S CONFIDENCE IN THE CR CONTRIBUTION

##### Spearman Rank Correlation results for factors affecting CTP:

- ☐ ability of the CR to contribute ideas to the design process ( $C_s = 0.5363$ ; sig. = 0.0039);
- ☐ ability of the CR to contribute ideas to the construction process ( $C_s = 0.5426$ ; sig. = 0.0030);
- ☐ the construction team's confidence in the CR's contribution ( $C_s = 0.6284$ ; sig. = 0.0006);
- ☐ impact of CR/CM working relationship ( $C_s = 0.6977$ ; sig. = 0.0001);
- ☐ CM's developing an organisational structure to maintain workflow ( $C_s = 0.4966$ ; sig. = 0.0065);
- ☐ CM's communication management to facilitate decision making ( $C_s = 0.5746$ ; sig. = 0.0016);
- ☐ CR and CM team communication effectiveness for decision making ( $C_s = 0.4483$ ; sig. = 0.0141);
- ☐ CR and design team communication effectiveness for decision making ( $C_s = 0.6020$ ; sig. = 0.0014);
- ☐ decision making communication within the CM team ( $C_s = 0.4462$ ; sig. = 0.0145);
- ☐ CM decision making, communicating and actioning ( $C_s = 0.4841$ ; sig. = 0.0080).

##### Spearman Rank Correlation results for factors NOT affecting CTP:

- ☐ project procurement method ( $C_s = 0.5581$ ; sig. = 0.0022);
- ☐ client organisation's confidence in the CR ( $C_s = 0.4761$ ; sig. = 0.0104);
- ☐ clarity of communication of client/CR objectives ( $C_s = 0.4849$ ; sig. = 0.0079);
- ☐ complexity of CR's influence upon the project's management ( $C_s = 0.5965$ ; sig. = 0.0011);
- ☐ CR's understanding the project's constraints ( $C_s = 0.6628$ ; sig. = 0.0003);
- ☐ CR's ability to quickly make authoritative decisions ( $C_s = 0.5689$ ; sig. = 0.0018);
- ☐ CR's ability to effectively brief the design team ( $C_s = 0.5406$ ; sig. = 0.0036);
- ☐ stability of CR decisions ( $C_s = 0.6243$ ; sig. = 0.0006);
- ☐ CR's confidence in the project design team ( $C_s = 0.4907$ ; sig. = 0.0072);
- ☐ the CR's confidence in the construction team ( $C_s = 0.5969$ ; sig. = 0.0011);
- ☐ the CR's ability to mould shared project goals and aspirations ( $C_s = 0.6106$ ; sig. = 0.0010);
- ☐ the overall CR contribution to project team harmony ( $C_s = 0.6061$ ; sig. = 0.0009);
- ☐ design team's organisational structure to manage risk ( $C_s = 0.4937$ ; sig. = 0.0068);
- ☐ CR's organisational structure to manage risk ( $C_s = 0.4923$ ; sig. = 0.0070);
- ☐ key sub-contractor's organisational structure to manage risk ( $C_s = 0.5847$ ; sig. = 0.0016);
- ☐ CM's effectiveness in team management to achieve synergy ( $C_s = 0.5615$ ; sig. = 0.0021);
- ☐ flexibility of the CR's management style ( $C_s = 0.4637$ ; sig. = 0.0111);
- ☐ task-orientation of the CR's management style ( $C_s = 0.4773$ ; sig. = 0.0089);
- ☐ direct use of power in the CR's management style ( $C_s = -0.6297$ ; sig. = 0.0006);
- ☐ flexibility of design team's management style ( $C_s = 0.4614$ ; sig. = 0.0130);
- ☐ task-orientation of the design team's management style ( $C_s = 0.4503$ ; sig. = 0.0172);
- ☐ design team's people-oriented management style ( $C_s = 0.4689$ ; sig. = 0.0168);
- ☐ direct use of power in the design team's management style ( $C_s = -0.5220$ ; sig. = 0.0123);
- ☐ flexibility of the CM's management style ( $C_s = 0.5440$ ; sig. = 0.0029);
- ☐ task-orientation of the CM's management style ( $C_s = 0.4626$ ; sig. = 0.0113);
- ☐ decision making communication within the design team ( $C_s = 0.5705$ ; sig. = 0.0025);
- ☐ design team's decision making, communicating and actioning ( $C_s = 0.4786$ ; sig. = 0.0088);
- ☐ CR's effective use of information technologies ( $C_s = 0.5568$ ; sig. = 0.0259).

## SUB-HYPOTHESIS NUMBER 31

## QUESTIONNAIRE NUMBER Q2.7.2

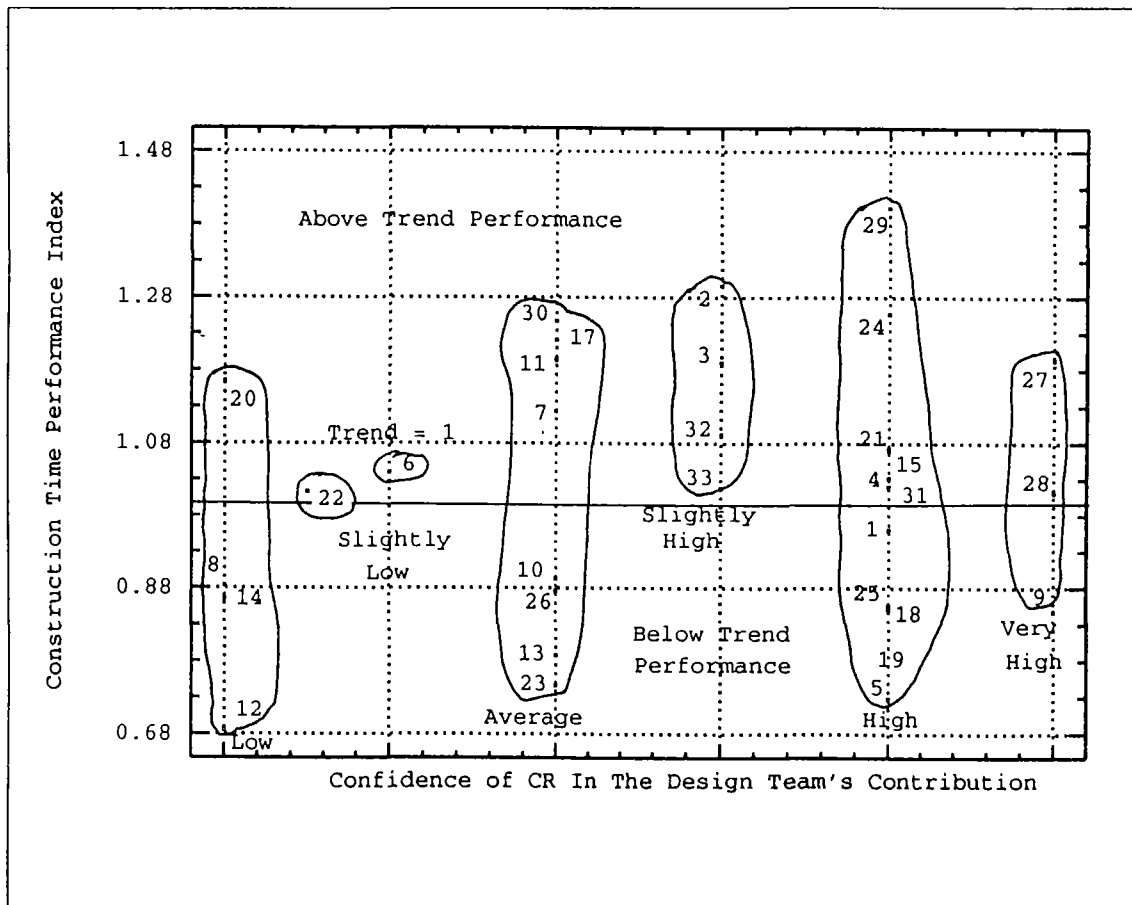
$H_0$  Construction time performance is **NOT** dependent upon the confidence of CR in the design team's contribution to the project.

$H_1$  Construction time performance **IS** dependent upon the confidence of CR in the design team's contribution to the project.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.654	0.7550	<b><math>H_0</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 31**

**DATA ITEM: CR'S CONFIDENCE IN THE PROJECT DESIGN TEAM**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ the project design team's confidence in the CR contribution ( $C_s = 0.4907$ ; sig. = 0.0072);
- ☐ CR and design team communication effectiveness for decision making ( $C_s = 0.5782$ ; sig. = 0.0018).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ credibility of achieving goals established by the CR/Client ( $C_s = 0.4795$ ; sig. = 0.0076);
- ☐ design coordination complexity ( $C_s = 0.4869$ ; sig. = 0.0067);
- ☐ **flexibility of design team's management style ( $C_s = 0.7467$ ; sig. = 0.0000);**
- ☐ *task-orientation of the design team's management style* ( $C_s = 0.5789$ ; sig. = 0.0018);
- ☐ *design team's people-oriented management style* ( $C_s = 0.6417$ ; sig. = 0.0009);
- ☐ *direct use of power in the design team's management style* ( $C_s = -0.5038$ ; sig. = 0.0136);
- ☐ decision making communication within the design team ( $C_s = 0.4681$ ; sig. = 0.0117).

## SUB-HYPOTHESIS NUMBER 32

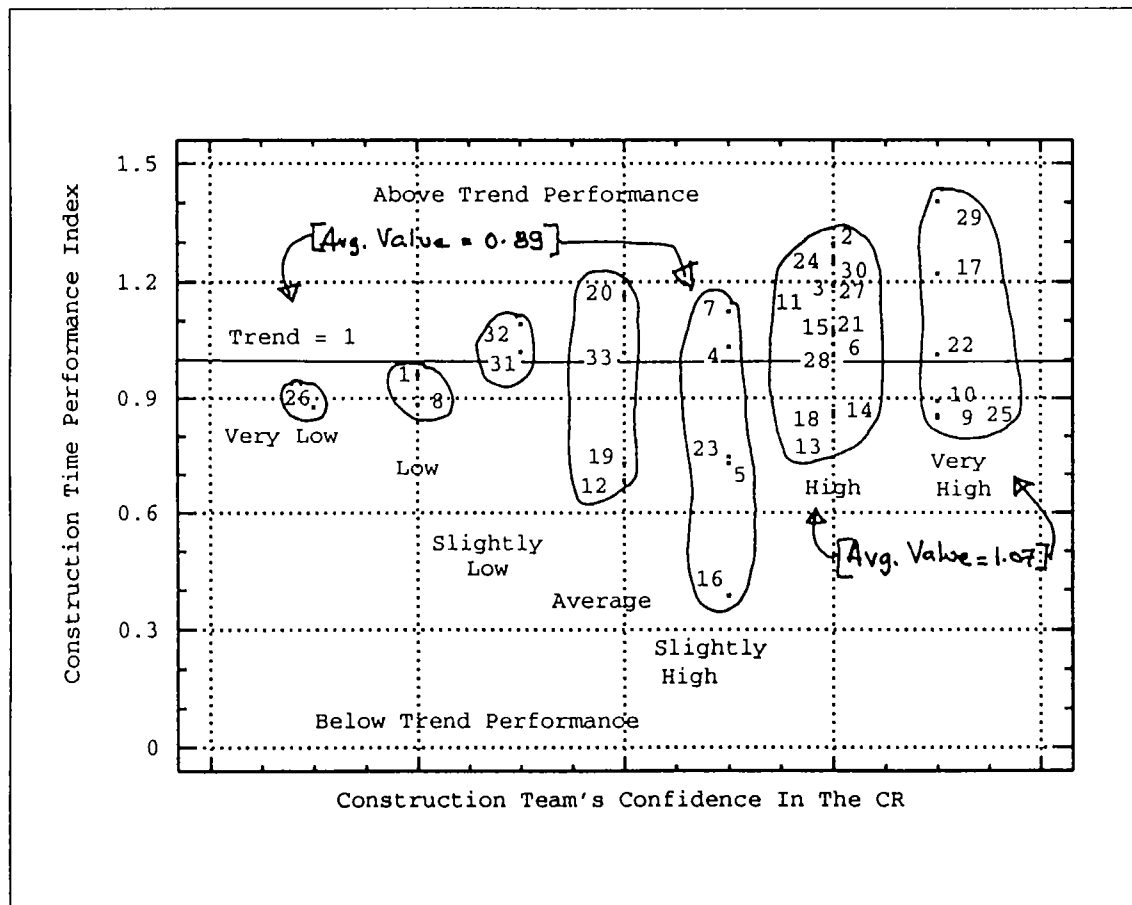
## QUESTIONNAIRE NUMBER Q2.7.3

- $H_0$  Construction time performance is **NOT** dependent upon a higher than slightly high confidence of construction team in the CR's contribution to the project.
- $H_1$  Construction time performance **IS** dependent upon a higher than slightly high confidence of construction team in the CR's contribution to the project.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
6.757	0.0142	<b><math>H_0</math> REJECTED: <math>H_1</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 32**

**DATA ITEM: THE CONSTRUCTION TEAM'S CONFIDENCE IN THE CR'S CONTRIBUTION**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *ability of the CR to contribute ideas to the design process ( $C_s = 0.5770$ ; sig. = 0.0013)*
- ☐ **CR's willingness to contribute effective and positive ideas ( $C_s = 0.7030$ ; sig. = 0.0001);**
- ☐ *ability of the CR to contribute ideas to the construction process ( $C_s = 0.6632$ ; sig. = 0.0002);*
- ☐ *the project design team's confidence in the CR contribution ( $C_s = 0.6284$ ; sig. = 0.0006);*
- ☐ **impact of CR/CM working relationship ( $C_s = 0.8279$ ; sig. = 0.0000);**
- ☐ *CM's forecasting planning data ( $C_s = 0.5581$ ; sig. = 0.0019);*
- ☐ *CM's analysing construction methods ( $C_s = 0.5644$ ; sig. = 0.0014);*
- ☐ *effectiveness of the construction team's planning ( $C_s = 0.5184$ ; sig. = 0.0034);*
- ☐ *CM's planning - responding to problems or opportunities ( $C_s = 0.4580$ ; sig. = 0.0096);*
- ☐ *CM's effectively coordinating resources ( $C_s = 0.5382$ ; sig. = 0.0023);*
- ☐ *CM's developing an organisational structure to maintain workflow ( $C_s = 0.5770$ ; sig. = 0.0011);*
- ☐ *effectiveness of the construction team's monitoring and control ( $C_s = 0.5872$ ; sig. = 0.0009);*
- ☐ **CM's organisational structure to manage risk ( $C_s = 0.7228$ ; sig. = 0.0000);**
- ☐ *key sub-contractor's task-oriented management style ( $C_s = 0.5023$ ; sig. = 0.0045);*
- ☐ *CM's communication management to facilitate decision making ( $C_s = 0.6577$ ; sig. = 0.0002);*
- ☐ *CR and CM team communication effectiveness for decision making ( $C_s = 0.6560$ ; sig. = 0.0002);*
- ☐ *CR and design team communication effectiveness for decision making ( $C_s = 0.5406$ ; sig. = 0.0031);*
- ☐ *decision making communication within the CM team ( $C_s = 0.6095$ ; sig. = 0.0006);*
- ☐ *CM decision making, communicating and actioning ( $C_s = 0.5982$ ; sig. = 0.0007);*
- ☐ *CM's effective use of information technologies ( $C_s = 0.4660$ ; sig. = 0.0084);*
- ☐ *effectiveness of the CM team in managing the construction process ( $C_s = 0.5560$ ; sig. = 0.0017).*

**SUB-HYPOTHESIS NUMBER 32**

**DATA ITEM: THE CONSTRUCTION TEAM'S CONFIDENCE IN THE CR'S CONTRIBUTION**

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ CR's experience with the building procurement process ( $C_s = 0.4915$ ; sig. = 0.0054);
- ☐ client organisation's confidence in the CR ( $C_s = 0.5349$ ; sig. = 0.0029);
- ☐ stability of client/CR objectives ( $C_s = 0.5912$ ; sig. = 0.0008);
- ☐ clarity of communication of client/CR objectives ( $C_s = 0.7690$ ; sig. = 0.0000);
- ☐ complexity of CR's influence upon the project's management ( $C_s = 0.7068$ ; sig. = 0.0001);
- ☐ CR's understanding the project's constraints ( $C_s = 0.6135$ ; sig. = 0.0005);
- ☐ CR's ability to quickly make authoritative decisions ( $C_s = 0.7379$ ; sig. = 0.0000);
- ☐ CR's ability to effectively brief the design team ( $C_s = 0.6610$ ; sig. = 0.0003);
- ☐ stability of CR decisions ( $C_s = 0.6444$ ; sig. = 0.0003);
- ☐ the CR's confidence in the construction team ( $C_s = 0.4516$ ; sig. = 0.0119);
- ☐ the CR's ability to mould shared project goals and aspirations ( $C_s = 0.7025$ ; sig. = 0.0001);
- ☐ the CR's willingness to accept effective and positive ideas ( $C_s = 0.6372$ ; sig. = 0.0003);
- ☐ the overall CR contribution to project team harmony ( $C_s = 0.7641$ ; sig. = 0.0000);
- ☐ quality management procedures used on-site ( $C_s = 0.4575$ ; sig. = 0.0109);
- ☐ CM's effectiveness in influencing the CR decision making process ( $C_s = 0.6895$ ; sig. = 0.0001);
- ☐ CM management systems and procedures ( $C_s = 0.4686$ ; sig. = 0.0080);
- ☐ CR's organisational structure to manage risk ( $C_s = 0.8067$ ; sig. = 0.0000);
- ☐ key sub-contractor's organisational structure to manage risk ( $C_s = 0.5049$ ; sig. = 0.0049);
- ☐ CM's effectiveness in team management to achieve synergy ( $C_s = 0.5023$ ; sig. = 0.0045);
- ☐ flexibility of the CR's management style ( $C_s = 0.6450$ ; sig. = 0.0003);
- ☐ task-orientation of the CR's management style ( $C_s = 0.5253$ ; sig. = 0.0034);
- ☐ CR's people-oriented management style ( $C_s = 0.6126$ ; sig. = 0.0006);
- ☐ direct use of power in the CR's management style ( $C_s = -0.5915$ ; sig. = 0.0010);
- ☐ flexibility of the CM's management style ( $C_s = 0.6187$ ; sig. = 0.0005);
- ☐ task-orientation of the CM's management style ( $C_s = 0.4611$ ; sig. = 0.0091);
- ☐ decision making communication within the CR team ( $C_s = 0.5452$ ; sig. = 0.0039);
- ☐ CR decision making, communicating and actioning ( $C_s = 0.6616$ ; sig. = 0.0002).

## SUB-HYPOTHESIS NUMBER 33

## QUESTIONNAIRE NUMBER Q2.7.4

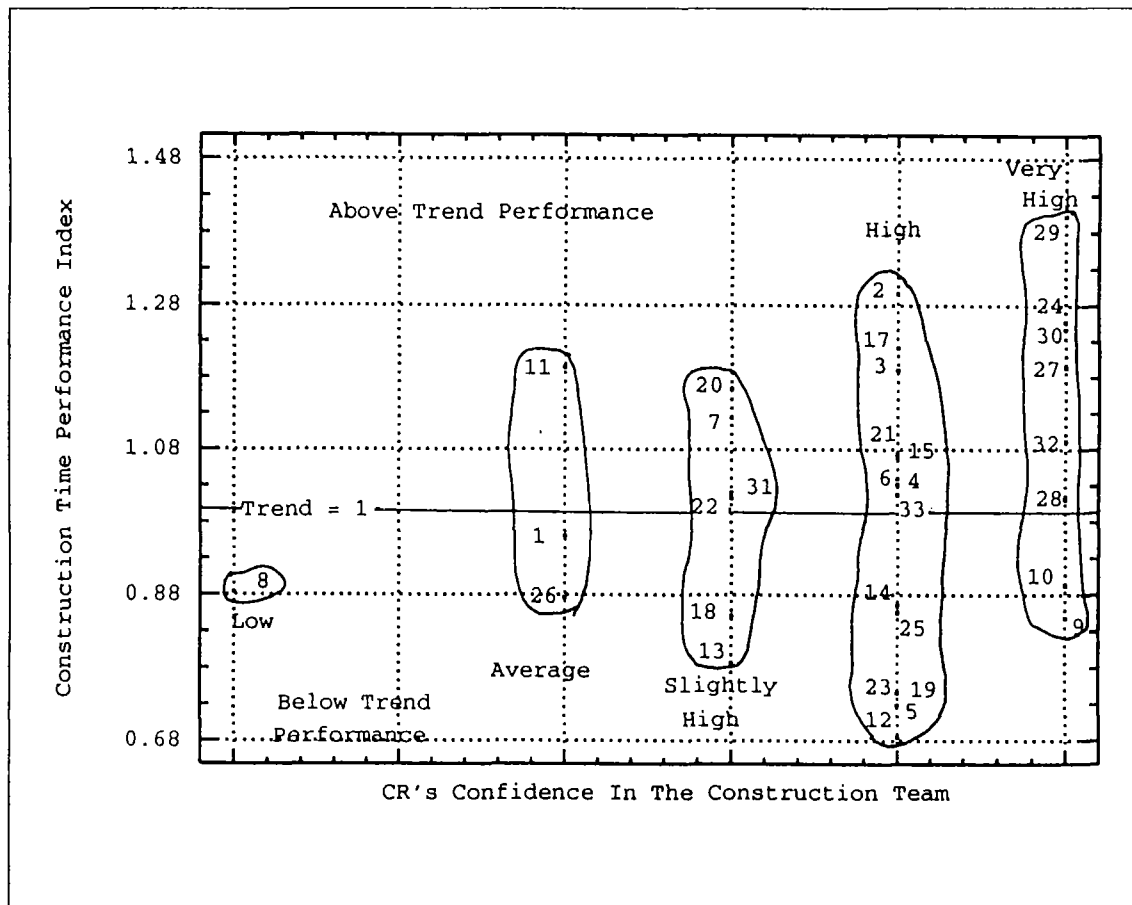
$H_0$  Construction time performance is **NOT** dependent upon the confidence of CR in the construction team's contribution to the project.

$H_1$  Construction time performance **IS** dependent upon the confidence of the CR in the construction team's contribution to the project.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.973	0.4385	<b><math>H_0</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*





**SUB-HYPOTHESIS NUMBER 33**

**DATA ITEM: THE CR'S CONFIDENCE IN THE CONSTRUCTION TEAM**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ construction end cost ( $C_s = 0.4759$ ; sig. = 0.0081);
- ☐ ability of the CR to contribute ideas to the design process ( $C_s = 0.5329$ ; sig. = 0.0035);
- ☐ the project design team's confidence in the CR contribution ( $C_s = 0.5969$ ; sig. = 0.0011);
- ☐ the construction team's confidence in the CR's contribution ( $C_s = 0.4516$ ; sig. = 0.0119);
- ☐ CR's willingness to contribute effective and positive ideas ( $C_s = 0.4683$ ; sig. = 0.0091);
- ☐ impact of CR/CM working relationship ( $C_s = 0.5653$ ; sig. = 0.0016);
- ☐ CM's forecasting planning data ( $C_s = 0.5446$ ; sig. = 0.0029);
- ☐ effectiveness of the construction team's planning ( $C_s = 0.5567$ ; sig. = 0.0019);
- ☐ CM's effectively coordinating resources ( $C_s = 0.4559$ ; sig. = 0.0111);
- ☐ CM's developing an organisational structure to maintain workflow ( $C_s = 0.5291$ ; sig. = 0.0032);
- ☐ effectiveness of the construction team's monitoring and control ( $C_s = 0.5454$ ; sig. = 0.0024);
- ☐ key sub-contractor's task-oriented management style ( $C_s = 0.4490$ ; sig. = 0.0124);
- ☐ CR and design team communication effectiveness for decision making ( $C_s = 0.5056$ ; sig. = 0.0064);
- ☐ CM decision making, communicating and actioning ( $C_s = 0.6318$ ; sig. = 0.0004);
- ☐ effectiveness of the CM team in managing the construction process ( $C_s = 0.4645$ ; sig. = 0.0097).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ complexity of CR's influence upon the project's management ( $C_s = 0.5208$ ; sig. = 0.0037);
- ☐ CR's understanding the project's constraints ( $C_s = 0.4857$ ; sig. = 0.0068);
- ☐ stability of CR decisions ( $C_s = 0.5119$ ; sig. = 0.0044);
- ☐ the CR's willingness to accept effective and positive ideas ( $C_s = 0.5515$ ; sig. = 0.0021);
- ☐ the overall CR contribution to project team harmony ( $C_s = 0.4974$ ; sig. = 0.0056);
- ☐ design coordination complexity ( $C_s = 0.4986$ ; sig. = 0.0055);
- ☐ quality management procedures used on-site ( $C_s = 0.4683$ ; sig. = 0.0103);
- ☐ CM's effectiveness in influencing the CR decision making process ( $C_s = 0.5717$ ; sig. = 0.0015);
- ☐ CM management systems and procedures ( $C_s = 0.5211$ ; sig. = 0.0037);
- ☐ CM's effectiveness in team management to achieve synergy ( $C_s = 0.6279$ ; sig. = 0.0005);
- ☐ task-orientation of the CR's management style ( $C_s = 0.4592$ ; sig. = 0.0106);
- ☐ CR's people-oriented management style ( $C_s = 0.5091$ ; sig. = 0.0046);
- ☐ direct use of power in the CR's management style ( $C_s = -0.5358$ ; sig. = 0.0029);
- ☐ task-orientation of the CM's management style ( $C_s = 0.6547$ ; sig. = 0.0003);
- ☐ CM's people-oriented management style ( $C_s = 0.4819$ ; sig. = 0.0073);
- ☐ decision making communication within the CR team ( $C_s = 0.4820$ ; sig. = 0.0123).

## SUB-HYPOTHESIS NUMBER 34

## QUESTIONNAIRE NUMBER Q2.7.5

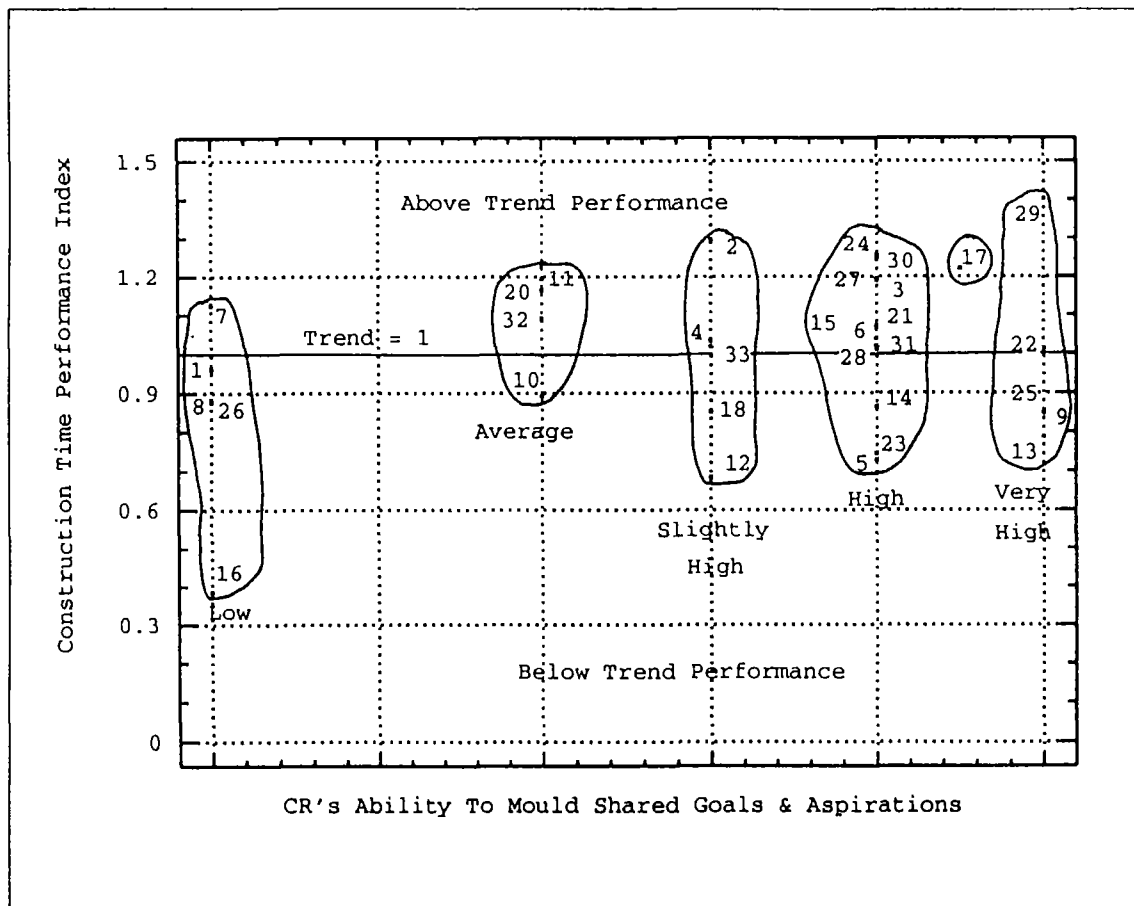
$H_0$  Construction time performance is **NOT** dependent upon the CR's ability to mould shared project goals and aspirations.

$H_1$  Construction time performance **IS** dependent upon the CR's ability to mould shared project goals and aspirations.

One-way ANOVA test results *measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.*

F-Ratio	Significance Level	Interpretation
0.968	0.4555	<b><math>H_0</math> ACCEPTED</b>

**Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)**



SUB-HYPOTHESIS NUMBER 34

DATA ITEM: THE CR'S ABILITY TO MOULD SHARED PROJECT GOALS AND ASPIRATIONS

Spearman Rank Correlation results for factors affecting CTP:

- ☐ ability of the CR to contribute ideas to the design process ( $C_s = 0.5486$ ; sig. = 0.0027);
- ☐ ability of the CR to contribute ideas to the construction process ( $C_s = 0.4840$ ; sig. = 0.0070);
- ☐ the project design team's confidence in the CR contribution ( $C_s = 0.6106$ ; sig. = 0.0010);
- ☐ **the construction team's confidence in the CR's contribution ( $C_s = 0.7025$ ; sig. = 0.0001);**
- ☐ impact of CR/CM working relationship ( $C_s = 0.5739$ ; sig. = 0.0014);
- ☐ CM's forecasting planning data ( $C_s = 0.4831$ ; sig. = 0.0081);
- ☐ effectiveness of the construction team's planning ( $C_s = 0.5350$ ; sig. = 0.0029);
- ☐ CM's organisational structure to manage risk ( $C_s = 0.5719$ ; sig. = 0.0015);
- ☐ CM's communication management to facilitate decision making ( $C_s = 0.6137$ ; sig. = 0.0006);
- ☐ CR and CM team communication effectiveness for decision making ( $C_s = 0.5588$ ; sig. = 0.0019);
- ☐ decision making communication within the CM team ( $C_s = 0.4829$ ; sig. = 0.0072);
- ☐ CM decision making, communicating and actioning ( $C_s = 0.6073$ ; sig. = 0.0007);
- ☐ effectiveness of the CM team in managing the construction process ( $C_s = 0.4489$ ; sig. = 0.0124).

Spearman Rank Correlation results for factors NOT affecting CTP:

- ☐ clarity of communication of client/CR objectives ( $C_s = 0.6640$ ; sig. = 0.0002);
- ☐ credibility of achieving goals established by the CR/Client ( $C_s = 0.4571$ ; sig. = 0.0109);
- ☐ complexity of CR's influence upon the project's management ( $C_s = 0.6429$ ; sig. = 0.0003);
- ☐ CR's understanding the project's constraints ( $C_s = 0.5591$ ; sig. = 0.0019);
- ☐ CR's ability to quickly make authoritative decisions ( $C_s = 0.5613$ ; sig. = 0.0018);
- ☐ CR's ability to effectively brief the design team ( $C_s = 0.5013$ ; sig. = 0.0069);
- ☐ stability of CR decisions ( $C_s = 0.5948$ ; sig. = 0.0009);
- ☐ the CR's willingness to accept effective and positive ideas ( $C_s = 0.6273$ ; sig. = 0.0005);
- ☐ **the overall CR contribution to project team harmony ( $C_s = 0.6973$ ; sig. = 0.0001);**
- ☐ quality management procedures used on-site ( $C_s = 0.6055$ ; sig. = 0.0009);
- ☐ CM's effectiveness in influencing the CR decision making process ( $C_s = 0.6326$ ; sig. = 0.0004);
- ☐ CM's analysing resource movement ( $C_s = 0.5205$ ; sig. = 0.0044);
- ☐ CR's organisational structure to manage risk ( $C_s = 0.6099$ ; sig. = 0.0007);
- ☐ key sub-contractor's organisational structure to manage risk ( $C_s = 0.5806$ ; sig. = 0.0015);
- ☐ flexibility of the CR's management style ( $C_s = 0.5771$ ; sig. = 0.0013);
- ☐ task-orientation of the CR's management style ( $C_s = 0.5389$ ; sig. = 0.0032);
- ☐ CR's people-oriented management style ( $C_s = 0.6210$ ; sig. = 0.0007);
- ☐ direct use of power in the CR's management style ( $C_s = -0.6406$ ; sig. = 0.0005);
- ☐ flexibility of design team's management style ( $C_s = 0.4851$ ; sig. = 0.0079);
- ☐ flexibility of the CM's management style ( $C_s = 0.5283$ ; sig. = 0.0033);
- ☐ task-orientation of the CM's management style ( $C_s = 0.5131$ ; sig. = 0.0043);
- ☐ decision making communication within the CR team ( $C_s = 0.4601$ ; sig. = 0.0149);
- ☐ CR decision making, communicating and actioning ( $C_s = 0.5183$ ; sig. = 0.0039).

## SUB-HYPOTHESIS NUMBER 35

## QUESTIONNAIRE NUMBER Q2.7.6

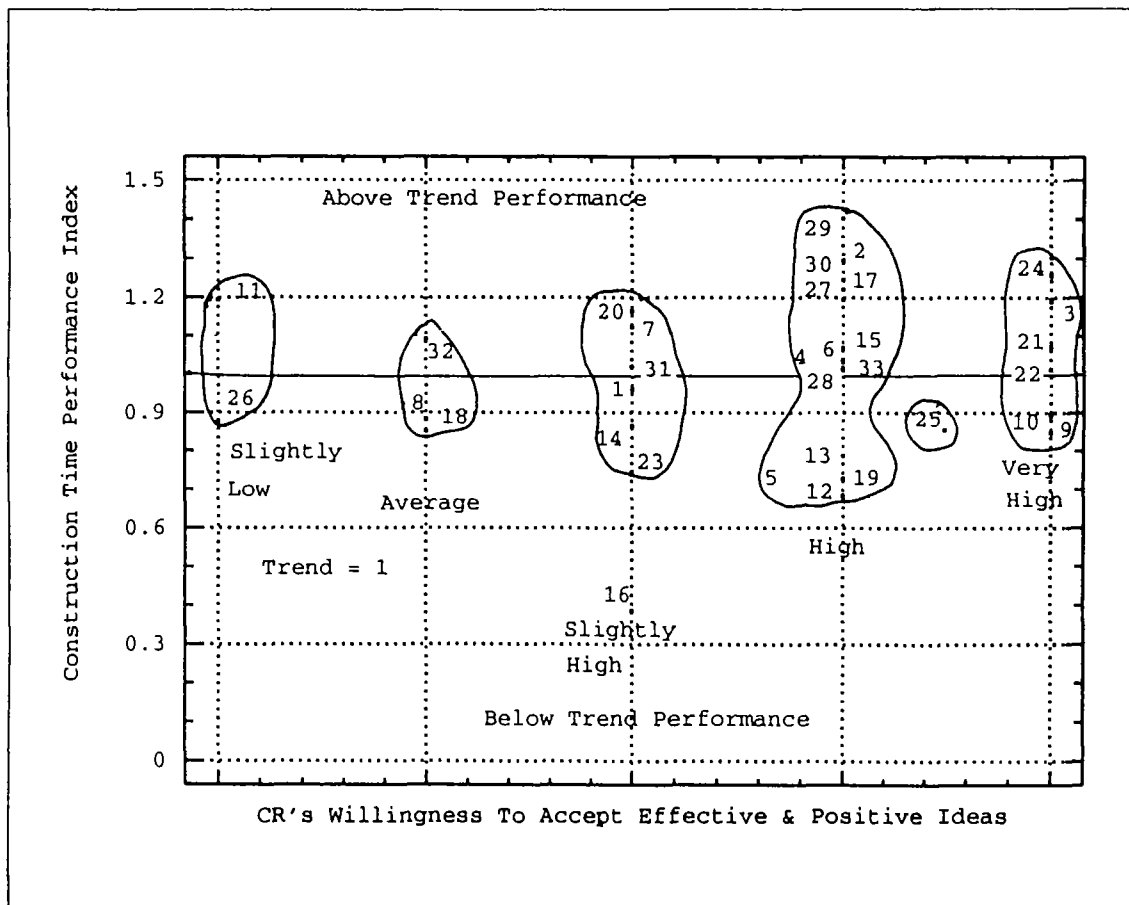
$H_0$  Construction time performance is **NOT** dependent upon the CR's willingness to accept effective and positive ideas.

$H_1$  Construction time performance **IS** dependent upon the CR's willingness to accept effective and positive ideas.

One-way ANOVA test results *measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.*

F-Ratio	Significance Level	Interpretation
0.556	0.7327	<b><math>H_0</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 35**

**DATA ITEM: THE CR'S WILLINGNESS TO ACCEPT EFFECTIVE AND POSITIVE IDEAS**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *the construction team's confidence in the CR's contribution* ( $C_s = 0.6372$ ; sig. = 0.0003);
- ☐ *CR's willingness to contribute effective and positive ideas* ( $C_s = 0.6945$ ; sig. = 0.0001);
- ☐ *impact of CR/CM working relationship* ( $C_s = 0.5693$ ; sig. = 0.0013);
- ☐ *CM's organisational structure to manage risk* ( $C_s = 0.4882$ ; sig. = 0.0058);
- ☐ *CM's communication management to facilitate decision making* ( $C_s = 0.5425$ ; sig. = 0.0022);
- ☐ **CR and CM team communication effectiveness for decision making** ( $C_s = 0.7157$ ; sig. = 0.0001);
- ☐ *CR and design team communication effectiveness for decision making* ( $C_s = 0.4700$ ; sig. = 0.0100);
- ☐ *CM decision making, communicating and actioning* ( $C_s = 0.5979$ ; sig. = 0.0007).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *clarity of communication of client/CR objectives* ( $C_s = 0.6341$ ; sig. = 0.0003);
- ☐ *credibility of achieving goals established by the CR/Client* ( $C_s = 0.5317$ ; sig. = 0.0026);
- ☐ *complexity of CR's influence upon the project's management* ( $C_s = 0.5514$ ; sig. = 0.0018);
- ☐ *the CR's confidence in the construction team* ( $C_s = 0.5515$ ; sig. = 0.0021);
- ☐ *the CR's ability to mould shared project goals and aspirations* ( $C_s = 0.6273$ ; sig. = 0.0005);
- ☐ *the overall CR contribution to project team harmony* ( $C_s = 0.6300$ ; sig. = 0.0004);
- ☐ *quality management procedures used on-site* ( $C_s = 0.6384$ ; sig. = 0.0004);
- ☐ *CM's effectiveness in influencing the CR decision making process* ( $C_s = 0.5737$ ; sig. = 0.0012);
- ☐ *CM management systems and procedures* ( $C_s = 0.4666$ ; sig. = 0.0080);
- ☐ *CR's organisational structure to manage risk* ( $C_s = 0.4632$ ; sig. = 0.0088);
- ☐ *flexibility of the CR's management style* ( $C_s = 0.5776$ ; sig. = 0.0011);
- ☐ *CR's people-oriented management style* ( $C_s = 0.6051$ ; sig. = 0.0008);
- ☐ *direct use of power in the CR's management style* ( $C_s = -0.6184$ ; sig. = 0.0006);
- ☐ *flexibility of design team's management style* ( $C_s = 0.5410$ ; sig. = 0.0026);
- ☐ *design team's people-oriented management style* ( $C_s = 0.5319$ ; sig. = 0.0057);
- ☐ *direct use of power in the design team's management style* ( $C_s = -0.5191$ ; sig. = 0.0110);
- ☐ *task-orientation of the CM's management style* ( $C_s = 0.5488$ ; sig. = 0.0019).

## SUB-HYPOTHESIS NUMBER 36

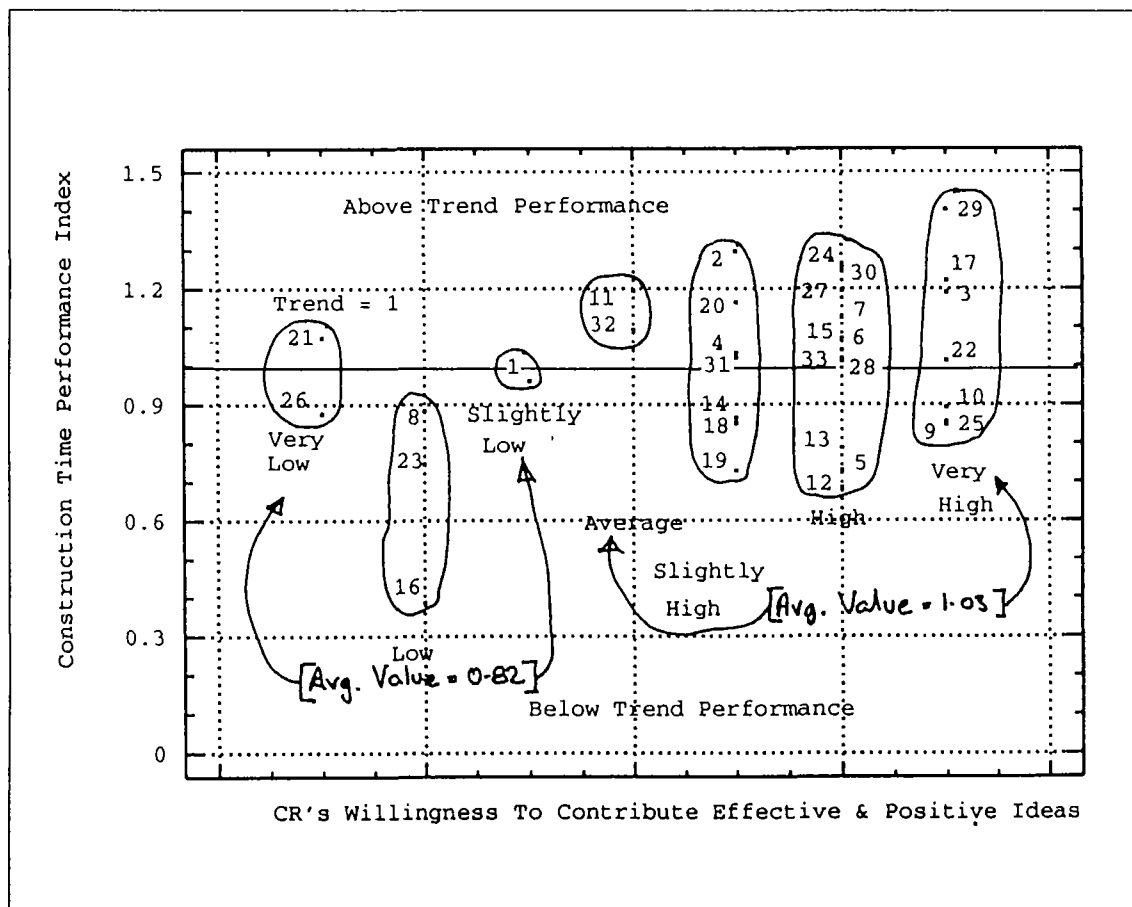
## QUESTIONNAIRE NUMBER Q2.7.7

- $H_0$  Construction time performance is NOT dependent upon the CR's greater than average willingness to contribute effective and positive ideas.
- $H_1$  Construction time performance IS dependent upon the CR's greater than average willingness to contribute effective and positive ideas.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
5.411	0.0267	<b><math>H_0</math> REJECTED: <math>H_1</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 36**

**DATA ITEM: CR'S WILLINGNESS TO CONTRIBUTE EFFECTIVE AND POSITIVE IDEAS**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ ability of the CR to contribute ideas to the design process ( $C_s = 0.6670$ ; sig. = 0.0002);
- ☐ ability of the CR to contribute ideas to the construction process ( $C_s = 0.5586$ ; sig. = 0.0016);
- ☐ **the construction team's confidence in the CR's contribution ( $C_s = 0.7030$ ; sig. = 0.0001);**
- ☐ impact of CR/CM working relationship ( $C_s = 0.6308$ ; sig. = 0.0004);
- ☐ CM's forecasting planning data ( $C_s = 0.4905$ ; sig. = 0.0063);
- ☐ CM's analysing construction methods ( $C_s = 0.4641$ ; sig. = 0.0087);
- ☐ effectiveness of the construction team's planning ( $C_s = 0.4666$ ; sig. = 0.0083);
- ☐ CM's planning - responding to problems or opportunities ( $C_s = 0.5503$ ; sig. = 0.0019);
- ☐ CM's effectively coordinating resources ( $C_s = 0.4824$ ; sig. = 0.0064);
- ☐ effectiveness of the construction team's monitoring and control ( $C_s = 0.5581$ ; sig. = 0.0016);
- ☐ CM's organisational structure to manage risk ( $C_s = 0.5716$ ; sig. = 0.0012);
- ☐ key sub-contractor's task-oriented management style ( $C_s = 0.5660$ ; sig. = 0.0014);
- ☐ CM's communication management to facilitate decision making ( $C_s = 0.5224$ ; sig. = 0.0031);
- ☐ CR and CM team communication effectiveness for decision making ( $C_s = 0.6636$ ; sig. = 0.0002);
- ☐ CR and design team communication effectiveness for decision making ( $C_s = 0.4991$ ; sig. = 0.0063);
- ☐ decision making communication within the CM team ( $C_s = 0.4690$ ; sig. = 0.0080);
- ☐ CM decision making, communicating and actioning ( $C_s = 0.5919$ ; sig. = 0.0008);
- ☐ effectiveness of the CM team in managing the construction process ( $C_s = 0.5653$ ; sig. = 0.0014).

**SUB-HYPOTHESIS NUMBER 36**

**DATA ITEM: CR'S WILLINGNESS TO CONTRIBUTE EFFECTIVE AND POSITIVE IDEAS**

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ clarity of communication of client/CR objectives ( $C_s = 0.5994$ ; sig. = 0.0007);
- ☐ the level of influence exercised on CTP by the CR ( $C_s = 0.4509$ ; sig. = 0.0108);
- ☐ CR's understanding the project's constraints ( $C_s = 0.4604$ ; sig. = 0.0092);
- ☐ CR's ability to quickly make authoritative decisions ( $C_s = 0.4458$ ; sig. = 0.0117);
- ☐ CR's ability to effectively brief the design team ( $C_s = 0.5061$ ; sig. = 0.0056);
- ☐ the CR's confidence in the construction team ( $C_s = 0.4683$ ; sig. = 0.0091);
- ☐ **the CR's willingness to accept effective and positive ideas ( $C_s = 0.6945$ ; sig. = 0.0001);**
- ☐ the CR's ability to mould shared project goals and aspirations ( $C_s = 0.6315$ ; sig. = 0.0004);
- ☐ the overall CR contribution to project team harmony ( $C_s = 0.6441$ ; sig. = 0.0003);
- ☐ quality management procedures used on-site ( $C_s = 0.6024$ ; sig. = 0.0008);
- ☐ **CM's effectiveness in influencing the CR decision making process ( $C_s = 0.7538$ ; sig. = 0.0000);**
- ☐ CR's organisational structure to manage risk ( $C_s = 0.6592$ ; sig. = 0.0002);
- ☐ CM's effectiveness in team management to achieve synergy ( $C_s = 0.4584$ ; sig. = 0.0095);
- ☐ flexibility of the CR's management style ( $C_s = 0.6666$ ; sig. = 0.0002);
- ☐ task-orientation of the CR's management style ( $C_s = 0.5735$ ; sig. = 0.0014);
- ☐ **CR's people-oriented management style ( $C_s = 0.7695$ ; sig. = 0.0000);**
- ☐ direct use of power in the CR's management style ( $C_s = -0.5433$ ; sig. = 0.0025);
- ☐ flexibility of the CM's management style ( $C_s = 0.5409$ ; sig. = 0.0022);
- ☐ task-orientation of the CM's management style ( $C_s = 0.5991$ ; sig. = 0.0007);
- ☐ decision making communication within the CR team ( $C_s = 0.5494$ ; sig. = 0.0036);
- ☐ CR decision making, communicating and actioning ( $C_s = 0.5260$ ; sig. = 0.0029).



## SUB-HYPOTHESIS NUMBER 37

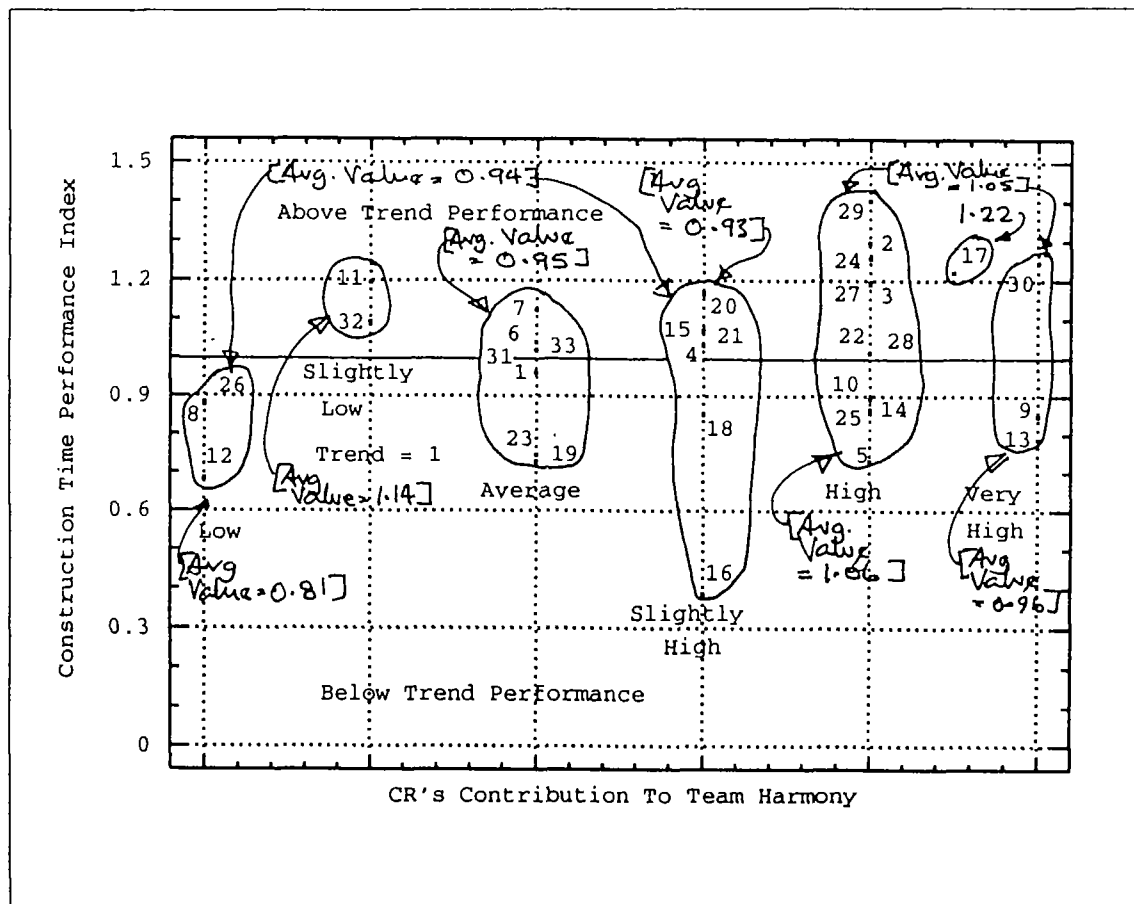
## QUESTIONNAIRE NUMBER Q2.7.8

- $H_0$  Construction time performance is **NOT** dependent upon the CR's contribution to team harmony.
- $H_1$  Construction time performance **IS** dependent upon the CR's contribution to team harmony.

One-way ANOVA test results *measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.*

F-Ratio	Significance Level	Interpretation
1.072	0.4045	$H_0$ ACCEPTED

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 37**

**DATA ITEM: THE OVERALL CR CONTRIBUTION TO PROJECT TEAM HARMONY**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ client/CR's time minimisation objective ( $C_s = 0.4497$ ; sig. = 0.0110);
- ☐ ability of the CR to contribute ideas to the design process ( $C_s = 0.6036$ ; sig. = 0.0008);
- ☐ ability of the CR to contribute ideas to the construction process ( $C_s = 0.6635$ ; sig. = 0.0008);
- ☐ the project design team's confidence in the CR contribution ( $C_s = 0.6061$ ; sig. = 0.0009);
- ☐ **the construction team's confidence in the CR's contribution ( $C_s = 0.7641$ ; sig. = 0.0000);**
- ☐ CR's willingness to contribute effective and positive ideas ( $C_s = 0.6441$ ; sig. = 0.0003);
- ☐ impact of CR/CM working relationship ( $C_s = 0.6754$ ; sig. = 0.0001);
- ☐ CM's organisational structure to manage risk ( $C_s = 0.5065$ ; sig. = 0.0042);
- ☐ CM's communication management to facilitate decision making ( $C_s = 0.6119$ ; sig. = 0.0005);
- ☐ **CR and CM team communication effectiveness for decision making ( $C_s = 0.7743$ ; sig. = 0.0000);**
- ☐ CR and design team communication effectiveness for decision making ( $C_s = 0.5366$ ; sig. = 0.0033);
- ☐ CM decision making, communicating and actioning ( $C_s = 0.5710$ ; sig. = 0.0012).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ building end use ( $C_s = 0.4585$ ; sig. = 0.0095);
- ☐ client organisation's confidence in the CR ( $C_s = 0.4853$ ; sig. = 0.0069);
- ☐ clarity of communication of client/CR objectives ( $C_s = 0.5577$ ; sig. = 0.0016);
- ☐ complexity of CR's influence upon the project's management ( $C_s = 0.6236$ ; sig. = 0.0004);
- ☐ CR's understanding the project's constraints ( $C_s = 0.5764$ ; sig. = 0.0011);
- ☐ CR's ability to quickly make authoritative decisions ( $C_s = 0.5675$ ; sig. = 0.0013);
- ☐ CR's ability to effectively brief the design team ( $C_s = 0.5607$ ; sig. = 0.0021);
- ☐ stability of CR decisions ( $C_s = 0.5052$ ; sig. = 0.0043);
- ☐ the CR's confidence in the construction team ( $C_s = 0.4974$ ; sig. = 0.0056);
- ☐ **the CR's ability to mould shared project goals and aspirations ( $C_s = 0.6973$ ; sig. = 0.0001);**
- ☐ the CR's willingness to accept effective and positive ideas ( $C_s = 0.6300$ ; sig. = 0.0004);
- ☐ quality management procedures used on-site ( $C_s = 0.4759$ ; sig. = 0.0081);
- ☐ CM's effectiveness in influencing the CR decision making process ( $C_s = 0.6622$ ; sig. = 0.0002);
- ☐ CR's organisational structure to manage risk ( $C_s = 0.5498$ ; sig. = 0.0019);
- ☐ flexibility of the CR's management style ( $C_s = 0.5959$ ; sig. = 0.0007);
- ☐ CR's people-oriented management style ( $C_s = 0.6501$ ; sig. = 0.0003);
- ☐ **direct use of power in the CR's management style ( $C_s = -0.8202$ ; sig. = 0.0000);**
- ☐ direct use of power in the design team's management style ( $C_s = -0.4995$ ; sig. = 0.0144);
- ☐ flexibility of the CR's management style ( $C_s = 0.5083$ ; sig. = 0.0040);

## SUB-HYPOTHESIS NUMBER 38

## QUESTIONNAIRE NUMBER Q3.1

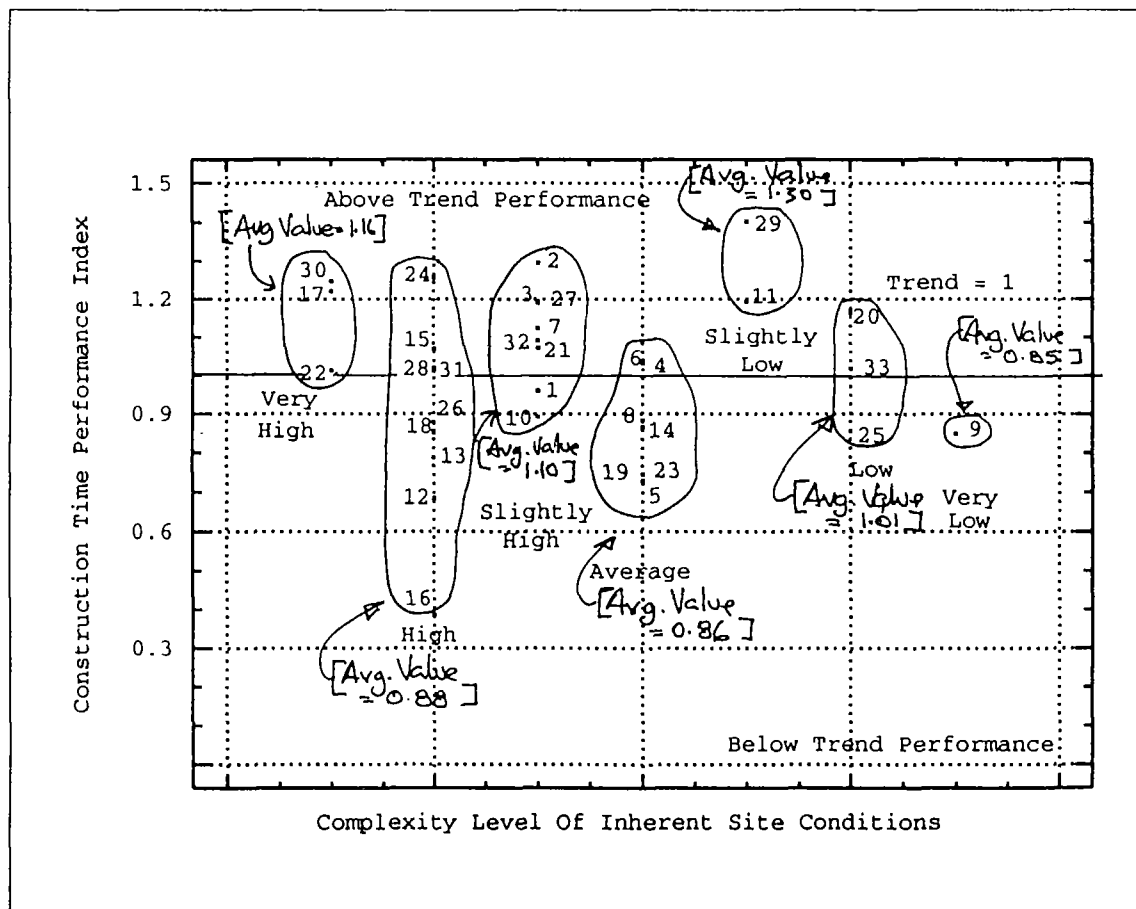
$H_0$  Construction time performance is **NOT** dependent upon inherent site conditions.

$H_1$  Construction time performance **IS** dependent upon inherent site conditions.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
3.203	0.0173	<b><math>H_0</math> REJECTED: <math>H_1</math> ACCEPTED</b>

**Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)**



**SUB-HYPOTHESIS NUMBER 38**

**DATA ITEM: INHERENT SITE CONDITIONS**

**Spearman Rank Correlation results for factors affecting CTP:**

☐ no significant correlation.

**Spearman Rank Correlation results for factors NOT affecting CTP:**

☐ access to and within site ( $C_s = 0.5817$ ; sig. = 0.0010).



**SUB-HYPOTHESIS NUMBER 39**

**DATA ITEM: DESIGN BUILDABILITY COMPLEXITY**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ no significant correlation.

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ client organisation's confidence in the CR ( $C_s = 0.4576$ ; sig. = 0.0108);
- ☐ complexity of CR's influence upon the project's management ( $C_s = 0.4481$ ; sig. = 0.0113);
- ☐ *CR's ability to effectively brief the design team* ( $C_s = 0.5104$ ; sig. = 0.0052);
- ☐ *design coordination complexity* ( $C_s = 0.5022$ ; sig. = 0.0045);
- ☐ *general project complexity* ( $C_s = 0.5561$ ; sig. = 0.0017);
- ☐ design team's organisational structure to manage risk ( $C_s = 0.4797$ ; sig. = 0.0067);
- ☐ level of CR mechanistic-oriented management style ( $C_s = -0.4640$ ; sig. = 0.0087).

## SUB-HYPOTHESIS NUMBER 40

## QUESTIONNAIRE NUMBER Q5.1

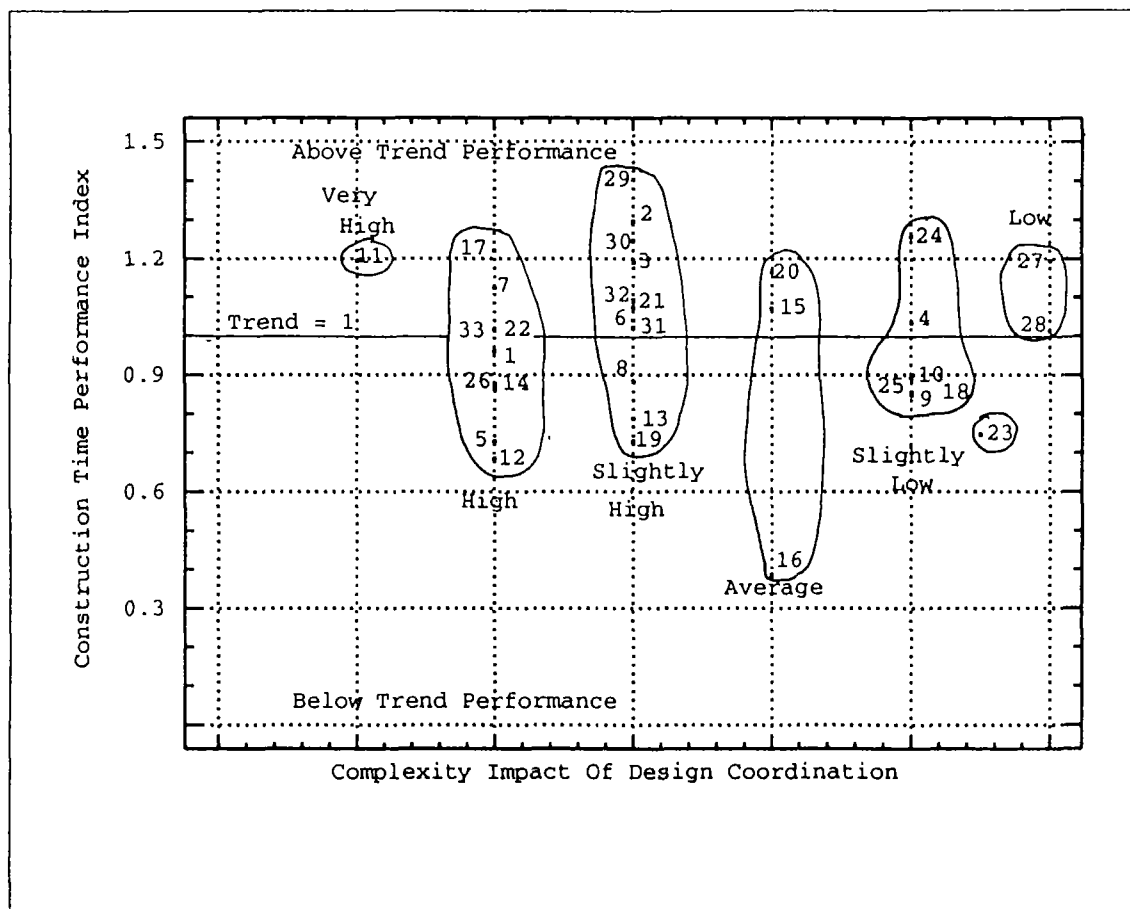
$H_0$  Construction time performance is **NOT** dependent upon the quality of design coordination.

$H_1$  Construction time performance **IS** dependent upon the quality of design coordination.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of *less than* 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.949	0.4782	<b><math>H_0</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 40**

**DATA ITEM: DESIGN COORDINATION COMPLEXITY**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ CR and design team communication effectiveness for decision making ( $C_s = 0.4711$ ; sig. = 0.0099).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ client representation form ( $C_s = 0.4617$ ; sig. = 0.0090);
- ☐ client organisation's confidence in the CR ( $C_s = 0.4630$ ; sig. = 0.0099);
- ☐ CR's ability to effectively brief the design team ( $C_s = 0.4830$ ; sig. = 0.0082);
- ☐ CR's confidence in the project design team ( $C_s = 0.4869$ ; sig. = 0.0067);
- ☐ *the CR's confidence in the construction team* ( $C_s = 0.4986$ ; sig. = 0.0055);
- ☐ *design buildability complexity* ( $C_s = 0.5022$ ; sig. = 0.0045);
- ☐ *general project complexity* ( $C_s = 0.6046$ ; sig. = 0.0006);
- ☐ physical environmental complexity ( $C_s = 0.4508$ ; sig. = 0.0108);
- ☐ *design team's organisational structure to manage risk* ( $C_s = 0.5709$ ; sig. = 0.0012);
- ☐ *design team's people-oriented management style* ( $C_s = 0.5606$ ; sig. = 0.0036).



## SUB-HYPOTHESIS NUMBER 41

## QUESTIONNAIRE NUMBER Q6.1

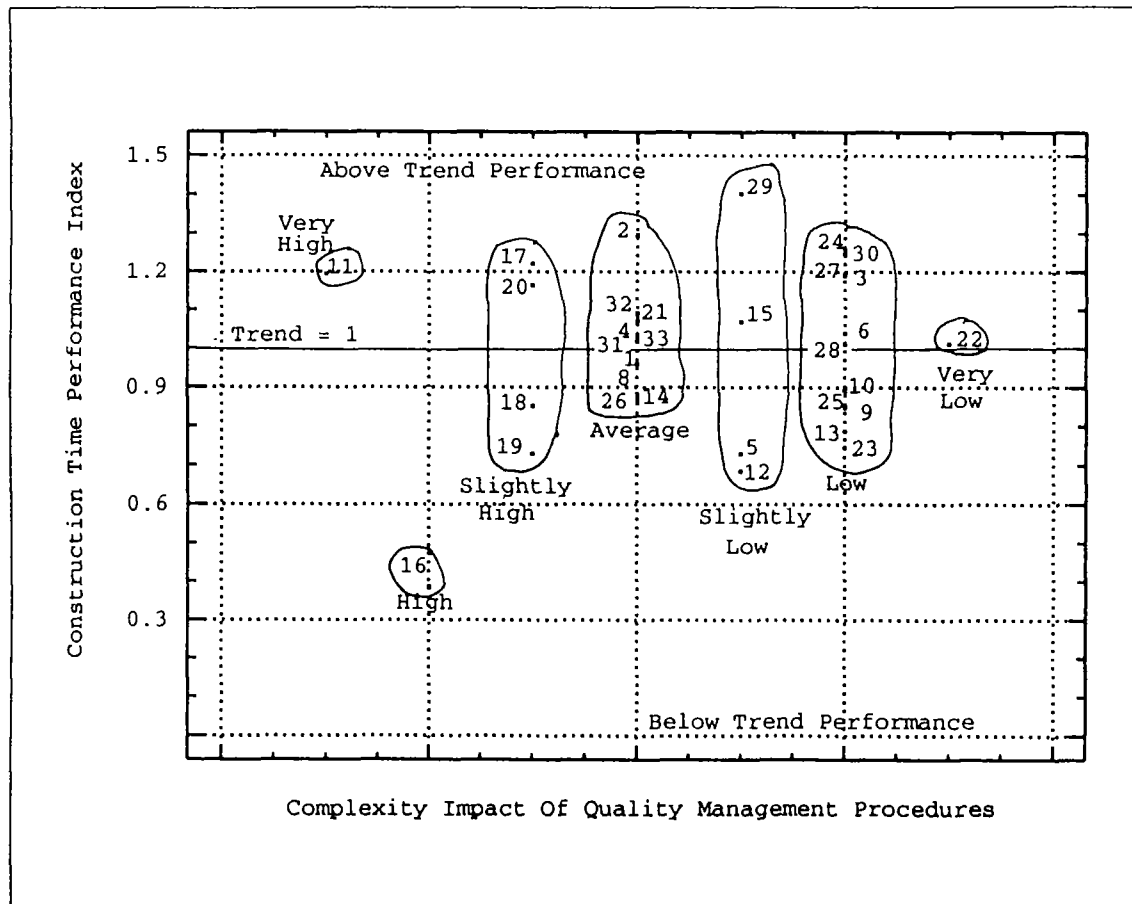
$H_0$  Construction time performance is **NOT** dependent upon the impact of quality management procedures adopted during construction.

$H_1$  Construction time performance **IS** dependent upon the impact of quality management procedures adopted during construction.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
1.688	0.1654	<b><math>H_0</math> ACCEPTED</b>

**Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)**



**SUB-HYPOTHESIS NUMBER 41**

**DATA ITEM: QUALITY MANAGEMENT PROCEDURES USED ON-SITE**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ the construction team's confidence in the CR's contribution ( $C_s = 0.4575$ ; sig. = 0.0109);
- ☐ CR's willingness to contribute effective and positive ideas ( $C_s = 0.6024$ ; sig. = 0.0008);
- ☐ CM's organisational structure to manage risk ( $C_s = 0.4717$ ; sig. = 0.0086);
- ☐ key sub-contractor's task-oriented management style ( $C_s = 0.4540$ ; sig. = 0.0115);
- ☐ CR and CM team communication effectiveness for decision making ( $C_s = 0.5227$ ; sig. = 0.0036);
- ☐ CM decision making, communicating and actioning ( $C_s = 0.4963$ ; sig. = 0.0057).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ the CR's confidence in the construction team ( $C_s = 0.4683$ ; sig. = 0.0103);
- ☐ the CR's ability to mould shared project goals and aspirations ( $C_s = 0.6055$ ; sig. = 0.0009);
- ☐ the CR's willingness to accept effective and positive ideas ( $C_s = 0.6384$ ; sig. = 0.0004);
- ☐ the overall CR contribution to project team harmony ( $C_s = 0.4759$ ; sig. = 0.0081);
- ☐ CM's effectiveness in influencing the CR decision making process ( $C_s = 0.5577$ ; sig. = 0.0019);
- ☐ CM's analysing resource movement ( $C_s = 0.4583$ ; sig. = 0.0121)
- ☐ task-orientation of the CR's management style ( $C_s = 0.4685$ ; sig. = 0.0103);
- ☐ CR's people-oriented management style ( $C_s = 0.5531$ ; sig. = 0.0025);
- ☐ direct use of power in the CR's management style ( $C_s = -0.5683$ ; sig. = 0.0019);
- ☐ task-orientation of the CM's management style ( $C_s = 0.5625$ ; sig. = 0.0017).

## SUB-HYPOTHESIS NUMBER 42

## QUESTIONNAIRE NUMBER Q7.1

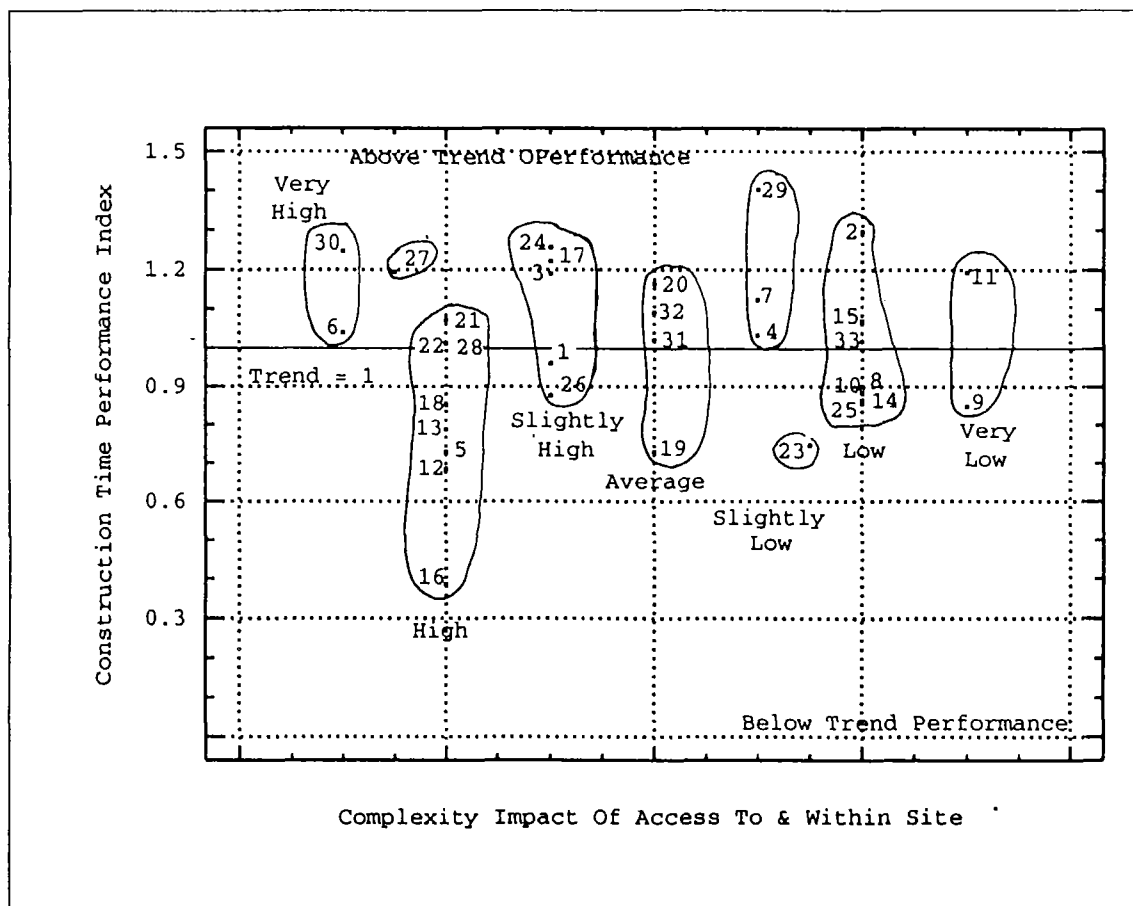
$H_0$  Construction time performance is **NOT** dependent upon the impact of access to or within site.

$H_1$  Construction time performance **IS** dependent upon the impact of access to or within site.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
1.901	0.1053	$H_0$ ACCEPTED

**Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)**



**SUB-HYPOTHESIS NUMBER 42**

**DATA ITEM: ACCESS TO AND WITHIN SITE**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ inherent site conditions ( $C_s = 0.5817$ ; sig. = 0.0010).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ general project complexity ( $C_s = 0.5681$ ; sig. = 0.0013);
- ☐ decision making communication within the design team ( $C_s = 0.5055$ ; sig. = 0.0065).

## SUB-HYPOTHESIS NUMBER 43

## QUESTIONNAIRE NUMBER Q7.3

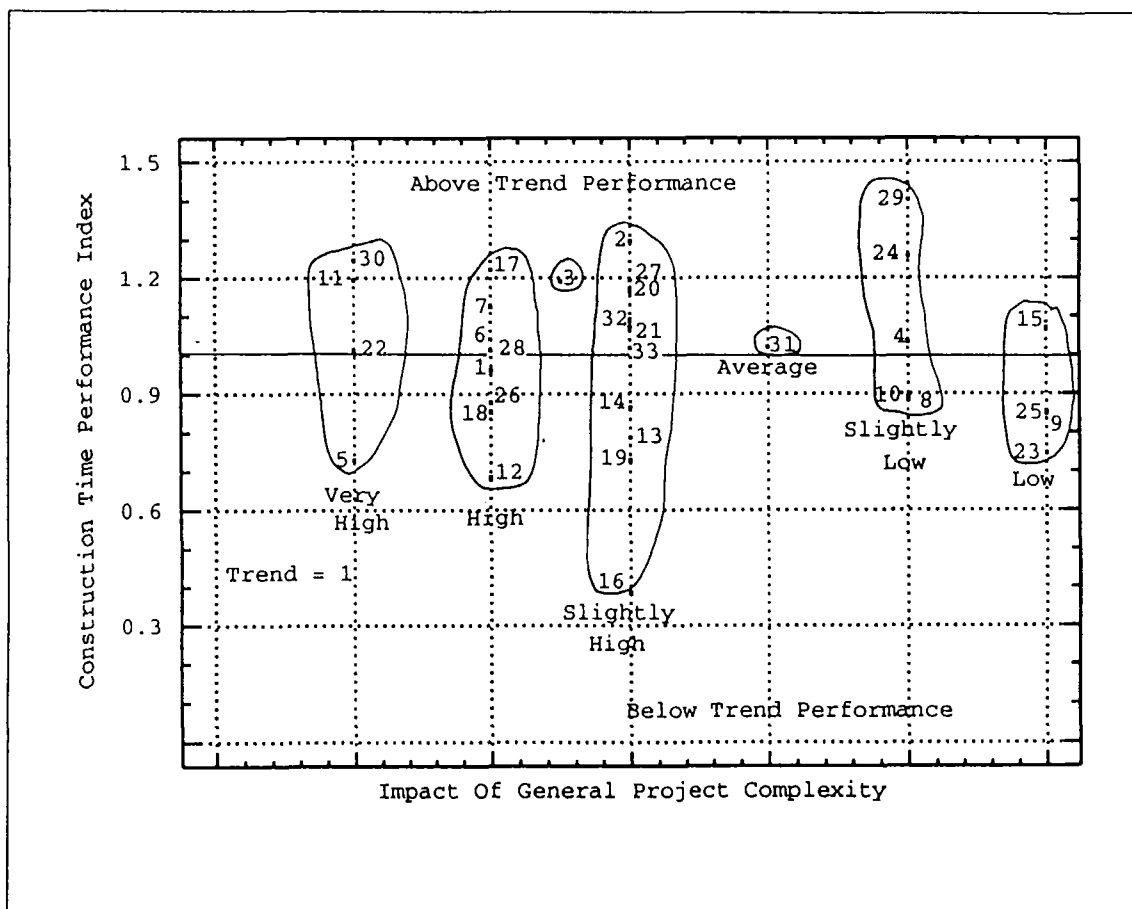
$H_0$  Construction time performance is **NOT** dependent upon the impact of general project complexity factors.

$H_1$  Construction time performance **IS** dependent upon the impact of general project complexity factors.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.559	0.7588	<b><math>H_0</math> ACCEPTED</b>

**Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)**



**SUB-HYPOTHESIS NUMBER 43**  
**DATA ITEM: GENERAL PROJECT COMPLEXITY**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ no significant correlation.

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ stability of CR decisions ( $C_s = 0.4749$ ; sig. = 0.0072);
- ☐ design buildability complexity ( $C_s = 0.5561$ ; sig. = 0.0017);
- ☐ design coordination complexity ( $C_s = 0.6046$ ; sig. = 0.0006);
- ☐ access to and within site ( $C_s = 0.5681$ ; sig. = 0.0013);
- ☐ design team's organisational structure to manage risk ( $C_s = 0.4481$ ; sig. = 0.0112);
- ☐ decision making communication within the design team ( $C_s = 0.5266$ ; sig. = 0.0046).

## SUB-HYPOTHESIS NUMBER 44

## QUESTIONNAIRE NUMBER Q8.1

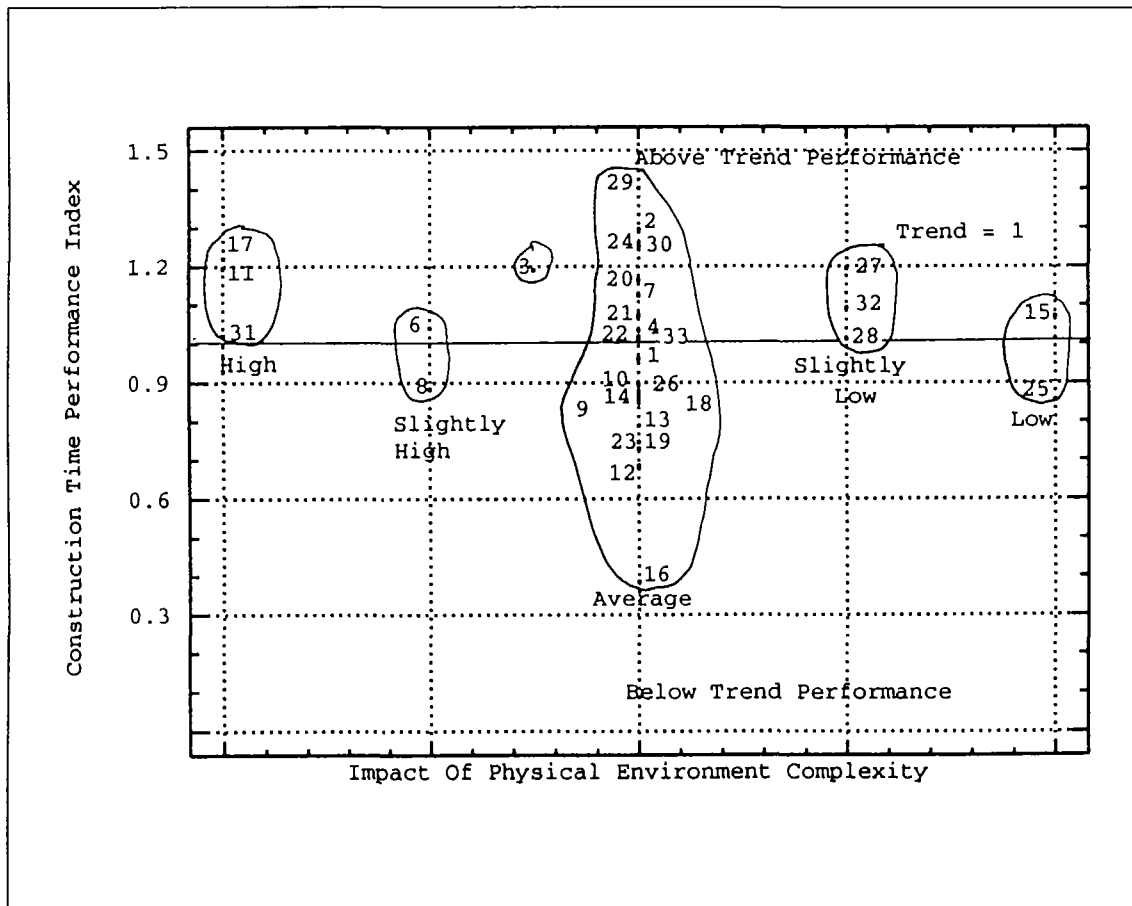
$H_0$  Construction time performance is **NOT** dependent upon the impact of the physical environment surrounding the site.

$H_1$  Construction time performance **IS** dependent upon the impact of the physical environment surrounding the site.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.757	0.5887	<b><math>H_0</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 44**

**DATA ITEM: PHYSICAL ENVIRONMENTAL COMPLEXITY**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ no significant correlation.

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ client representation form ( $C_s = 0.4606$ ; sig. = 0.0092);
- ☐ *design coordination complexity* ( $C_s = 0.4508$ ; sig. = 0.0108);
- ☐ decision making communication within the CR team ( $C_s = 0.4626$ ; sig. = 0.0144).



## SUB-HYPOTHESIS NUMBER 45

## QUESTIONNAIRE NUMBER Q9.1

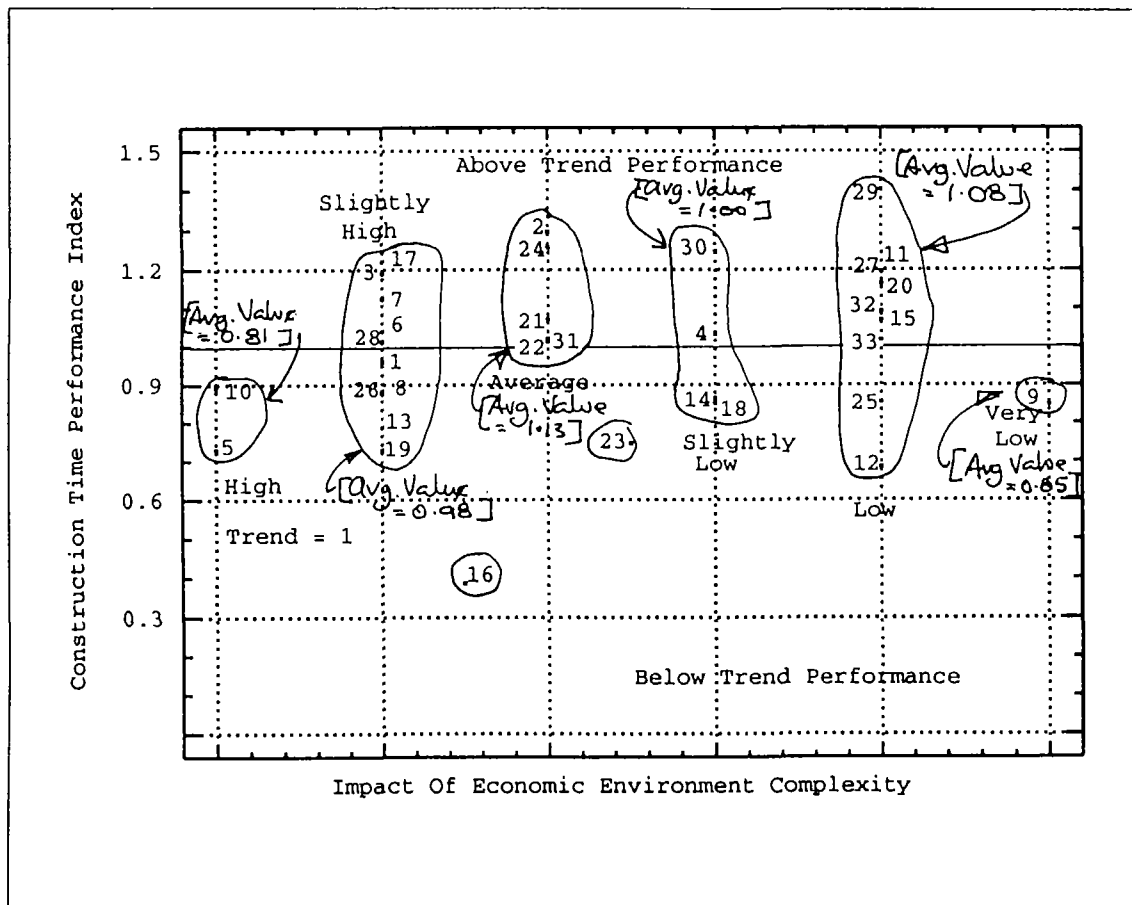
$H_0$  Construction time performance is **NOT** dependent upon the impact of the economical environment prevailing during construction.

$H_1$  Construction time performance **IS** dependent upon the impact of the economical environment prevailing during construction.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
3.076	0.0177	<b><math>H_0</math> REJECTED: <math>H_1</math> ACCEPTED</b>

**Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)**



**SUB-HYPOTHESIS NUMBER 45**

**DATA ITEM: ECONOMIC ENVIRONMENTAL COMPLEXITY**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ effectiveness of the construction team's planning ( $C_s = 0.4482$ ; sig. = 0.0112);
- ☐ CM's monitoring and updating plans to reflect work status ( $C_s = 0.4508$ ; sig. = 0.0108);
- ☐ *CM's developing an organisational structure to maintain workflow* ( $C_s = 0.5107$ ; sig. = 0.0039);
- ☐ *decision making communication within the CM team* ( $C_s = 0.5176$ ; sig. = 0.0034).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *CR's experience with the building procurement process* ( $C_s = 0.5170$ ; sig. = 0.0035);
- ☐ *impact of the IR environment* ( $C_s = 0.5100$ ; sig. = 0.0039);
- ☐ *impact of general environmental factors* ( $C_s = 0.6584$ ; sig. = 0.0002);
- ☐ *CM's analysing work sequencing to achieve and maintain workflow* ( $C_s = 0.5440$ ; sig. = 0.0021);
- ☐ design team's decision making, communicating and actioning ( $C_s = 0.4784$ ; sig. = 0.0068).

## SUB-HYPOTHESIS NUMBER 46

## QUESTIONNAIRE NUMBER Q10.1

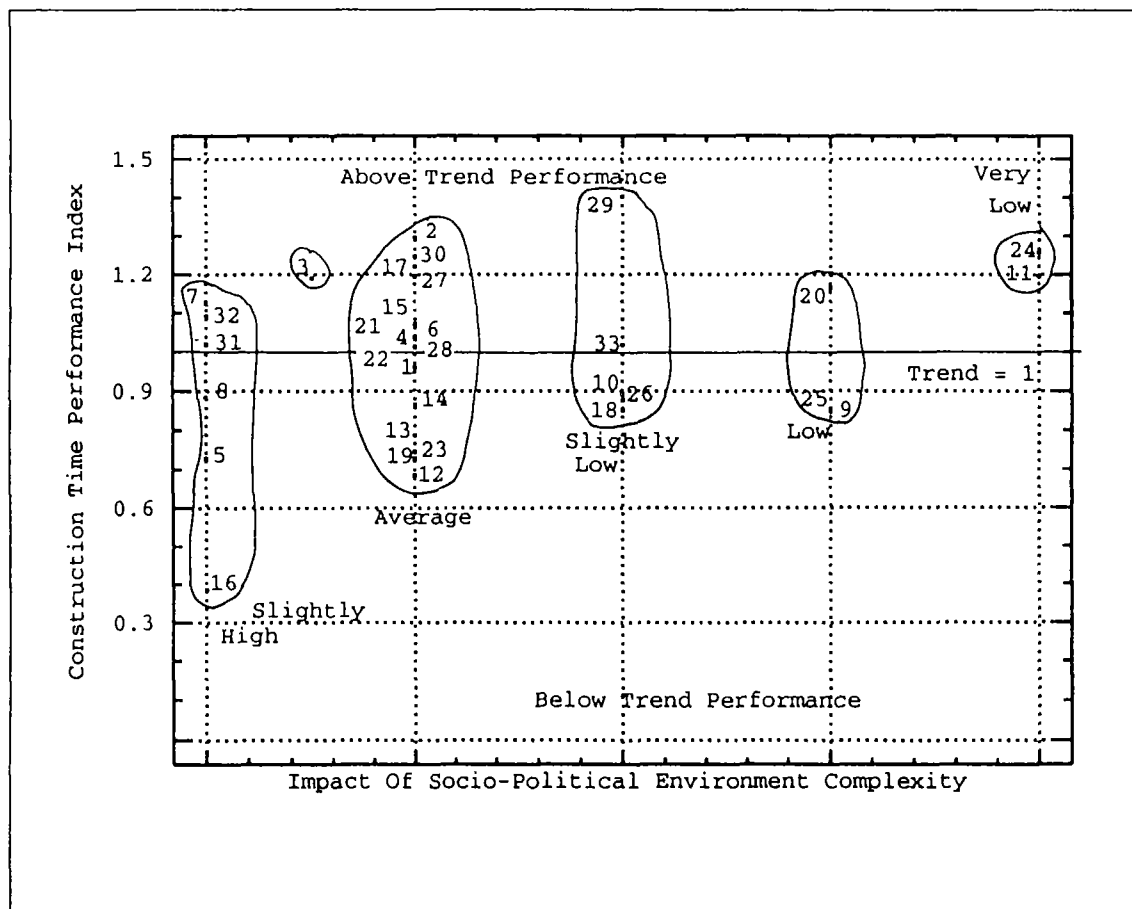
$H_0$  Construction time performance is **NOT** dependent upon the impact of the socio-political environment prevailing during construction.

$H_1$  Construction time performance **IS** dependent upon the impact of the socio-political environment prevailing during construction.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
1.061	0.4035	<b><math>H_0</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 46**

**DATA ITEM: SOCIO-POLITICAL ENVIRONMENTAL COMPLEXITY**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *decision making communication within the CM team ( $C_s = 0.5210$ ; sig. = 0.0032).*

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *design development stage at start of construction ( $C_s = 0.4633$ ; sig. = 0.0088);*
- ☐ *CR's experience with the building procurement process ( $C_s = 0.5723$ ; sig. = 0.0012);*
- ☐ *CR's ability to quickly make authoritative decisions ( $C_s = 0.5103$ ; sig. = 0.0039).*

## SUB-HYPOTHESIS NUMBER 47

## QUESTIONNAIRE NUMBER Q11.1

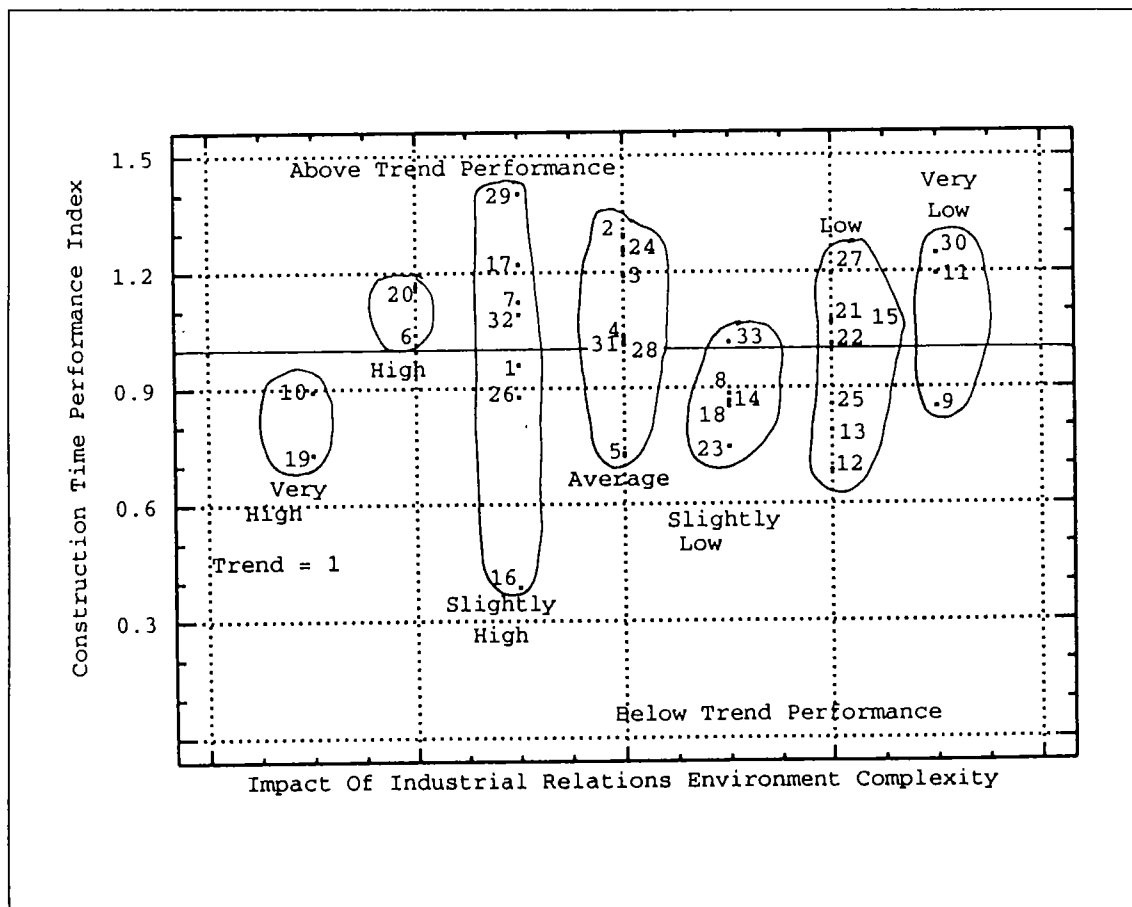
$H_0$  Construction time performance is **NOT** dependent upon the impact of the industrial relations environment prevailing during construction.

$H_1$  Construction time performance **IS** dependent upon the impact of the industrial relations environment prevailing during construction.

One-way ANOVA test results *measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.*

F-Ratio	Significance Level	Interpretation
0.922	0.4955	<b><math>H_0</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 47**

**DATA ITEM: IMPACT OF THE IR COMPLEXITY**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *economic environmental complexity ( $C_s = 0.5100$ ; sig. = 0.0039);*
- ☐ *decision making communication within the CM team ( $C_s = 0.5208$ ; sig. = 0.0032).*

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ **impact of general environmental factors ( $C_s = 0.8698$ ; sig. = 0.0000);**
- ☐ *task-orientation of the CR's management style ( $C_s = 0.4875$ ; sig. = 0.0066);*
- ☐ *flexibility of key sub-contractor's management style ( $C_s = 0.4977$ ; sig. = 0.0049);*
- ☐ *decision making communication within the design team ( $C_s = 0.5037$ ; sig. = 0.0067).*

## SUB-HYPOTHESIS NUMBER 48

## QUESTIONNAIRE NUMBER Q11.3

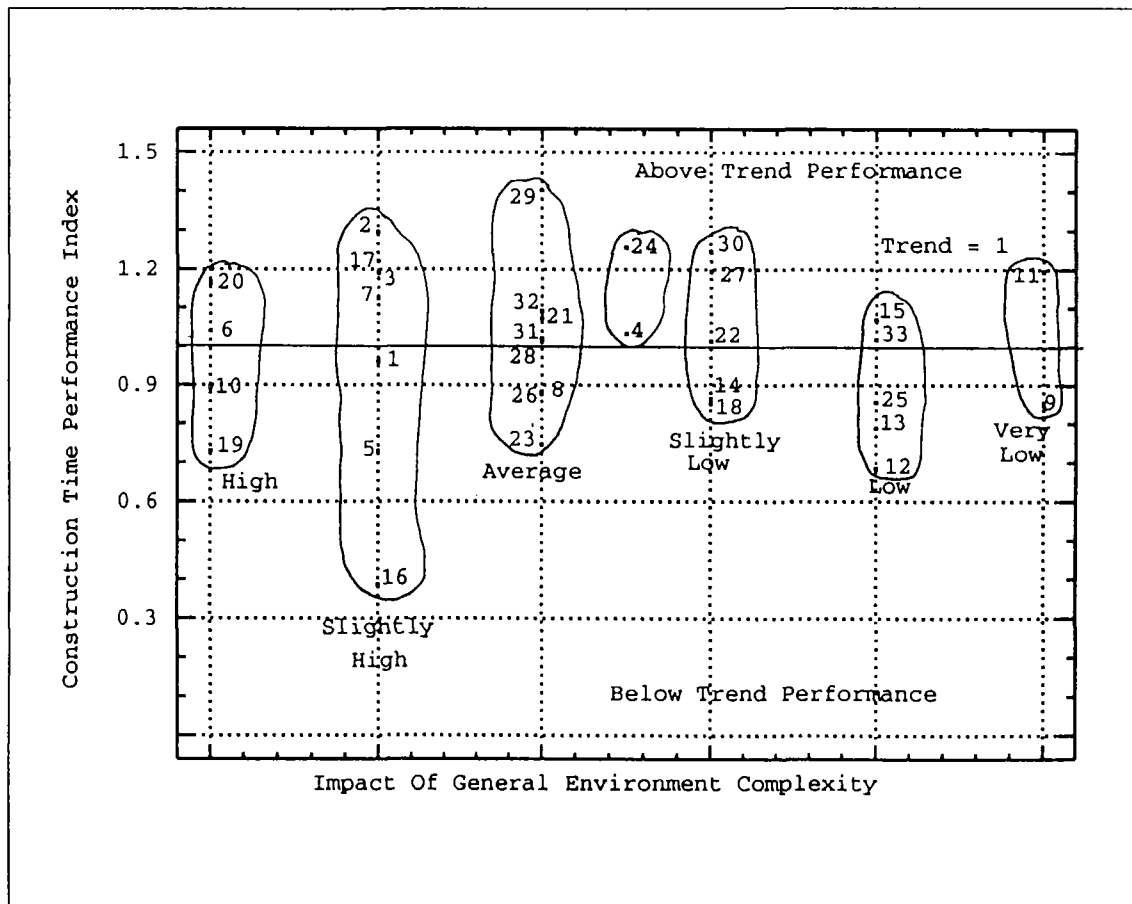
$H_0$  Construction time performance is **NOT** dependent upon the impact of general environmental factors prevailing during construction.

$H_1$  Construction time performance **IS** dependent upon the impact of general environmental factors prevailing during construction.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.406	0.8681	<b><math>H_0</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 48**

**DATA ITEM: IMPACT OF GENERAL ENVIRONMENTAL FACTORS**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *economic environmental complexity* ( $C_s = 0.6584$ ; sig. = 0.0002);
- ☐ *decision making communication within the CM team* ( $C_s = 0.5010$ ; sig. = 0.0046).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ CR's experience with the building procurement process ( $C_s = 0.4575$ ; sig. = 0.0097);
- ☐ **impact of the IR environment** ( $C_s = 0.8693$ ; sig. = 0.0000);
- ☐ task-orientation of the CR's management style ( $C_s = 0.4540$ ; sig. = 0.0115);
- ☐ flexibility of key sub-contractor's management style ( $C_s = 0.4819$ ; sig. = 0.0064);
- ☐ decision making communication within the design team ( $C_s = 0.4591$ ; sig. = 0.0134).



## SUB-HYPOTHESIS NUMBER 49

## QUESTIONNAIRE NUMBER Q12.1

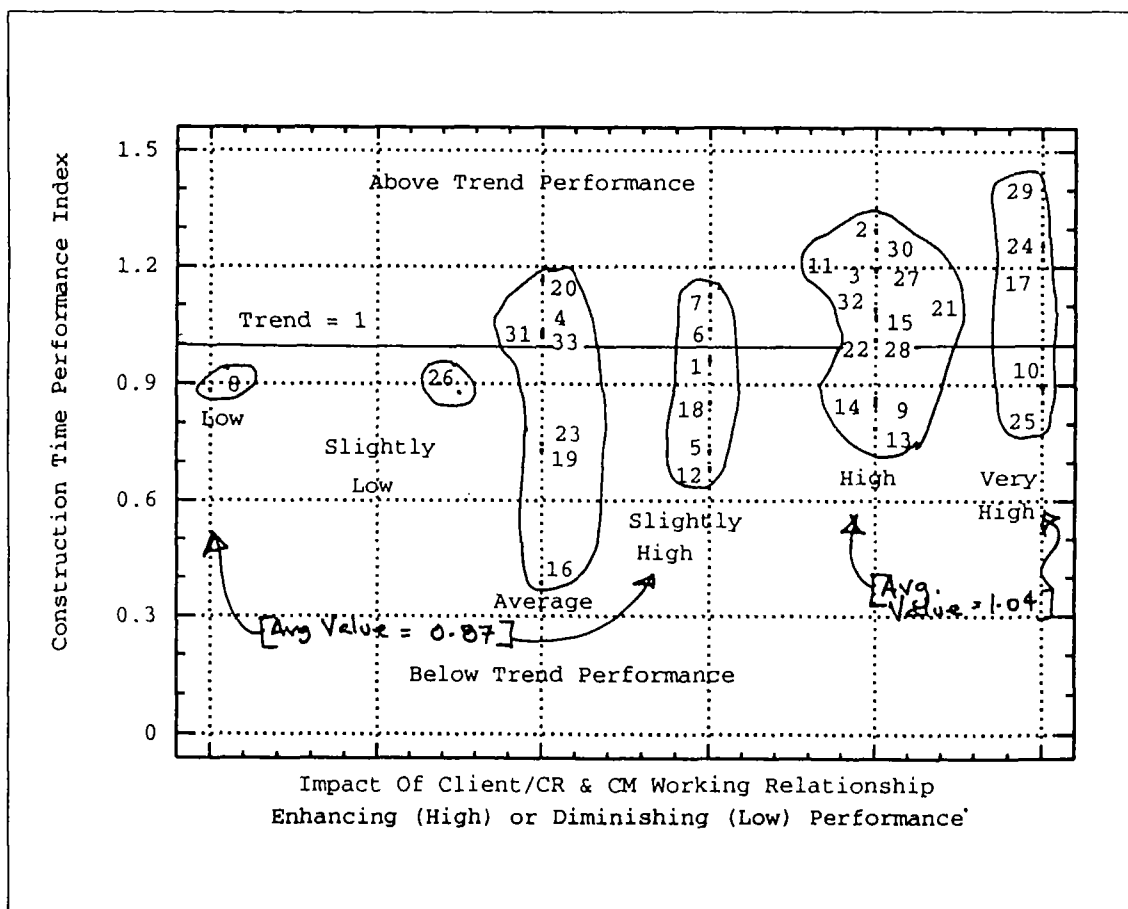
$H_0$  Construction time performance is **NOT** dependent upon the impact of a better or equal to slightly good level of client/construction team working relationship.

$H_1$  Construction time performance **IS** dependent upon the impact of a better or equal to slightly good level of client/construction team working relationship.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of *less than* 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
4.289	0.0468	<b><math>H_0</math> REJECTED: <math>H_1</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 49**

**DATA ITEM: IMPACT OF CR/CM WORKING RELATIONSHIP**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *construction time estimate plus approved EOT being within 5% of actual construction time ( $C_s = 0.5032$ ; sig. = 0.0044);*
- ☐ *client/CR's time minimisation objective ( $C_s = 0.5537$ ; sig. = 0.0017);*
- ☐ *ability of the CR to contribute ideas to the design process ( $C_s = 0.6273$ ; sig. = 0.0005);*
- ☐ *ability of the CR to contribute ideas to the construction process ( $C_s = 0.5551$ ; sig. = 0.0017);*
- ☐ **the project design team's confidence in the CR contribution ( $C_s = 0.6977$ ; sig. = 0.0001);**
- ☐ **the construction team's confidence in the CR's contribution ( $C_s = 0.8278$ ; sig. = 0.0000);**
- ☐ *CR's willingness to contribute effective and positive ideas ( $C_s = 0.6308$ ; sig. = 0.0004);*
- ☐ *CM's forecasting planning data ( $C_s = 0.5671$ ; sig. = 0.0016);*
- ☐ *CM's analysing construction methods ( $C_s = 0.5407$ ; sig. = 0.0022);*
- ☐ *effectiveness of the construction team's planning ( $C_s = 0.6014$ ; sig. = 0.0007);*
- ☐ *CM's monitoring and updating plans to reflect work status ( $C_s = 0.5057$ ; sig. = 0.0042);*
- ☐ *CM's planning - responding to problems or opportunities ; sig. = 0.5775; sig. = 0.0011);*
- ☐ *CM's effectively coordinating resources ( $C_s = 0.6161$ ; sig. = 0.0005);*
- ☐ *CM's developing an organisational structure to maintain workflow ( $C_s = 0.5781$ ; sig. = 0.0011);*
- ☐ *effectiveness of the construction team's monitoring and control ( $C_s = 0.6782$ ; sig. = 0.0001);*
- ☐ *CM's organisational structure to manage risk ( $C_s = 0.6354$ ; sig. = 0.0003);*
- ☐ *key sub-contractor's task-oriented management style ( $C_s = 0.6008$ ; sig. = 0.0007);*
- ☐ **CM's communication management to facilitate decision making ( $C_s = 0.7080$ ; sig. = 0.0001);**
- ☐ *CR and CM team communication effectiveness for decision making ( $C_s = 0.6394$ ; sig. = 0.0003);*
- ☐ *CR and design team communication effectiveness for decision making ( $C_s = 0.5523$ ; sig. = 0.0025);*
- ☐ *decision making communication within the CM team ( $C_s = 0.6355$ ; sig. = 0.0003);*
- ☐ *CM decision making, communicating and actioning ( $C_s = 0.6273$ ; sig. = 0.0004);*
- ☐ *CM's effective use of information technologies ( $C_s = 0.4509$ ; sig. = 0.0107);*
- ☐ *effectiveness of the CM team in managing the construction process ( $C_s = 0.5939$ ; sig. = 0.0008).*

**SUB-HYPOTHESIS NUMBER 49**

**DATA ITEM: IMPACT OF CR/CM WORKING RELATIONSHIP**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *construction time estimate plus approved EOT being within 5% of actual construction time ( $C_s = 0.5032$ ; sig. = 0.0044);*
- ☐ *client/CR's time minimisation objective ( $C_s = 0.5537$ ; sig. = 0.0017);*
- ☐ *ability of the CR to contribute ideas to the design process ( $C_s = 0.6273$ ; sig. = 0.0005);*
- ☐ *ability of the CR to contribute ideas to the construction process ( $C_s = 0.5551$ ; sig. = 0.0017);*
- ☐ **the project design team's confidence in the CR contribution ( $C_s = 0.6977$ ; sig. = 0.0001);**
- ☐ **the construction team's confidence in the CR's contribution ( $C_s = 0.8278$ ; sig. = 0.0000);**
- ☐ *CR's willingness to contribute effective and positive ideas ( $C_s = 0.6308$ ; sig. = 0.0004);*
- ☐ *CM's forecasting planning data ( $C_s = 0.5671$ ; sig. = 0.0016);*
- ☐ *CM's analysing construction methods ( $C_s = 0.5407$ ; sig. = 0.0022);*
- ☐ *effectiveness of the construction team's planning ( $C_s = 0.6014$ ; sig. = 0.0007);*
- ☐ *CM's monitoring and updating plans to reflect work status ( $C_s = 0.5057$ ; sig. = 0.0042);*
- ☐ *CM's planning - responding to problems or opportunities ; sig. = 0.5775; sig. = 0.0011);*
- ☐ *CM's effectively coordinating resources ( $C_s = 0.6161$ ; sig. = 0.0005);*
- ☐ *CM's developing an organisational structure to maintain workflow ( $C_s = 0.5781$ ; sig. = 0.0011);*
- ☐ *effectiveness of the construction team's monitoring and control ( $C_s = 0.6782$ ; sig. = 0.0001);*
- ☐ *CM's organisational structure to manage risk ( $C_s = 0.6354$ ; sig. = 0.0003);*
- ☐ *key sub-contractor's task-oriented management style ( $C_s = 0.6008$ ; sig. = 0.0007);*
- ☐ **CM's communication management to facilitate decision making ( $C_s = 0.7080$ ; sig. = 0.0001);**
- ☐ *CR and CM team communication effectiveness for decision making ( $C_s = 0.6394$ ; sig. = 0.0003);*
- ☐ *CR and design team communication effectiveness for decision making ( $C_s = 0.5523$ ; sig. = 0.0025);*
- ☐ *decision making communication within the CM team ( $C_s = 0.6355$ ; sig. = 0.0003);*
- ☐ *CM decision making, communicating and actioning ( $C_s = 0.6273$ ; sig. = 0.0004);*
- ☐ *CM's effective use of information technologies ( $C_s = 0.4509$ ; sig. = 0.0107);*
- ☐ *effectiveness of the CM team in managing the construction process ( $C_s = 0.5939$ ; sig. = 0.0008).*

**SUB-HYPOTHESIS NUMBER 49**

**DATA ITEM: IMPACT OF CR/CM WORKING RELATIONSHIP**

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *building end use* ( $C_s = 0.6230$ ; sig. = 0.0004);
- ☐ *client organisation's confidence in the CR* ( $C_s = 0.4882$ ; sig. = 0.0066);
- ☐ *stability of client/CR objectives* ( $C_s = 0.5141$ ; sig. = 0.0036);
- ☐ *clarity of communication of client/CR objectives* ( $C_s = 0.6395$ ; sig. = 0.0003);
- ☐ *complexity of CR's influence upon the project's management* ( $C_s = 0.6018$ ; sig. = 0.0007);
- ☐ *CR's understanding the project's constraints* ( $C_s = 0.4580$ ; sig. = 0.0096);
- ☐ **CR's ability to quickly make authoritative decisions** ( $C_s = 0.7399$ ; sig. = 0.0000);
- ☐ *CR's ability to effectively brief the design team* ( $C_s = 0.5837$ ; sig. = 0.0014);
- ☐ *stability of CR decisions* ( $C_s = 0.6081$ ; sig. = 0.0006);
- ☐ *the CR's confidence in the construction team* ( $C_s = 0.5653$ ; sig. = 0.0016);
- ☐ *the CR's ability to mould shared project goals and aspirations* ( $C_s = 0.5739$ ; sig. = 0.0014);
- ☐ *the CR's willingness to accept effective and positive ideas* ( $C_s = 0.5693$ ; sig. = 0.0013);
- ☐ *the overall CR contribution to project team harmony* ( $C_s = 0.6754$ ; sig. = 0.0001);
- ☐ **CM's effectiveness in influencing the CR decision making process** ( $C_s = 0.7277$ ; sig. = 0.0000);
- ☐ *CM management systems and procedures* ( $C_s = 0.5241$ ; sig. = 0.0030);
- ☐ **CR's organisational structure to manage risk** ( $C_s = 0.7212$ ; sig. = 0.0000);
- ☐ *key sub-contractor's organisational structure to manage risk* ( $C_s = 0.5556$ ; sig. = 0.0020);
- ☐ *CM's effectiveness in team management to achieve synergy* ( $C_s = 0.6831$ ; sig. = 0.0001);
- ☐ *flexibility of the CR's management style* ( $C_s = 0.5779$ ; sig. = 0.0011);
- ☐ *CR's people-oriented management style* ( $C_s = 0.4900$ ; sig. = 0.0064);
- ☐ *direct use of power in the CR's management style* ( $C_s = -0.5603$ ; sig. = 0.0018);
- ☐ *direct use of power in the design team's management style* ( $C_s = -0.4618$ ; sig. = 0.0237);
- ☐ *flexibility of the CM's management style* ( $C_s = 0.5420$ ; sig. = 0.0022);
- ☐ *task-orientation of the CM's management style* ( $C_s = 0.4687$ ; sig. = 0.0080);
- ☐ *decision making communication within the CR team* ( $C_s = 0.5610$ ; sig. = 0.0030);
- ☐ *CR decision making, communicating and actioning* ( $C_s = 0.5961$ ; sig. = 0.0007);
- ☐ *CR's effective use of information technologies* ( $C_s = 0.4573$ ; sig. = 0.0674).

## SUB-HYPOTHESIS NUMBER 50

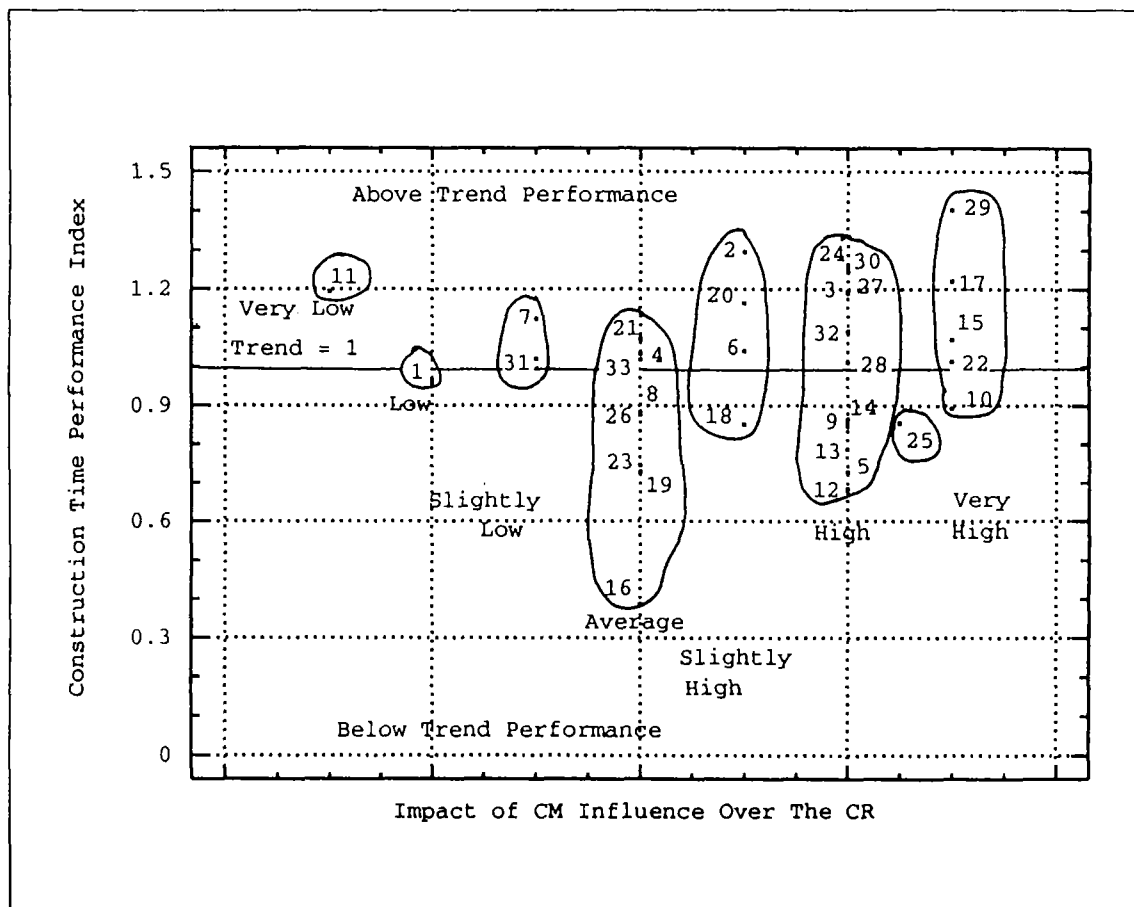
## QUESTIONNAIRE NUMBER Q12.2

- $H_0$  Construction time performance is **NOT** dependent upon the impact of the influence the construction manager may have over the CR decision making process.
- $H_1$  Construction time performance **IS** dependent upon the impact of the influence the construction manager may have over the CR decision making process.

One-way ANOVA test results *measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.*

F-Ratio	Significance Level	Interpretation
1.210	0.3338	<b><math>H_0</math> ACCEPTED</b>

**Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)**



**SUB-HYPOTHESIS NUMBER 50**

**DATA ITEM: CM'S INFLUENCING THE CR DECISION MAKING PROCESS**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *client/CR's time minimisation objective* ( $C_s = 0.5522$ ; sig. = 0.0018);
- ☐ *ability of the CR to contribute ideas to the design process* ( $C_s = 0.6266$ ; sig. = 0.0005);
- ☐ *ability of the CR to contribute ideas to the construction process* ( $C_s = 0.5172$ ; sig. = 0.0034);
- ☐ *the construction team's confidence in the CR's contribution* ( $C_s = 0.6895$ ; sig. = 0.0001);
- ☐ **CR's willingness to contribute effective and positive ideas** ( $C_s = 0.7538$ ; sig. = 0.0000);
- ☐ **impact of CR/CM working relationship** ( $C_s = 0.7277$ ; sig. = 0.0000);
- ☐ *CM's forecasting planning data* ( $C_s = 0.5591$ ; sig. = 0.0019);
- ☐ *CM's analysing construction methods* ( $C_s = 0.6893$ ; sig. = 0.0001);
- ☐ *effectiveness of the construction team's planning* ( $C_s = 0.6746$ ; sig. = 0.0001);
- ☐ *CM's monitoring and updating plans to reflect work status* ( $C_s = 0.5046$ ; sig. = 0.0043);
- ☐ *CM's planning - responding to problems or opportunities* ( $C_s = 0.5935$ ; sig. = 0.0008);
- ☐ *CM's effectively coordinating resources* ( $C_s = 0.6113$ ; sig. = 0.0005);
- ☐ *CM's developing an organisational structure to maintain workflow* ( $C_s = 0.4643$ ; sig. = 0.0086);
- ☐ *effectiveness of the construction team's monitoring and control* ( $C_s = 0.6199$ ; sig. = 0.0005);
- ☐ *CM's organisational structure to manage risk* ( $C_s = 0.4932$ ; sig. = 0.0053);
- ☐ *key sub-contractor's task-oriented management style* ( $C_s = 0.5477$ ; sig. = 0.0019);
- ☐ *CM's communication management to facilitate decision making* ( $C_s = 0.5822$ ; sig. = 0.0010);
- ☐ *CR and CM team communication effectiveness for decision making* ( $C_s = 0.6386$ ; sig. = 0.0003);
- ☐ *decision making communication within the CM team* ( $C_s = 0.5591$ ; sig. = 0.0016);
- ☐ **CM decision making, communicating and actioning** ( $C_s = 0.7630$ ; sig. = 0.0000);
- ☐ *effectiveness of the CM team in managing the construction process* ( $C_s = 0.4849$ ; sig. = 0.0061).

**SUB-HYPOTHESIS NUMBER 50**

**DATA ITEM: CM'S INFLUENCING THE CR DECISION MAKING PROCESS**

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *client organisation's confidence in the CR* ( $C_s = 0.5280$ ; sig. = 0.0033);
- ☐ *clarity of communication of client/CR objectives* ( $C_s = 0.5591$ ; sig. = 0.0016);
- ☐ *complexity of CR's influence upon the project's management* ( $C_s = 0.5322$ ; sig. = 0.0026);
- ☐ *CR's understanding the project's constraints* ( $C_s = 0.5215$ ; sig. = 0.0032);
- ☐ *CR's ability to quickly make authoritative decisions* ( $C_s = 0.4611$ ; sig. = 0.0091);
- ☐ *CR's ability to effectively brief the design team* ( $C_s = 0.6200$ ; sig. = 0.0007);
- ☐ *stability of CR decisions* ( $C_s = 0.6130$ ; sig. = 0.0005);
- ☐ *the CR's confidence in the construction team* ( $C_s = 0.5717$ ; sig. = 0.1105);
- ☐ *the CR's ability to mould shared project goals and aspirations* ( $C_s = 0.6326$ ; sig. = 0.0004);
- ☐ *the CR's willingness to accept effective and positive ideas* ( $C_s = 0.5737$ ; sig. = 0.0012);
- ☐ *the overall CR contribution to project team harmony* ( $C_s = 0.6622$ ; sig. = 0.0002);
- ☐ *quality management procedures used on-site* ( $C_s = 0.5577$ ; sig. = 0.0109);
- ☐ *CR's organisational structure to manage risk* ( $C_s = 0.5052$ ; sig. = 0.0043);
- ☐ *CM's effectiveness in team management to achieve synergy* ( $C_s = 0.6028$ ; sig. = 0.0006);
- ☐ *flexibility of the CR's management style* ( $C_s = 0.6417$ ; sig. = 0.0003);
- ☐ *CR's people-oriented management style* ( $C_s = 0.6174$ ; sig. = 0.0006);
- ☐ *direct use of power in the CR's management style* ( $C_s = -0.5156$ ; sig. = 0.0041);
- ☐ *flexibility of the CM's management style* ( $C_s = 0.4589$ ; sig. = 0.0094);
- ☐ *task-orientation of the CM's management style* ( $C_s = 0.5452$ ; sig. = 0.0020);
- ☐ **decision making communication within the CR team** ( $C_s = 0.6954$ ; sig. = 0.0002);
- ☐ *CR decision making, communicating and actioning* ( $C_s = 0.5051$ ; sig. = 0.0043).

## SUB-HYPOTHESIS NUMBER 51

## QUESTIONNAIRE NUMBER Q13.1

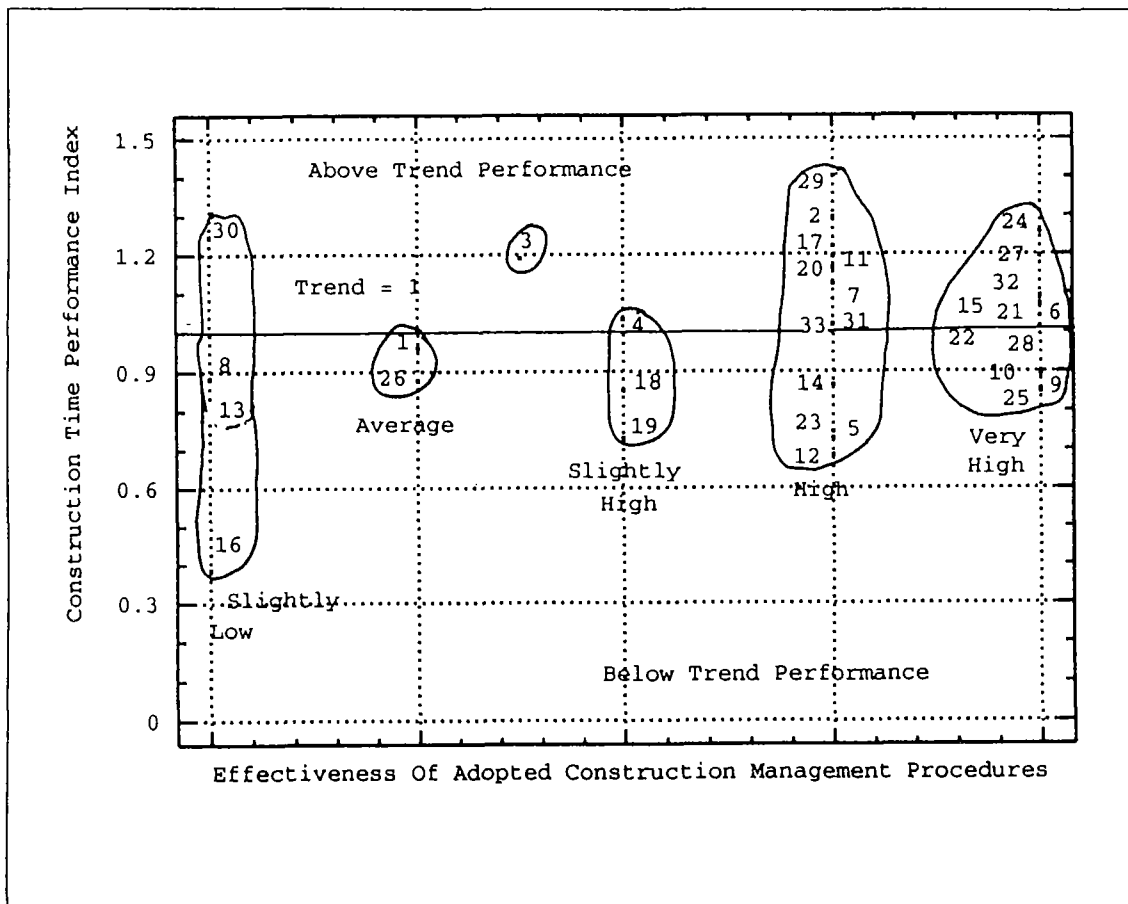
$H_0$  Construction time performance is **NOT** dependent upon effective construction management procedures.

$H_1$  Construction time performance **IS** dependent upon the effective construction management procedures.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
1.104	0.3813	<b><math>H_0</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*





**SUB-HYPOTHESIS NUMBER 51**

**DATA ITEM: CM MANAGEMENT SYSTEMS AND PROCEDURES**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ client/CR's time minimisation objective ( $C_s = 0.4748$ ; sig. = 0.0072);
- ☐ the construction team's confidence in the CR's contribution ( $C_s = 0.4686$ ; sig. = 0.0080);
- ☐ *impact of CR/CM working relationship* ( $C_s = 0.5241$ ; sig. = 0.0030);
- ☐ *CM's forecasting planning data* ( $C_s = 0.6609$ ; sig. = 0.0002);
- ☐ *CM's analysing construction methods* ( $C_s = 0.5912$ ; sig. = 0.0008);
- ☐ **effectiveness of the construction team's planning** ( $C_s = 0.7058$ ; sig. = 0.0001);
- ☐ *CM's monitoring and updating plans to reflect work status* ( $C_s = 0.6332$ ; sig. = 0.0003);
- ☐ *CM's planning - responding to problems or opportunities* ( $C_s = 0.6323$ ; sig. = 0.0003);
- ☐ **CM's effectively coordinating resources** ( $C_s = 0.7186$ ; sig. = 0.0000);
- ☐ **CM's developing an organisational structure to maintain workflow** ( $C_s = 0.8032$ ; sig. = 0.0000);
- ☐ **effectiveness of the construction team's planning** ( $C_s = 0.7334$ ; sig. = 0.0000);
- ☐ *CM's organisational structure to manage risk* ( $C_s = 0.5804$ ; sig. = 0.0010);
- ☐ key sub-contractor's task-oriented management style ( $C_s = 0.4716$ ; sig. = 0.0076);
- ☐ *CM's communication management to facilitate decision making* ( $C_s = 0.6083$ ; sig. = 0.0006);
- ☐ decision making communication within the CM team ( $C_s = 0.4889$ ; sig. = 0.0057);
- ☐ *CM decision making, communicating and actioning* ( $C_s = 0.6630$ ; sig. = 0.0002);
- ☐ **effectiveness of the CM team in managing the construction process** ( $C_s = 0.7035$ ; sig. = 0.0001).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *ratio of EOT:actual construction time* ( $C_s = -0.5339$ ; sig. = 0.0025);
- ☐ *stability of client/CR objectives* ( $C_s = 0.6221$ ; sig. = 0.0004);
- ☐ *clarity of communication of client/CR objectives* ( $C_s = 0.6218$ ; sig. = 0.0004);
- ☐ *complexity of CR's influence upon the project's management* ( $C_s = 0.5340$ ; sig. = 0.0025);
- ☐ *CR's ability to quickly make authoritative decisions* ( $C_s = 0.5051$ ; sig. = 0.0043);
- ☐ *stability of CR decisions* ( $C_s = 0.5275$ ; sig. = 0.0028);
- ☐ the CR's willingness to accept effective and positive ideas ( $C_s = 0.4666$ ; sig. = 0.0083);
- ☐ *the CR's confidence in the construction team* ( $C_s = 0.5211$ ; sig. = 0.0037);
- ☐ *CM's analysing resource movement* ( $C_s = 0.5986$ ; sig. = 0.0009);
- ☐ *CM's analysing work sequencing to achieve and maintain workflow* ( $C_s = 0.6638$ ; sig. = 0.0002);
- ☐ *CR's organisational structure to manage risk* ( $C_s = 0.5309$ ; sig. = 0.0027);
- ☐ key sub-contractor's organisational structure to manage risk ( $C_s = 0.4665$ ; sig. = 0.0094);
- ☐ *CM's effectiveness in team management to achieve synergy* ( $C_s = 0.6532$ ; sig. = 0.0002);
- ☐ *flexibility of the CR's management style* ( $C_s = 0.4745$ ; sig. = 0.0072);
- ☐ *task-orientation of the CM's management style* ( $C_s = 0.5067$ ; sig. = 0.0042);
- ☐ *CM's people-oriented management style* ( $C_s = 0.5997$ ; sig. = 0.0007);
- ☐ *key sub-contractor's people-oriented management style* ( $C_s = 0.5293$ ; sig. = 0.0028);
- ☐ *decision making communication within the CR team* ( $C_s = 0.5585$ ; sig. = 0.0031);
- ☐ *CR decision making, communicating and actioning* ( $C_s = 0.6686$ ; sig. = 0.0002);

## SUB-HYPOTHESIS NUMBER 52

## QUESTIONNAIRE NUMBER Q13.3.1

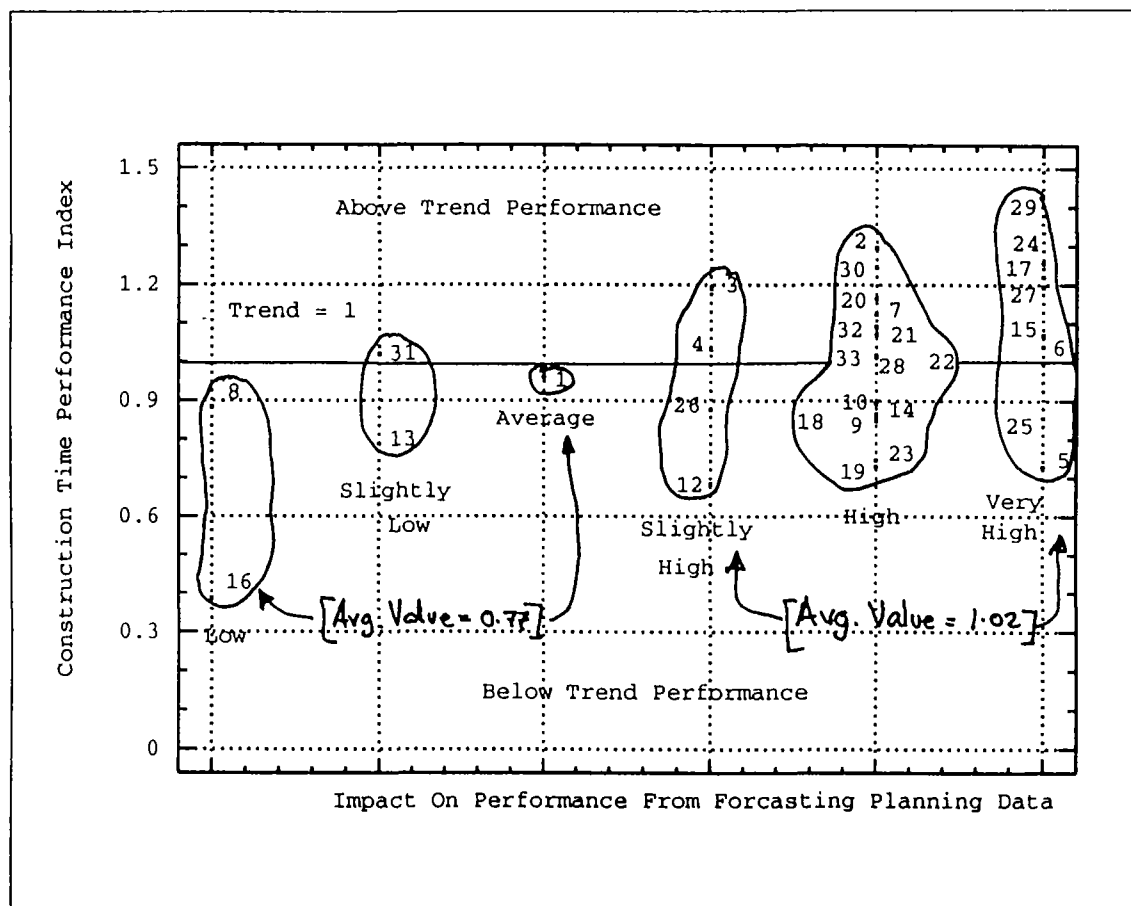
$H_0$  Construction time performance is **NOT** dependent upon the CM achieving a better than average level of forecasting planning data.

$H_1$  Construction time performance **IS** dependent upon the CM achieving a better than average level of forecasting planning data.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
5.369	0.0275	<b><math>H_0</math> REJECTED: <math>H_1</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 52**

**DATA ITEM: CM'S FORECASTING PLANNING DATA**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ client/CR's time minimisation objective ( $C_s = 0.4835$ ; sig. = 0.0071);
- ☐ client/CR's quality performance objective ( $C_s = 0.6029$ ; sig. = 0.0008);
- ☐ ability of the CR to contribute ideas to the design process ( $C_s = 0.6283$ ; sig. = 0.0006);
- ☐ CR's willingness to contribute effective and positive ideas ( $C_s = 0.4905$ ; sig. = 0.0063);
- ☐ the construction team's confidence in the CR's contribution ( $C_s = 0.5581$ ; sig. = 0.0019);
- ☐ impact of CR/CM working relationship ( $C_s = 0.5671$ ; sig. = 0.0016);
- ☐ **CM's analysing construction methods ( $C_s = 0.7214$ ; sig. = 0.0001);**
- ☐ **effectiveness of the construction team's planning ( $C_s = 0.7872$ ; sig. = 0.0000);**
- ☐ CM's monitoring and updating plans to reflect work status ( $C_s = 0.6718$ ; sig. = 0.0002);
- ☐ CM's planning - responding to problems or opportunities ( $C_s = 0.5709$ ; sig. = 0.0015);
- ☐ CM's effectively coordinating resources ( $C_s = 0.4886$ ; sig. = 0.0065);
- ☐ CM's developing an organisational structure to maintain workflow ( $C_s = 0.6849$ ; sig. = 0.0001);
- ☐ effectiveness of the construction team's monitoring and control ( $C_s = 0.5647$ ; sig. = 0.0017);
- ☐ CM's organisational structure to manage risk ( $C_s = 0.6144$ ; sig. = 0.0006);
- ☐ key sub-contractor's task-oriented management style ( $C_s = 0.5184$ ; sig. = 0.0039);
- ☐ CM's communication management to facilitate decision making ( $C_s = 0.5417$ ; sig. = 0.0026);
- ☐ CM decision making, communicating and actioning ( $C_s = 0.6328$ ; sig. = 0.0004);
- ☐ CM's effective use of information technologies ( $C_s = 0.4544$ ; sig. = 0.0114);
- ☐ **effectiveness of the CM team in managing the construction process ( $C_s = 0.7968$ ; sig. = 0.0000).**

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ stability of client/CR objectives ( $C_s = 0.5054$ ; sig. = 0.0049);
- ☐ clarity of communication of client/CR objectives ( $C_s = 0.5656$ ; sig. = 0.0016);
- ☐ complexity of CR's influence upon the project's management ( $C_s = 0.5086$ ; sig. = 0.0046);
- ☐ CR's ability to quickly make authoritative decisions ( $C_s = 0.4796$ ; sig. = 0.0074);
- ☐ stability of CR decisions ( $C_s = 0.5275$ ; sig. = 0.0033);
- ☐ the CR's confidence in the construction team ( $C_s = 0.5446$ ; sig. = 0.0029);
- ☐ the CR's ability to mould shared project goals and aspirations ( $C_s = 0.4831$ ; sig. = 0.0081);
- ☐ CM's effectiveness in influencing the CR decision making process ( $C_s = 0.5591$ ; sig. = 0.0019);
- ☐ CM management systems and procedures ( $C_s = 0.6609$ ; sig. = 0.0002);
- ☐ CM's analysing work sequencing to achieve and maintain workflow ( $C_s = 0.6216$ ; sig. = 0.0005);
- ☐ CR's organisational structure to manage risk ( $C_s = 0.4706$ ; sig. = 0.0088);
- ☐ CM's effectiveness in team management to achieve synergy ( $C_s = 0.5110$ ; sig. = 0.0044);
- ☐ flexibility of the CM's management style ( $C_s = 0.4749$ ; sig. = 0.0082);
- ☐ task-orientation of the CM's management style ( $C_s = 0.4809$ ; sig. = 0.0074);
- ☐ decision making communication within the CR team ( $C_s = 0.5404$ ; sig. = 0.0050);
- ☐ CR decision making, communicating and actioning ( $C_s = 0.5484$ ; sig. = 0.0023).

## SUB-HYPOTHESIS NUMBER 53

## QUESTIONNAIRE NUMBER Q13.3.2

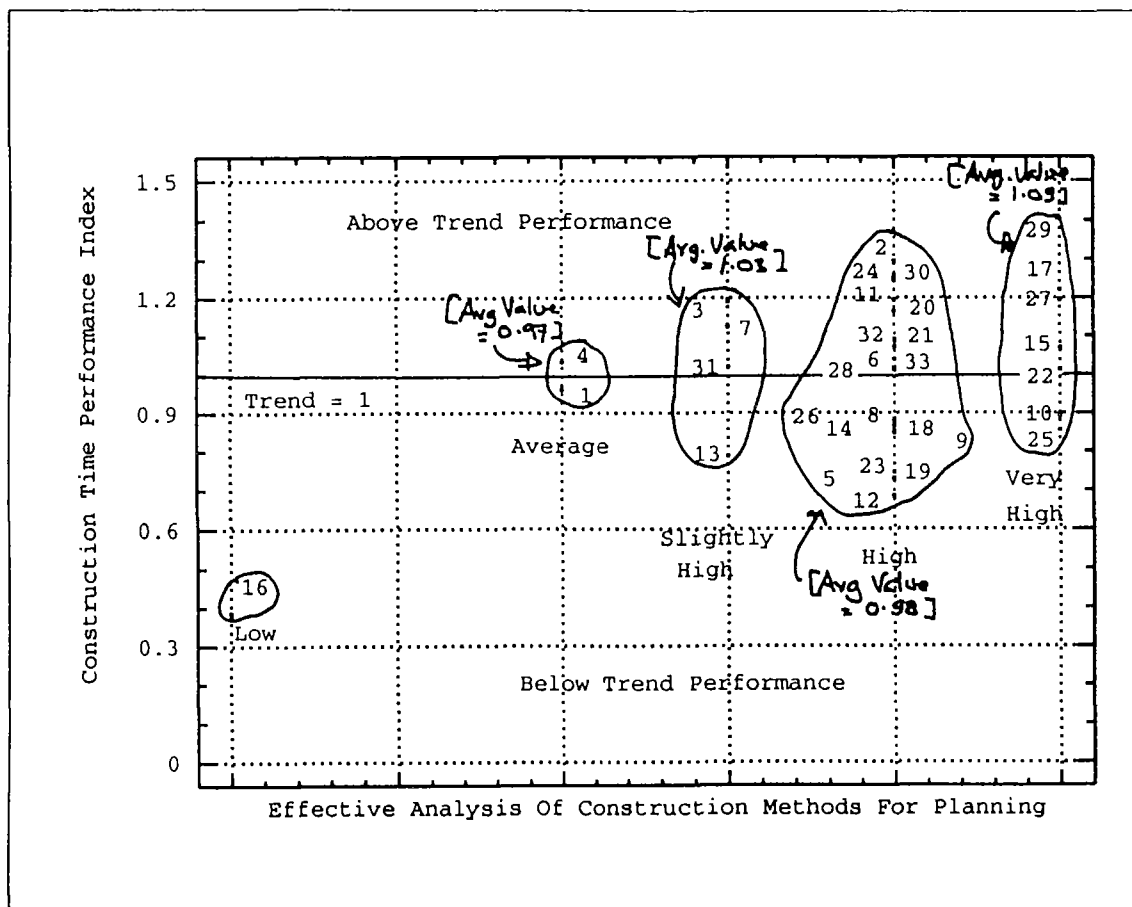
$H_0$  Construction time performance is **NOT** dependent upon effective analysis of construction methods for planning.

$H_1$  Construction time performance **IS** dependent upon effective analysis of construction methods for planning.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
3.094	0.0315	<b><math>H_0</math> REJECTED: <math>H_1</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 53**

**DATA ITEM: CM'S ANALYSING CONSTRUCTION METHODS**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ client/CR's quality performance objective ( $C_s = 0.4641$ ; sig. = 0.0087);
- ☐ CR's willingness to contribute effective and positive ideas ( $C_s = 0.4641$ ; sig. = 0.0087);
- ☐ *the construction team's confidence in the CR's contribution* ( $C_s = 0.5644$ ; sig. = 0.0014);
- ☐ **CM's forecasting planning data** ( $C_s = 0.7214$ ; sig. = 0.0001);
- ☐ **effectiveness of the construction team's planning** ( $C_s = 0.8626$ ; sig. = 0.0000);
- ☐ **CM's monitoring and updating plans to reflect work status** ( $C_s = 0.7221$ ; sig. = 0.0000);
- ☐ **CM's planning - responding to problems or opportunities** ( $C_s = 0.7031$ ; sig. = 0.0001);
- ☐ *CM's effectively coordinating resources* ( $C_s = 0.6390$ ; sig. = 0.0003);
- ☐ *CM's developing an organisational structure to maintain workflow* ( $C_s = 0.5851$ ; sig. = 0.0009);
- ☐ *effectiveness of the construction team's monitoring and control* ( $C_s = 0.6218$ ; sig. = 0.0004);
- ☐ *CM's organisational structure to manage risk* ( $C_s = 0.5707$ ; sig. = 0.0012);
- ☐ *CM's communication management to facilitate decision making* ( $C_s = 0.4947$ ; sig. = 0.0051);
- ☐ *decision making communication within the CM team* ( $C_s = 0.5967$ ; sig. = 0.0007);
- ☐ *CM decision making, communicating and actioning* ( $C_s = 0.6570$ ; sig. = 0.0002);
- ☐ *effectiveness of the CM team in managing the construction process* ( $C_s = 0.5870$ ; sig. = 0.0009).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *CR's experience with the building procurement process* ( $C_s = 0.4947$ ; sig. = 0.0051);
- ☐ stability of client/CR objectives ( $C_s = 0.4786$ ; sig. = 0.0068);
- ☐ clarity of communication of client/CR objectives ( $C_s = 0.4555$ ; sig. = 0.0100);
- ☐ *the level of influence exercised on CTP by the CR* ( $C_s = 0.5358$ ; sig. = 0.0024);
- ☐ complexity of CR's influence upon the project's management ( $C_s = 0.4645$ ; sig. = 0.0086);
- ☐ CR's ability to quickly make authoritative decisions ( $C_s = 0.4731$ ; sig. = 0.0074);
- ☐ CR's ability to effectively brief the design team ( $C_s = 0.4717$ ; sig. = 0.0098);
- ☐ *stability of CR decisions* ( $C_s = 0.5782$ ; sig. = 0.0011);
- ☐ *CM's effectiveness in influencing the CR decision making process* ( $C_s = 0.6893$ ; sig. = 0.0001);
- ☐ *CM management systems and procedures* ( $C_s = 0.5912$ ; sig. = 0.0008);
- ☐ *CM's analysing resource movement* ( $C_s = 0.6129$ ; sig. = 0.6129);
- ☐ **CM's analysing work sequencing to achieve and maintain workflow** ( $C_s = 0.7705$ ; sig. = 0.0000);
- ☐ *CM's effectiveness in team management to achieve synergy* ( $C_s = 0.5993$ ; sig. = 0.0007);
- ☐ *flexibility of the CM's management style* ( $C_s = 0.5289$ ; sig. = 0.0028);
- ☐ *decision making communication within the CR team* ( $C_s = 0.6185$ ; sig. = 0.0011);
- ☐ *CR decision making, communicating and actioning* ( $C_s = 0.5777$ ; sig. = 0.0011);
- ☐ CR's effective use of information technologies ( $C_s = 0.4763$ ; sig. = 0.0568).

## SUB-HYPOTHESIS NUMBER 54

## QUESTIONNAIRE NUMBER Q13.3.3

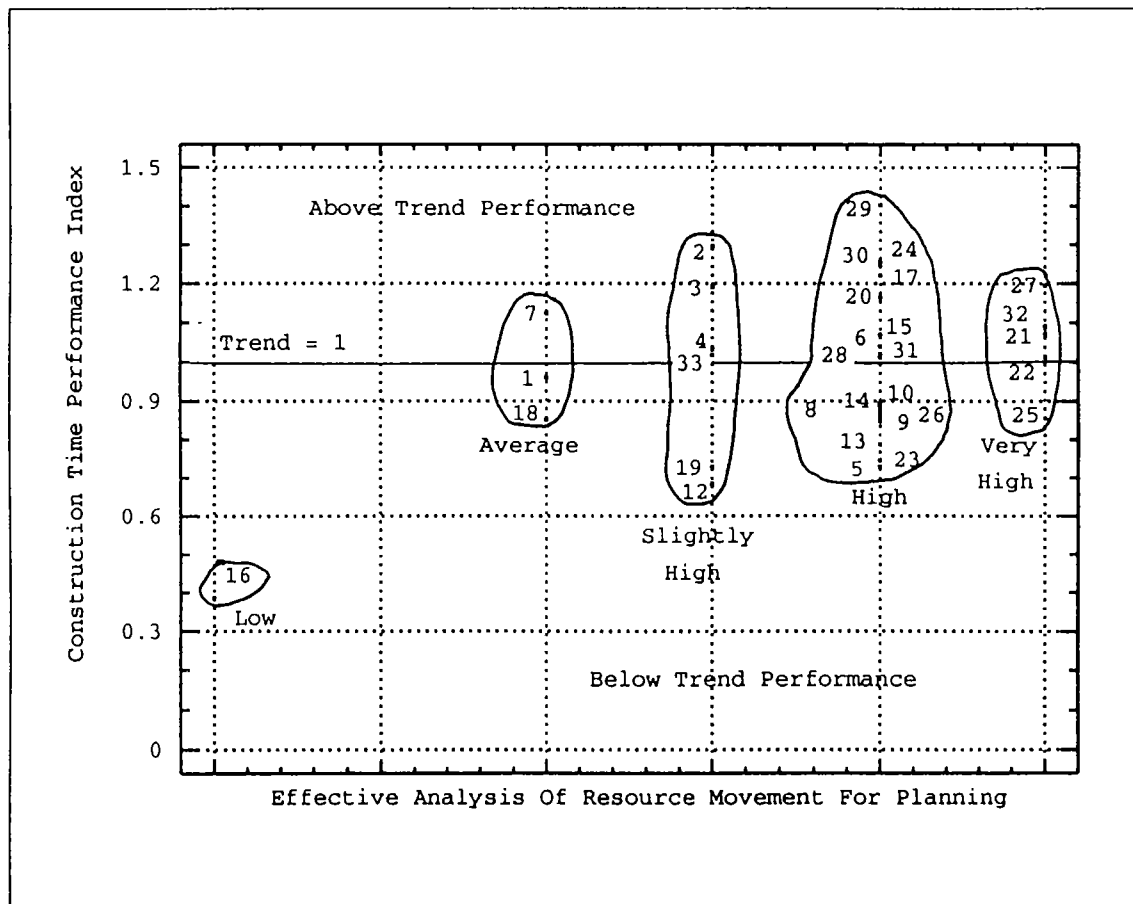
$H_0$  Construction time performance is **NOT** dependent upon effective analysis of resource movement for planning.

$H_1$  Construction time performance **IS** dependent upon effective analysis of resource movement for planning.

One-way ANOVA test results *measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.*

F-Ratio	Significance Level	Interpretation
2.502	0.0659	$H_0$ ACCEPTED

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 54**

**DATA ITEM: CM'S ANALYSING RESOURCE MOVEMENT**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *client/CR's time minimisation objective* ( $C_s = 0.5693$ ; sig. = 0.0015);
- ☐ *CM's analysing construction methods* ( $C_s = 0.6129$ ; sig. = 0.0006);
- ☐ *effectiveness of the construction team's planning* ( $C_s = 0.6678$ ; sig. = 0.0002);
- ☐ **CM's monitoring and updating plans to reflect work status** ( $C_s = 0.7188$ ; sig. = 0.0001);
- ☐ *CM's planning - responding to problems or opportunities* ( $C_s = 0.5762$ ; sig. = 0.0013);
- ☐ *CM's effectively coordinating resources* ( $C_s = 0.6195$ ; sig. = 0.0006);
- ☐ *CM's developing an organisational structure to maintain workflow* ( $C_s = 0.5917$ ; sig. = 0.0010);
- ☐ *effectiveness of the construction team's monitoring and control* ( $C_s = 0.5947$ ; sig. = 0.0009);
- ☐ *CM's communication management to facilitate decision making* ( $C_s = 0.6329$ ; sig. = 0.0004);
- ☐ *decision making communication within the CM team* ( $C_s = 0.4740$ ; sig. = 0.0083);
- ☐ *CM decision making, communicating and actioning* ( $C_s = 0.6498$ ; sig. = 0.0003);
- ☐ *effectiveness of the CM team in managing the construction process* ( $C_s = 0.4639$ ; sig. = 0.0098).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *the CR's ability to mould shared project goals and aspirations* ( $C_s = 0.5205$ ; sig. = 0.0044);
- ☐ *quality management procedures used on-site* ( $C_s = 0.4583$ ; sig. = 0.0121);
- ☐ *CM management systems and procedures* ( $C_s = 0.5986$ ; sig. = 0.0009);
- ☐ *key sub-contractor's organisational structure to manage risk* ( $C_s = 0.5909$ ; sig. = 0.0012);
- ☐ *CM's effectiveness in team management to achieve synergy* ( $C_s = 0.4706$ ; sig. = 0.0088);
- ☐ *decision making communication within the design team* ( $C_s = 0.5156$ ; sig. = 0.0074);
- ☐ *CR decision making, communicating and actioning* ( $C_s = 0.4477$ ; sig. = 0.0127);
- ☐ *CR's effective use of information technologies* ( $C_s = 0.5962$ ; sig. = 0.0209).

## SUB-HYPOTHESIS NUMBER 55

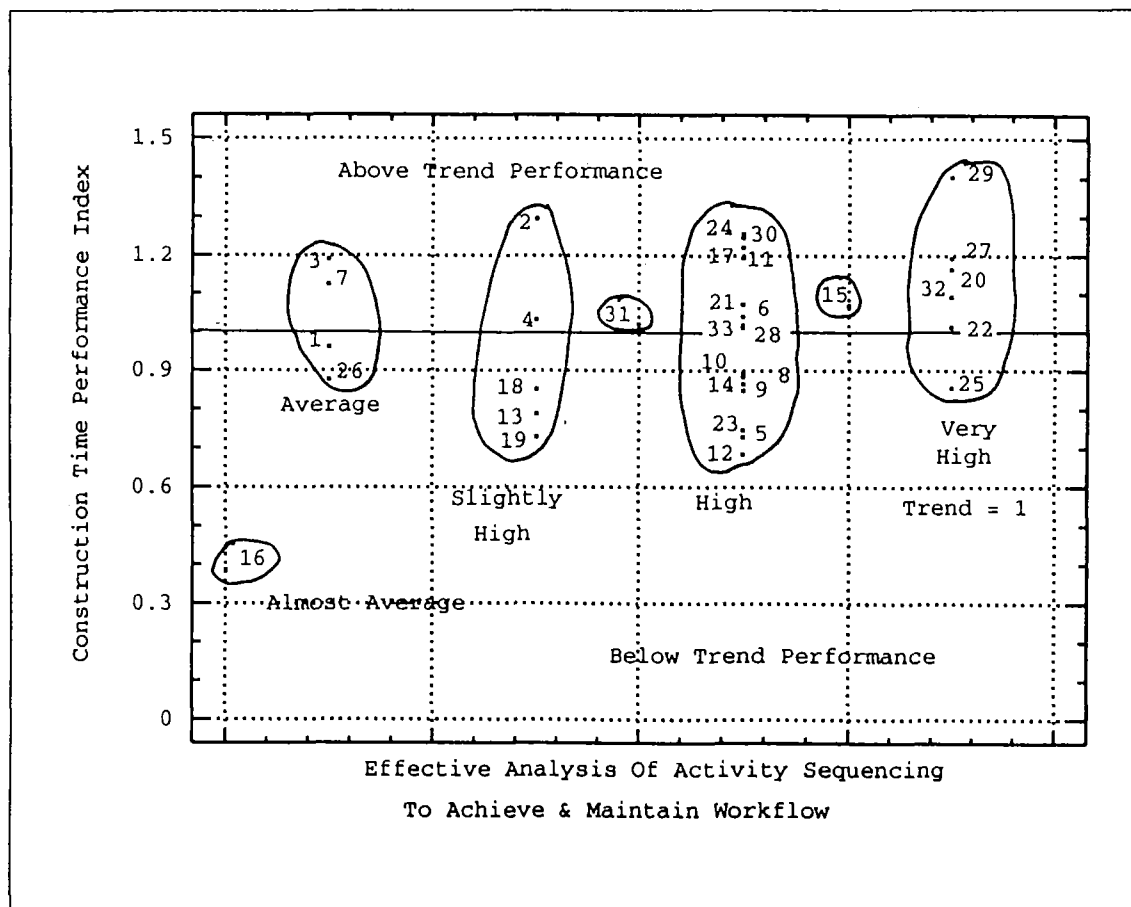
## QUESTIONNAIRE NUMBER Q13.3.4

- $H_0$  Construction time performance is **NOT** dependent upon effective analysis of activity sequencing to achieve & maintain workflow.
- $H_1$  Construction time performance **IS** dependent upon effective analysis of activity sequencing to achieve & maintain workflow.

One-way ANOVA test results *measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.*

F-Ratio	Significance Level	Interpretation
1.138	0.3503	<b><math>H_0</math> ACCEPTED</b>

**Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)**





**SUB-HYPOTHESIS NUMBER 55**

**DATA ITEM: CM'S SEQUENCING ACTIVITIES TO ACHIEVE AND MAINTAIN WORKFLOW**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *client/CR's time minimisation objective* ( $C_s = 0.5089$ ; sig. = 0.0040);
- ☐ *client/CR's quality performance objective* ( $C_s = 0.5134$ ; sig. = 0.0037);
- ☐ *economic environmental complexity* ( $C_s = 0.5440$ ; sig. = 0.0021);
- ☐ *CM's forecasting planning data* ( $C_s = 0.6216$ ; sig. = 0.0005);
- ☐ **CM's analysing construction methods** ( $C_s = 0.7705$ ; sig. = 0.0000);
- ☐ **effectiveness of the construction team's planning** ( $C_s = 0.8649$ ; sig. = 0.0000);
- ☐ **CM's monitoring and updating plans to reflect work status** ( $C_s = 0.8613$ ; sig. = 0.0000);
- ☐ **CM's planning - responding to problems or opportunities** ( $C_s = 0.7866$ ; sig. = 0.0000);
- ☐ **CM's effectively coordinating resources** ( $C_s = 0.7375$ ; sig. = 0.0000);
- ☐ **CM's developing an organisational structure to maintain workflow** ( $C_s = 0.7197$ ; sig. = 0.0000);
- ☐ **effectiveness of the construction team's monitoring and control** ( $C_s = 0.7089$ ; sig. = 0.0001);
- ☐ *CM's organisational structure to manage risk* ( $C_s = 0.5152$ ; sig. = 0.0036);
- ☐ *key sub-contractor's task-oriented management style* ( $C_s = 0.4652$ ; sig. = 0.0085);
- ☐ *CM's communication management to facilitate decision making* ( $C_s = 0.5692$ ; sig. = 0.0013);
- ☐ *decision making communication within the CM team* ( $C_s = 0.6187$ ; sig. = 0.0005);
- ☐ **CM decision making, communicating and actioning** ( $C_s = 0.7247$ ; sig. = 0.0000);
- ☐ *effectiveness of the CM team in managing the construction process* ( $C_s = 0.6717$ ; sig. = 0.0001).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *client organisation's experience with the building procurement process* ( $C_s = 0.5139$ ; sig. = 0.0036);
- ☐ *stability of client/CR objectives* ( $C_s = 0.4458$ ; sig. = 0.0117);
- ☐ *CM management systems and procedures* ( $C_s = 0.6638$ ; sig. = 0.0002);
- ☐ *key sub-contractor's organisational structure to manage risk* ( $C_s = 0.5358$ ; sig. = 0.0029);
- ☐ *CM's effectiveness in team management to achieve synergy* ( $C_s = 0.5986$ ; sig. = 0.0007);
- ☐ *flexibility of key sub-contractor's CR's management style* ( $C_s = 0.6896$ ; sig. = 0.0003);
- ☐ *CR decision making, communicating and actioning* ( $C_s = 0.4741$ ; sig. = 0.0073);
- ☐ *CR's effective use of information technologies* ( $C_s = 0.4805$ ; sig. = 0.0546).

## SUB-HYPOTHESIS NUMBER 56

## QUESTIONNAIRE NUMBER (AVG 13.3.1 TO 13.3.4)

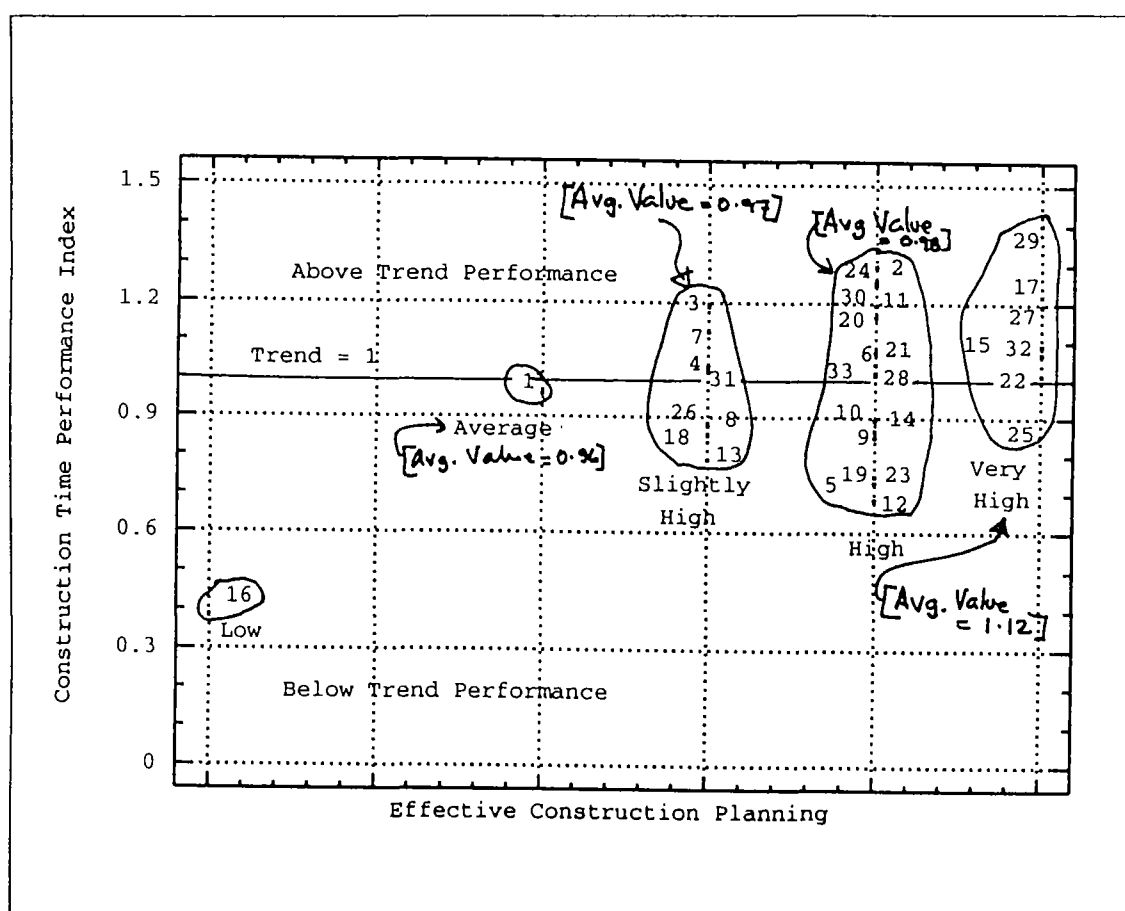
$H_0$  Construction time performance is **NOT** dependent upon effective construction planning being adopted by the CM team.

$H_1$  Construction time performance **IS** dependent upon the effective construction planning being adopted by the CM team.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
3.529	0.0188	<b><math>H_0</math> REJECTED: <math>H_1</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 56**

**DATA ITEM: EFFECTIVENESS OF THE CONSTRUCTION TEAM'S PLANNING**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ client/CR's time minimisation objective ( $C_s = 0.4710$ ; sig. = 0.0077);
- ☐ client/CR's quality performance objective ( $C_s = 0.4820$ ; sig. = 0.0064);
- ☐ ability of the CR to contribute ideas to the design process ( $C_s = 0.4666$ ; sig. = 0.0094);
- ☐ CR's willingness to contribute effective and positive ideas ( $C_s = 0.4666$ ; sig. = 0.0083);
- ☐ *the construction team's confidence in the CR's contribution* ( $C_s = 0.5184$ ; sig. = 0.0034);
- ☐ economic environmental complexity ( $C_s = 0.4482$ ; sig. = 0.0112);
- ☐ *impact of CR/CM working relationship* ( $C_s = 0.6014$ ; sig. = 0.0007);
- ☐ **CM's forecasting planning data** ( $C_s = 0.7872$ ; sig. = 0.0000);
- ☐ **CM's analysing construction methods** ( $C_s = 0.8626$ ; sig. = 0.0000);
- ☐ **CM's monitoring and updating plans to reflect work status** ( $C_s = 0.8186$ ; sig. = 0.0000);
- ☐ **CM's planning - responding to problems or opportunities** ( $C_s = 0.7562$ ; sig. = 0.0000);
- ☐ *CM's effectively coordinating resources* ( $C_s = 0.6788$ ; sig. = 0.0001);
- ☐ **CM's developing an organisational structure to maintain workflow** ( $C_s = 0.7410$ ; sig. = 0.0000);
- ☐ **effectiveness of the construction team's monitoring and control** ( $C_s = 0.7138$ ; sig. = 0.0002);
- ☐ *CM's organisational structure to manage risk* ( $C_s = 0.6007$ ; sig. = 0.0007);
- ☐ *key sub-contractor's task-oriented management style* ( $C_s = 0.5168$ ; sig. = 0.0035);
- ☐ *CM's communication management to facilitate decision making* ( $C_s = 0.6061$ ; sig. = 0.0006);
- ☐ *decision making communication within the CM team* ( $C_s = 0.6486$ ; sig. = 0.0002);
- ☐ **CM decision making, communicating and actioning** ( $C_s = 0.7338$ ; sig. = 0.0000);
- ☐ **effectiveness of the CM team in managing the construction process** ( $C_s = 0.7215$ ; sig. = 0.0000).

**SUB-HYPOTHESIS NUMBER 56**

**DATA ITEM: EFFECTIVENESS OF THE CONSTRUCTION TEAM'S PLANNING**

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ client organisation's confidence in the CR ( $C_s = 0.4445$ ; sig. = 0.0133);
- ☐ *stability of client/CR objectives* ( $C_s = 0.5179$ ; sig. = 0.0034);
- ☐ clarity of communication of client/CR objectives ( $C_s = 0.4678$ ; sig. = 0.0081);
- ☐ complexity of CR's influence upon the project's management ( $C_s = 0.4756$ ; sig. = 0.0071);
- ☐ CR's ability to quickly make authoritative decisions ( $C_s = 0.4562$ ; sig. = 0.0099);
- ☐ CR's ability to effectively brief the design team ( $C_s = 0.4461$ ; sig. = 0.0146);
- ☐ *stability of CR decisions* ( $C_s = 0.6034$ ; sig. = 0.0006);
- ☐ *the CR's confidence in the construction team* ( $C_s = 0.5567$ ; sig. = 0.0019);
- ☐ *the CR's ability to mould shared project goals and aspirations* ( $C_s = 0.5350$ ; sig. = 0.0029);
- ☐ *CM's effectiveness in influencing the CR decision making process* ( $C_s = 0.6746$ ; sig. = 0.0001)
- ☐ **CM management systems and procedures** ( $C_s = 0.7058$ ; sig. = 0.0001);
- ☐ *CM's analysing resource movement* ( $C_s = 0.6678$ ; sig. = 0.0002);
- ☐ **CM's analysing work sequencing to achieve and maintain workflow** ( $C_s = 0.8649$ ; sig. = 0.0000);
- ☐ CR's organisational structure to manage risk ( $C_s = 0.4804$ ; sig. = 0.0066);
- ☐ *key sub-contractor's organisational structure to manage risk* ( $C_s = 0.5850$ ; sig. = 0.0011);
- ☐ *CM's effectiveness in team management to achieve synergy* ( $C_s = 0.6889$ ; sig. = 0.0001);
- ☐ *flexibility of the CM's management style* ( $C_s = 0.5373$ ; sig. = 0.0024);
- ☐ task-orientation of the CM's management style ( $C_s = 0.4683$ ; sig. = 0.0081);
- ☐ CM's people-oriented management style ( $C_s = 0.4812$ ; sig. = 0.0065);
- ☐ *decision making communication within the CR team* ( $C_s = 0.6808$ ; sig. = 0.0003);
- ☐ *CR decision making, communicating and actioning* ( $C_s = 0.5682$ ; sig. = 0.0013);
- ☐ CR's effective use of information technologies ( $C_s = 0.4518$ ; sig. = 0.0707).

## SUB-HYPOTHESIS NUMBER 57

## QUESTIONNAIRE NUMBER Q13.3.5

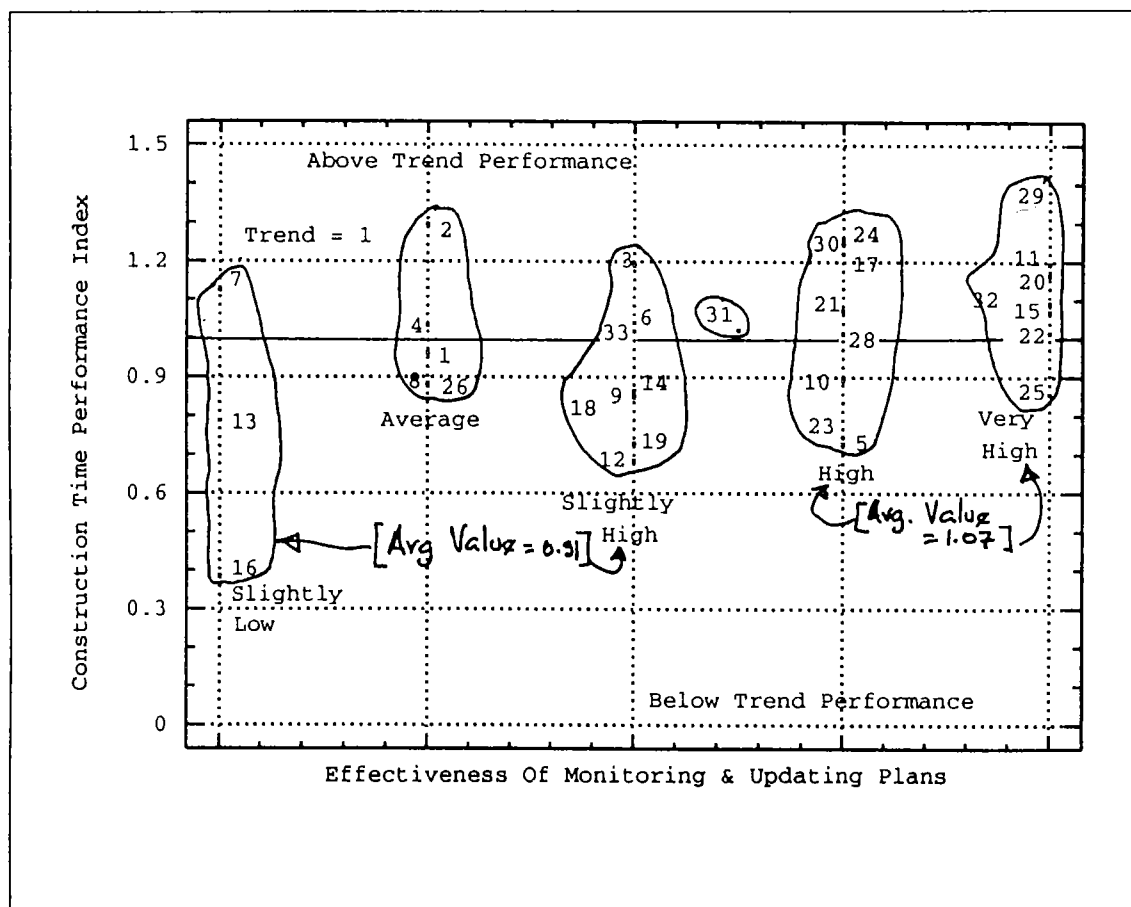
$H_0$  Construction time performance is **NOT** dependent upon high or very high effectiveness in monitoring and updating construction plans.

$H_1$  Construction time performance **IS** dependent upon high or very high effectiveness in monitoring and updating construction plans.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
5.143	0.0305	<b><math>H_0</math> REJECTED: <math>H_1</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 57**

**DATA ITEM: CM'S MONITORING AND UPDATING PLANS TO REFLECT WORK STATUS**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ client/CR's time minimisation objective ( $C_s = 0.4568$ ; sig. = 0.0098);
- ☐ client/CR's quality performance objective ( $C_s = 0.5279$ ; sig. = 0.0028);
- ☐ economic environmental complexity ( $C_s = 0.4508$ ; sig. = 0.0108);
- ☐ impact of CR/CM working relationship ( $C_s = 0.5057$ ; sig. = 0.0042);
- ☐ CM's forecasting planning data ( $C_s = 0.6718$ ; sig. = 0.0002);
- ☐ **CM's analysing construction methods ( $C_s = 0.7221$ ; sig. = 0.0000);**
- ☐ **effectiveness of the construction team's planning ( $C_s = 0.8186$ );**
- ☐ **CM's planning - responding to problems or opportunities ( $C_s = 0.7295$ ; sig. = 0.0000);**
- ☐ CM's effectively coordinating resources ( $C_s = 0.6365$ ; sig. = 0.0003);
- ☐ CM's developing an organisational structure to maintain workflow ( $C_s = 0.6551$ ; sig. = 0.0002);
- ☐ effectiveness of the construction team's monitoring and control ( $C_s = 0.6591$ ; sig. = 0.0002);
- ☐ CM's organisational structure to manage risk ( $C_s = 0.5484$ ; sig. = 0.0019);
- ☐ key sub-contractor's task-oriented management style ( $C_s = 0.5171$ ; sig. = 0.0034);
- ☐ CM's communication management to facilitate decision making ( $C_s = 0.6074$ ; sig. = 0.0006);
- ☐ decision making communication within the CM team ( $C_s = 0.5727$ ; sig. = 0.0012);
- ☐ CM decision making, communicating and actioning ( $C_s = 0.6447$ ; sig. = 0.0003);
- ☐ effectiveness of the CM team in managing the construction process ( $C_s = 0.6264$ ; sig. = 0.0004).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ stability of CR decisions ( $C_s = 0.4790$ ; sig. = 0.0067);
- ☐ CM's effectiveness in influencing the CR decision making process ( $C_s = 0.5046$ ; sig. = 0.0043);
- ☐ CM management systems and procedures ( $C_s = 0.6332$ ; sig. = 0.0003);
- ☐ **CM's analysing resource movement ( $C_s = 0.7188$ ; sig. = 0.0001);**
- ☐ **CM's analysing work sequencing to achieve and maintain workflow ( $C_s = 0.8613$ ; sig. = 0.0000);**
- ☐ key sub-contractor's organisational structure to manage risk ( $C_s = 0.4971$ ; sig. = 0.0056);
- ☐ CM's effectiveness in team management to achieve synergy ( $C_s = 0.6087$ ; sig. = 0.0006);
- ☐ flexibility of the CM's management style ( $C_s = 0.4796$ ; sig. = 0.0067);
- ☐ decision making communication within the CR team ( $C_s = 0.5630$ ; sig. = 0.0029);
- ☐ CR decision making, communicating and actioning ( $C_s = 0.5601$ ; sig. = 0.0015);
- ☐ CR's effective use of information technologies ( $C_s = 0.5207$ ; sig. = 0.0373).

## SUB-HYPOTHESIS NUMBER 58

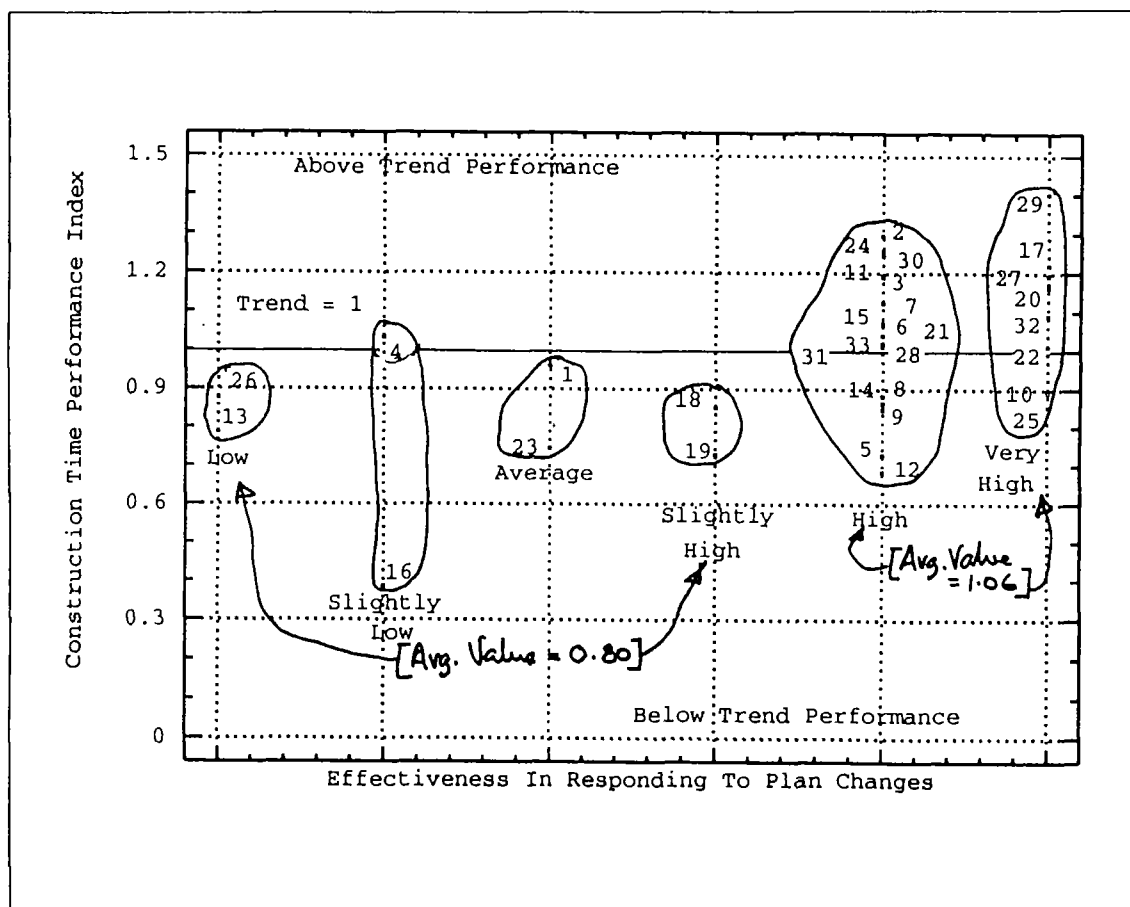
## QUESTIONNAIRE NUMBER Q13.3.6

- $H_0$  Construction time performance is **NOT** dependent upon high or very high effectiveness in responding to changes in construction plans.
- $H_1$  Construction time performance **IS** dependent upon high or very high effectiveness in responding to changes in construction plans.

One-way ANOVA test results *measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.*

F-Ratio	Significance Level	Interpretation
12.029	0.0016	<b><math>H_0</math> REJECTED: <math>H_1</math> ACCEPTED</b>

**Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)**



### SUB-HYPOTHESIS NUMBER 58

#### DATA ITEM: CM'S PLANNING - RESPONDING TO PROBLEMS OR OPPORTUNITIES

##### Spearman Rank Correlation results for factors affecting CTP:

- ☐ construction time performance ( $C_s = 0.4992$ ; sig. = 0.0047);
- ☐ client/CR's time minimisation objective ( $C_s = 0.6042$ ; sig. = 0.0006);
- ☐ CR's willingness to contribute effective and positive ideas ( $C_s = 0.5503$ ; sig. = 0.0019);
- ☐ the construction team's confidence in the CR's contribution ( $C_s = 0.4580$ ; sig. = 0.0096);
- ☐ impact of CR/CM working relationship ( $C_s = 0.5775$ ; sig. = 0.0011);
- ☐ CM's forecasting planning data ( $C_s = 0.5709$ ; sig. = 0.0015);
- ☐ CM's analysing construction methods ( $C_s = 0.7131$ ; sig. = 0.0001);
- ☐ effectiveness of the construction team's planning ( $C_s = 0.7562$ ; sig. = 0.0000);
- ☐ CM's monitoring and updating plans to reflect work status ( $C_s = 0.7295$ ; sig. = 0.0000);
- ☐ CM's effectively coordinating resources ( $C_s = 0.8506$ ; sig. = 0.0000);
- ☐ CM's developing an organisational structure to maintain workflow ( $C_s = 0.6369$ ; sig. = 0.0003);
- ☐ effectiveness of the construction team's monitoring and control ( $C_s = 0.8550$ ; sig. = 0.0000);
- ☐ CM's organisational structure to manage risk ( $C_s = 0.6137$ ; sig. = 0.0005);
- ☐ key sub-contractor's task-oriented management style ( $C_s = 0.4375$ ; sig. = 0.0133);
- ☐ CM's communication management to facilitate decision making ( $C_s = 0.6682$ ; sig. = 0.0002);
- ☐ CR and CM team communication effectiveness for decision making ( $C_s = 0.4758$ ; sig. = 0.0071);
- ☐ decision making communication within the CM team ( $C_s = 0.5091$ ; sig. = 0.0040);
- ☐ CM decision making, communicating and actioning ( $C_s = 0.6801$ ; sig. = 0.0001);
- ☐ effectiveness of the CM team in managing the construction process ( $C_s = 0.6716$ ; sig. = 0.0001).

##### Spearman Rank Correlation results for factors NOT affecting CTP:

- ☐ CM's effectiveness in influencing the CR decision making process ( $C_s = 0.5935$ ; sig. = 0.0008);
- ☐ CM management systems and procedures ( $C_s = 0.6323$ ; sig. = 0.0003);
- ☐ CM's analysing resource movement ( $C_s = 0.5762$ ; sig. = 0.0013);
- ☐ CM's analysing work sequencing to achieve and maintain workflow ( $C_s = 0.7866$ ; sig. = 0.0000);
- ☐ CR's organisational structure to manage risk ( $C_s = 0.5132$ ; sig. = 0.0037);
- ☐ key sub-contractor's organisational structure to manage risk ( $C_s = 0.4556$ ; sig. = 0.0112);
- ☐ CM's effectiveness in team management to achieve synergy ( $C_s = 0.6050$ ; sig. = 0.0006);
- ☐ decision making communication within the CR team ( $C_s = 0.6587$ ; sig. = 0.0005);
- ☐ CR decision making, communicating and actioning ( $C_s = 0.5373$ ; sig. = 0.0024).



## SUB-HYPOTHESIS NUMBER 59

## QUESTIONNAIRE NUMBER Q13.3.7

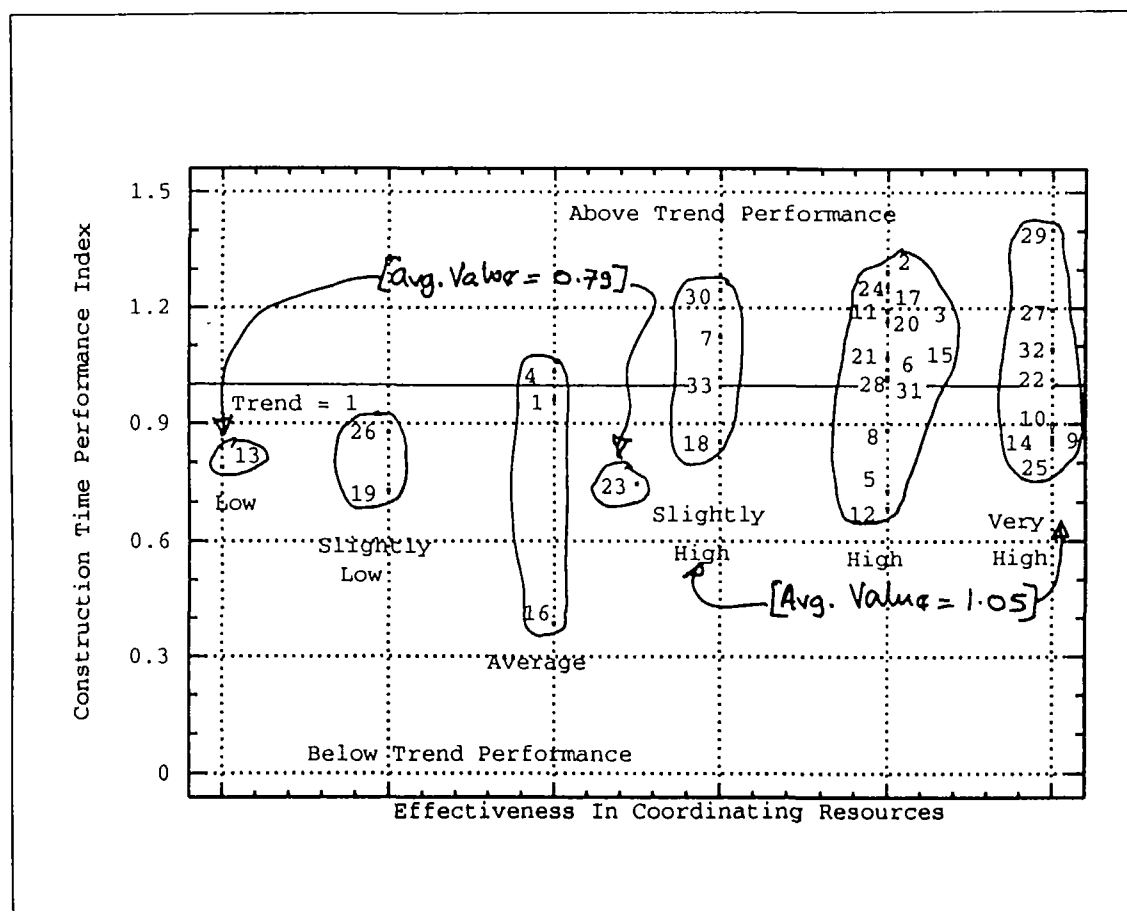
$H_0$  Construction time performance is NOT dependent upon slightly high or better effectiveness in effectively coordinating resources.

$H_1$  Construction time performance IS dependent upon slightly high or better effectiveness in effectively coordinating resources.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
10.583	0.0028	<b><math>H_0</math> REJECTED: <math>H_1</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 59**

**DATA ITEM: CM'S EFFECTIVELY COORDINATING RESOURCES**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ client/CR's time minimisation objective ( $C_s = 0.4716$ ; sig. = 0.0076);
- ☐ ability of the CR to contribute ideas to the design process ( $C_s = 0.4910$ ; sig. = 0.0063);
- ☐ CR's willingness to contribute effective and positive ideas ( $C_s = 0.4824$ ; sig. = 0.0064);
- ☐ *the construction team's confidence in the CR's contribution* ( $C_s = 0.5382$ ; sig. = 0.0023);
- ☐ *impact of CR/CM working relationship* ( $C_s = 0.6161$ ; sig. = 0.0005);
- ☐ CM's effectively coordinating resources ( $C_s = 0.4886$ ; sig. = 0.0065);
- ☐ *CM's analysing construction methods* ( $C_s = 0.6390$ ; sig. = 0.0003);
- ☐ *effectiveness of the construction team's planning* ( $C_s = 0.6788$ ; sig. = 0.0001);
- ☐ *CM's monitoring and updating plans to reflect work status* ( $C_s = 0.6365$ ; sig. = 0.0003);
- ☐ **CM's planning - responding to problems or opportunities** ( $C_s = 0.8506$ ; sig. = 0.0000);
- ☐ **CM's developing an organisational structure to maintain workflow** ( $C_s = 0.7481$ ; sig. = 0.0000);
- ☐ **effectiveness of the construction team's monitoring and control** ( $C_s = 0.9509$ ; sig. = 0.0000);
- ☐ *CM's organisational structure to manage risk* ( $C_s = 0.6869$ ; sig. = 0.0001);
- ☐ *key sub-contractor's task-oriented management style* ( $C_s = 0.5341$ ; sig. = 0.0025);
- ☐ **CM's communication management to facilitate decision making** ( $C_s = 0.7153$ ; sig. = 0.0001);
- ☐ decision making communication within the CM team ( $C_s = 0.4794$ ; sig. = 0.0067);
- ☐ **CM decision making, communicating and actioning** ( $C_s = 0.7226$ ; sig. = 0.0000);
- ☐ **effectiveness of the CM team in managing the construction process** ( $C_s = 0.6941$ ; sig. = 0.0001).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *ratio of EOT:actual construction time* ( $C_s = -0.5017$ ; sig. = 0.0045);
- ☐ *stability of client/CR objectives* ( $C_s = 0.5037$ ; sig. = 0.0044);
- ☐ *clarity of communication of client/CR objectives* ( $C_s = 0.5187$ ; sig. = 0.0033);
- ☐ the level of influence exercised on CTP by the CR ( $C_s = 0.4800$ ; sig. = 0.0066);
- ☐ CR's ability to effectively brief the design team ( $C_s = 0.4849$ ; sig. = 0.0079);
- ☐ *stability of CR decisions* ( $C_s = 0.5506$ ; sig. = 0.0018);
- ☐ the CR's confidence in the construction team ( $C_s = 0.4559$ ; sig. = 0.0111);
- ☐ *CM's effectiveness in influencing the CR decision making process* ( $C_s = 0.6113$ ; sig. = 0.0005);
- ☐ **CM management systems and procedures** ( $C_s = 0.7186$ ; sig. = 0.0000);
- ☐ *CM's analysing resource movement* ( $C_s = 0.6195$ ; sig. = 0.0006);
- ☐ **CM's analysing work sequencing to achieve and maintain workflow** ( $C_s = 0.7375$ ; sig. = 0.0000);
- ☐ *CR's organisational structure to manage risk* ( $C_s = 0.5622$ ; sig. = 0.0015);
- ☐ *key sub-contractor's organisational structure to manage risk* ( $C_s = 0.5164$ ; sig. = 0.0040);
- ☐ **CM's effectiveness in team management to achieve synergy** ( $C_s = 0.7146$ ; sig. = 0.0001);
- ☐ *flexibility of the CR's management style* ( $C_s = 0.5382$ ; sig. = 0.0023);
- ☐ *CM's people-oriented management style* ( $C_s = 0.5191$ ; sig. = 0.0033);
- ☐ key sub-contractor's people-oriented management style ( $C_s = 0.4615$ ; sig. = 0.0090);
- ☐ *decision making communication within the CR team* ( $C_s = 0.6221$ ; sig. = 0.0010);
- ☐ *CR decision making, communicating and actioning* ( $C_s = 0.6501$ ; sig. = 0.0002).

## SUB-HYPOTHESIS NUMBER 60

## QUESTIONNAIRE NUMBER Q13.3.8

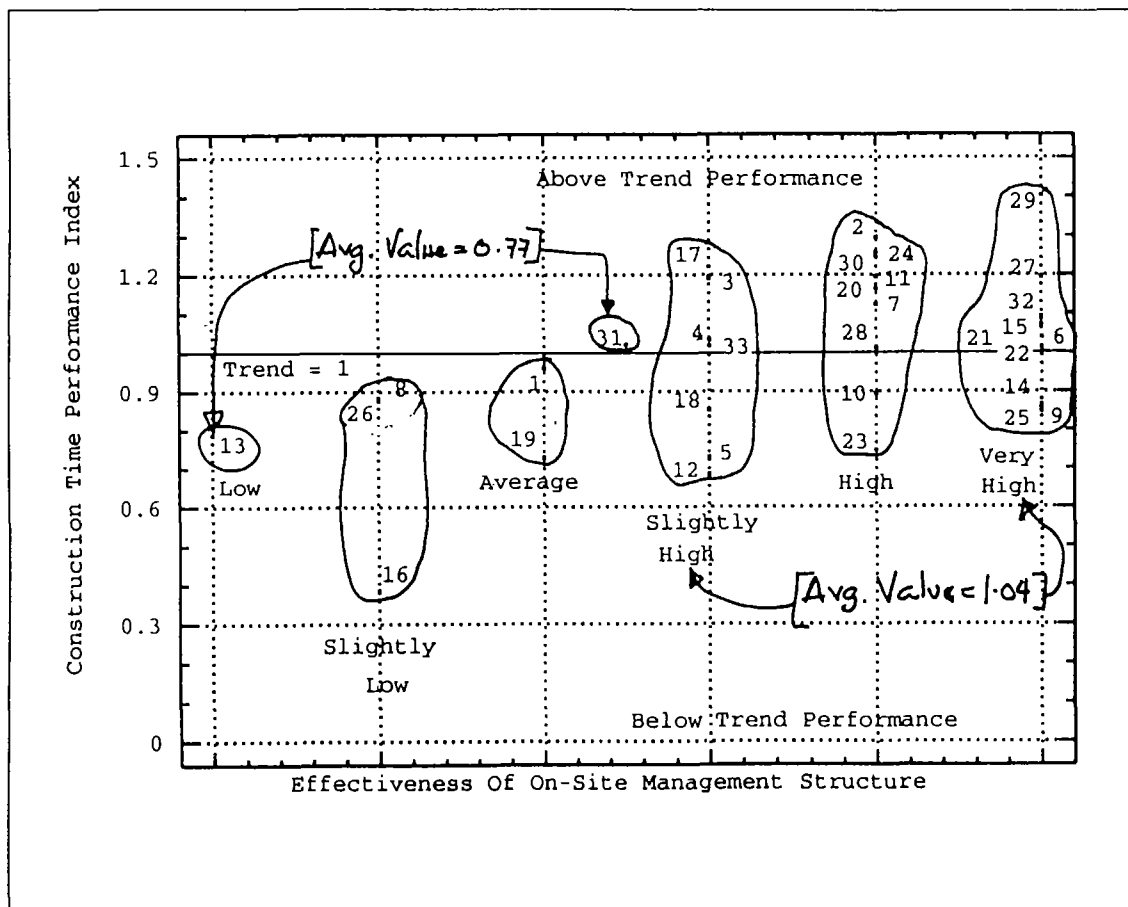
$H_0$  Construction time performance is **NOT** dependent upon a slightly high or better effectiveness of on-site construction team structure.

$H_1$  Construction time performance **IS** dependent upon a slightly high or better effectiveness of on-site construction team structure.

One-way ANOVA test results *measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.*

F-Ratio	Significance Level	Interpretation
10.234	0.0032	<b><math>H_0</math> REJECTED: <math>H_1</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 60**

**DATA ITEM: CM'S ORGANISATIONAL STRUCTURE TO MAINTAIN WORKFLOW**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *ability of the CR to contribute ideas to the design process* ( $C_s = 0.5378$ ; sig. = 0.0028);
- ☐ *the project design team's confidence in the CR contribution* ( $C_s = 0.4966$ ; sig. = 0.0065);
- ☐ *the construction team's confidence in the CR's contribution* ( $C_s = 0.5770$ ; sig. = 0.0011);
- ☐ *economic environmental complexity* ( $C_s = 0.5107$ ; sig. = 0.0039);
- ☐ *impact of CR/CM working relationship* ( $C_s = 0.5781$ ; sig. = 0.0011);
- ☐ *CM's forecasting planning data* ( $C_s = 0.6849$ ; sig. = 0.0001);
- ☐ *CM's analysing construction methods* ( $C_s = 0.5851$ ; sig. = 0.0009);
- ☐ **effectiveness of the construction team's planning** ( $C_s = 0.7410$ ; sig. = 0.0000);
- ☐ *CM's monitoring and updating plans to reflect work status* ( $C_s = 0.6551$ ; sig. = 0.0002);
- ☐ *CM's planning - responding to problems or opportunities* ( $C_s = 0.6396$ ; sig. = 0.0003);
- ☐ **CM's effectively coordinating resources** ( $C_s = 0.7481$ ; sig. = 0.0000)
- ☐ **effectiveness of the construction team's monitoring and control** ( $C_s = 0.8248$ ; sig. = 0.0000);
- ☐ **CM's organisational structure to manage risk** ( $C_s = 0.7802$ ; sig. = 0.0000);
- ☐ *key sub-contractor's task-oriented management style* ( $C_s = 0.4983$ ; sig. = 0.0048);
- ☐ *CM's communication management to facilitate decision making* ( $C_s = 0.5944$ ; sig. = 0.0008);
- ☐ *decision making communication within the CM team* ( $C_s = 0.5359$ ; sig. = 0.0024);
- ☐ **CM decision making, communicating and actioning** ( $C_s = 0.7103$ ; sig. = 0.0001);
- ☐ **effectiveness of the CM team in managing the construction process** ( $C_s = 0.7544$ ; sig. = 0.0000).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *ratio of EOT:actual construction time* ( $C_s = -0.4475$ ; sig. = 0.0114);
- ☐ *stability of client/CR objectives* ( $C_s = 0.6456$ ; sig. = 0.0003);
- ☐ *clarity of communication of client/CR objectives* ( $C_s = 0.5702$ ; sig. = 0.0013);
- ☐ *complexity of CR's influence upon the project's management* ( $C_s = 0.5238$ ; sig. = 0.0030);
- ☐ *stability of CR decisions* ( $C_s = 0.5868$ ; sig. = 0.0009);
- ☐ *the CR's confidence in the construction team* ( $C_s = 0.5291$ ; sig. = 0.0032);
- ☐ *CM's effectiveness in influencing the CR decision making process* ( $C_s = 0.4643$ ; sig. = 0.0086);
- ☐ **CM management systems and procedures** ( $C_s = 0.8032$ ; sig. = 0.0000);
- ☐ *CM's analysing resource movement* ( $C_s = 0.5917$ ; sig. = 0.0010);
- ☐ **CM's developing an organisational structure to maintain workflow** ( $C_s = 0.7197$ ; sig. = 0.0000);
- ☐ *CR's organisational structure to manage risk* ( $C_s = 0.5267$ ; sig. = 0.0029);
- ☐ *key sub-contractor's organisational structure to manage risk* ( $C_s = 0.5802$ ; sig. = 0.0012);
- ☐ *CM's effectiveness in team management to achieve synergy* ( $C_s = 0.6063$ ; sig. = 0.0006);
- ☐ *task-orientation of the CM's management style* ( $C_s = 0.4503$ ; sig. = 0.0109);
- ☐ *CM's people-oriented management style* ( $C_s = 0.4621$ ; sig. = 0.0089);
- ☐ *decision making communication within the CR team* ( $C_s = 0.6371$ ; sig. = 0.0007);
- ☐ *CR decision making, communicating and actioning* ( $C_s = 0.5172$ ; sig. = 0.0034).

## SUB-HYPOTHESIS NUMBER 61

## QUESTIONNAIRE NUMBER (AVERAGE 13.3.5-13.3.8)

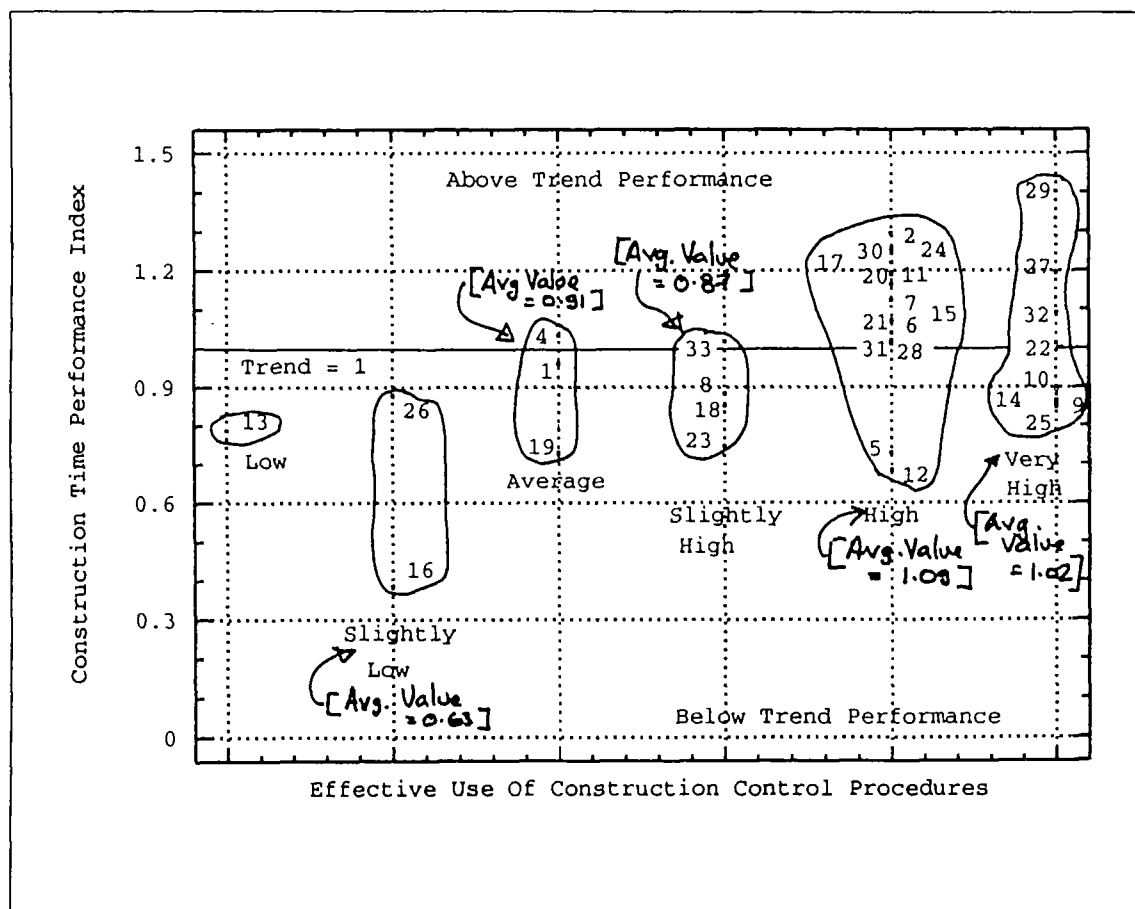
$H_0$  Construction time performance is NOT dependent upon effective construction control procedures being adopted.

$H_1$  Construction time performance IS dependent upon effective construction control procedures being adopted.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
3.027	0.0269	<b><math>H_0</math> REJECTED: <math>H_1</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 61**

**DATA ITEM: EFFECTIVENESS OF THE CM TEAM'S MONITORING AND CONTROL**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *client/CR's time minimisation objective* ( $C_s = 0.4981$ ; sig. = 0.0048);
- ☐ *ability of the CR to contribute ideas to the design process* ( $C_s = 0.5762$ ; sig. = 0.0013);
- ☐ *CR's willingness to contribute effective and positive ideas* ( $C_s = 0.5581$ ; sig. = 0.0016);
- ☐ *the construction team's confidence in the CR's contribution* ( $C_s = 0.5872$ ; sig. = 0.0009);
- ☐ *impact of CR/CM working relationship* ( $C_s = 0.6782$ ; sig. = 0.0001);
- ☐ *CM's forecasting planning data* ( $C_s = 0.5647$ ; sig. = 0.0017);
- ☐ *CM's analysing construction methods* ( $C_s = 0.6218$ ; sig. = 0.0004);
- ☐ **effectiveness of the construction team's planning** ( $C_s = 0.7138$ ; sig. = 0.0001);
- ☐ *CM's monitoring and updating plans to reflect work status* ( $C_s = 0.6591$ ; sig. = 0.0002);
- ☐ **CM's planning - responding to problems or opportunities** ( $C_s = 0.8550$ ; sig. = 0.0000);
- ☐ **CM's effectively coordinating resources** ( $C_s = 0.9509$ ; sig. = 0.0000);
- ☐ **CM's developing an organisational structure to maintain workflow** ( $C_s = 0.8248$ ; ; sig. = 0.0000);
- ☐ **CM's organisational structure to manage risk** ( $C_s = 0.7758$ ; sig. = 0.0000);
- ☐ *key sub-contractor's task-oriented management style* ( $C_s = 0.5802$ ; sig. = 0.0010);
- ☐ **CM's communication management to facilitate decision making** ( $C_s = 0.7037$ ; sig. = 0.0001);
- ☐ *CR and CM team communication effectiveness for decision making* ( $C_s = 0.5147$ ; sig. = 0.0036);
- ☐ *decision making communication within the CM team* ( $C_s = 0.5230$ ; sig. = 0.0031);
- ☐ **CM decision making, communicating and actioning** ( $C_s = 0.7522$ ; sig. = 0.0000);
- ☐ **effectiveness of the CM team in managing the construction process** ( $C_s = 0.7525$ ; sig. = 0.0000).

**SUB-HYPOTHESIS NUMBER 61**

**DATA ITEM: EFFECTIVENESS OF THE CM TEAM'S MONITORING AND CONTROL**

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ ratio of EOT:actual construction time ( $C_s = -0.4639$ ; sig. = 0.0087);
- ☐ client organisation's confidence in the CR ( $C_s = 0.4561$ ; sig. = 0.0111);
- ☐ *stability of client/CR objectives* ( $C_s = 0.6058$ ; sig. = 0.0006);
- ☐ *clarity of communication of client/CR objectives* ( $C_s = 0.5509$ ; sig. = 0.0010);
- ☐ CR's ability to effectively brief the design team ( $C_s = 0.4781$ ; sig. = 0.0088);
- ☐ *stability of CR decisions* ( $C_s = 0.5325$ ; sig. = 0.0026);
- ☐ *the CR's confidence in the construction team* ( $C_s = 0.5454$ ; sig. = 0.0024);
- ☐ *CM's effectiveness in influencing the CR decision making process* ( $C_s = 0.6199$ ; sig. = 0.0005);
- ☐ **CM management systems and procedures** ( $C_s = 0.7334$ ; sig. = 0.0000);
- ☐ *CM's analysing resource movement* ( $C_s = 0.5947$ ; sig. = 0.0009);
- ☐ **CM's analysing work sequencing to achieve & maintain workflow** ( $C_s = 0.7089$ ; sig. = 0.0001);
- ☐ *CR's organisational structure to manage risk* ( $C_s = 0.6010$ ; sig. = 0.0007);
- ☐ *key sub-contractor's organisational structure to manage risk* ( $C_s = 0.5465$ ; sig. = 0.0023);
- ☐ **CM's effectiveness in team management to achieve synergy** ( $C_s = 0.7351$ ; sig. = 0.0000);
- ☐ *flexibility of the CR's management style* ( $C_s = 0.5129$ ; sig. = 0.0037);
- ☐ flexibility of the CM's management style ( $C_s = 0.4706$ ; sig. = 0.0078);
- ☐ task-orientation of the CM's management style ( $C_s = 0.4548$ ; sig. = 0.0101);
- ☐ *CM's people-oriented management style* ( $C_s = 0.5310$ ; sig. = 0.0027);
- ☐ *key sub-contractor's people-oriented management style* ( $C_s = 0.5003$ ; sig. = 0.0047);
- ☐ **decision making communication within the CR team** ( $C_s = 0.7046$ ; sig. = 0.0002);
- ☐ *CR decision making, communicating and actioning* ( $C_s = 0.6227$ ; sig. = 0.0004).

## SUB-HYPOTHESIS NUMBER 62

## QUESTIONNAIRE NUMBER Q14.1

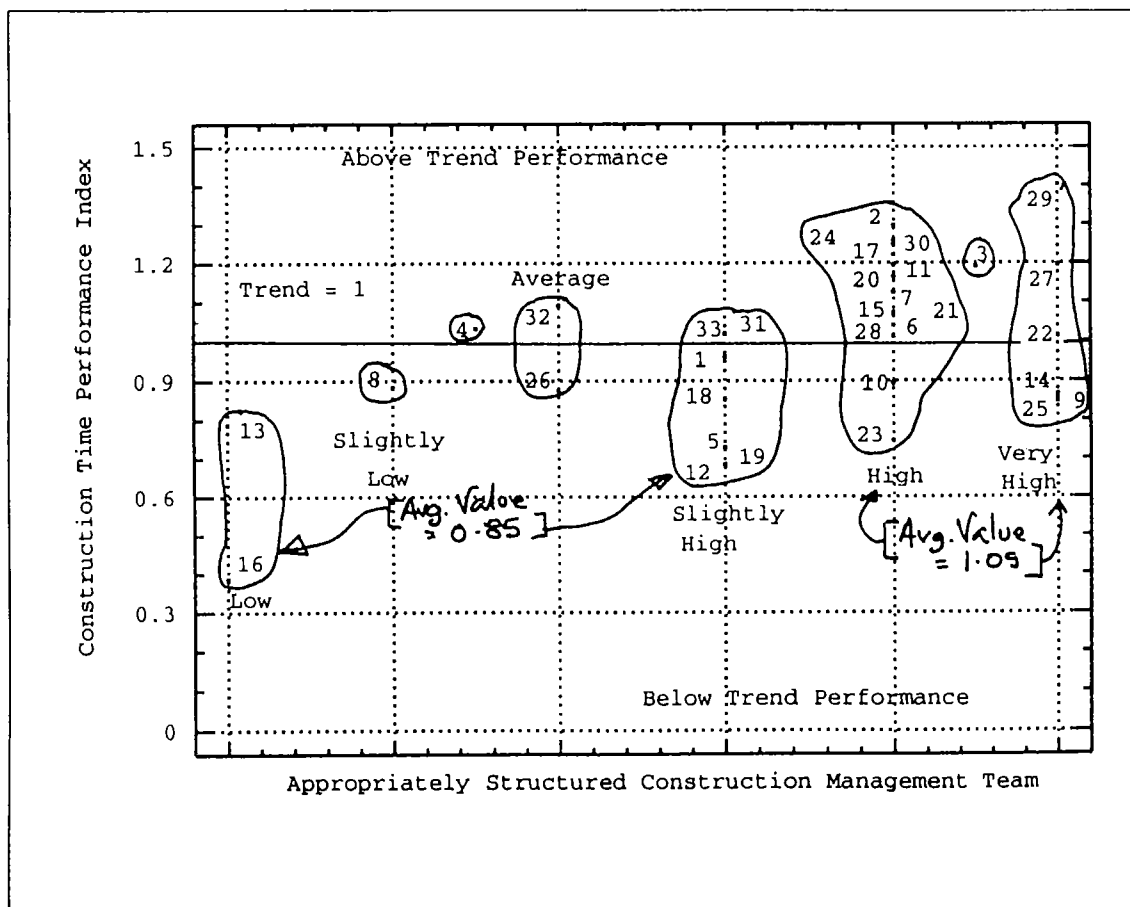
$H_0$  Construction time performance is **NOT** dependent upon a highly appropriate CM team structure.

$H_1$  Construction time performance **IS** dependent upon a highly appropriate CM team structure.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
13.207	0.0010	<b><math>H_0</math> REJECTED: <math>H_1</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*





**SUB-HYPOTHESIS NUMBER 62**

**DATA ITEM: CM'S ORGANISATIONAL STRUCTURE TO MANAGE RISK**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *ability of the CR to contribute ideas to the design process ( $C_s = 0.5728$ ; sig. = 0.0014);*
- ☐ *ability of the CR to contribute ideas to the construction process ( $C_s = 0.5502$ ; sig. = 0.0019);*
- ☐ **the construction team's confidence in the CR's contribution ( $C_s = 0.7228$ ; sig. = 0.0000);**
- ☐ *CR's willingness to contribute effective and positive ideas ( $C_s = 0.5716$ ; sig. = 0.0012);*
- ☐ *impact of CR/CM working relationship ( $C_s = 0.6354$ ; sig. = 0.0003);*
- ☐ *CM's forecasting planning data ( $C_s = 0.6144$ ; sig. = 0.0006);*
- ☐ *CM's analysing construction methods ( $C_s = 0.5707$ ; sig. = 0.0012);*
- ☐ *effectiveness of the construction team's planning ( $C_s = 0.6007$ ; sig. = 0.0007);*
- ☐ *CM's monitoring and updating plans to reflect work status ( $C_s = 0.5484$ ; sig. = 0.0019);*
- ☐ *CM's planning - responding to problems or opportunities ( $C_s = 0.6137$ ; sig. = 0.0005);*
- ☐ *CM's effectively coordinating resources ( $C_s = 0.6869$ ; sig. = 0.0001);*
- ☐ **CM's developing an organisational structure to maintain workflow ( $C_s = 0.7802$ ; sig. = 0.0000);**
- ☐ **effectiveness of the construction team's monitoring and control ( $C_s = 0.7758$ ; sig. = 0.0000);**
- ☐ *key sub-contractor's task-oriented management style ( $C_s = 0.5100$ ; sig. = 0.0039);*
- ☐ *CM's communication management to facilitate decision making ( $C_s = 0.6423$ ; sig. = 0.0003);*
- ☐ *CR and CM team communication effectiveness for decision making ( $C_s = 0.5437$ ; sig. = 0.0021);*
- ☐ *decision making communication within the CM team ( $C_s = 0.4580$ ; sig. = 0.0096);*
- ☐ *CM decision making, communicating and actioning ( $C_s = 0.5974$ ; sig. = 0.0007);*
- ☐ *effectiveness of the CM team in managing the construction process ( $C_s = 0.6522$ ; sig. = 0.0002).*

**SUB-HYPOTHESIS NUMBER 62**

**DATA ITEM: CM'S ORGANISATIONAL STRUCTURE TO MANAGE RISK**

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ CR's experience with the building procurement process ( $C_s = 0.4475$ ; sig. = 0.0114);
- ☐ stability of client/CR objectives ( $C_s = 0.6308$ ; sig. = 0.0004);
- ☐ clarity of communication of client/CR objectives ( $C_s = 0.6130$ ; sig. = 0.0005);
- ☐ complexity of CR's influence upon the project's management ( $C_s = 0.4917$ ; sig. = 0.0054);
- ☐ CR's understanding the project's constraints ( $C_s = 0.4721$ ; sig. = 0.0076);
- ☐ CR's ability to quickly make authoritative decisions ( $C_s = 0.5310$ ; sig. = 0.0027);
- ☐ CR's ability to effectively brief the design team ( $C_s = 0.5649$ ; sig. = 0.0020);
- ☐ stability of CR decisions ( $C_s = 0.6123$ ; sig. = 0.0005);
- ☐ the CR's ability to mould shared project goals and aspirations ( $C_s = 0.5719$ ; sig. = 0.0015);
- ☐ the CR's willingness to accept effective and positive ideas ( $C_s = 0.4882$ ; sig. = 0.0058);
- ☐ the overall CR contribution to project team harmony ( $C_s = 0.5056$ ; sig. = 0.0042);
- ☐ quality management procedures used on-site ( $C_s = 0.4717$ ; sig. = 0.0086);
- ☐ CM's effectiveness in influencing the CR decision making process ( $C_s = 0.4932$ ; sig. = 0.0053);
- ☐ CM management systems and procedures ( $C_s = 0.5804$ ; sig. = 0.0010);
- ☐ CM's analysing work sequencing to achieve and maintain workflow ( $C_s = 0.5152$ ; sig. = 0.0036);
- ☐ CR's organisational structure to manage risk ( $C_s = 0.6886$ ; sig. = 0.0001);
- ☐ task-orientation of the CR's management style ( $C_s = 0.4564$ ; sig. = 0.0111);
- ☐ flexibility of the CM's management style ( $C_s = 0.4650$ ; sig. = 0.0085);
- ☐ decision making communication within the CR team ( $C_s = 0.4739$ ; sig. = 0.0121);
- ☐ CR decision making, communicating and actioning ( $C_s = 0.6207$ ; sig. = 0.0004).

## ASUB-HYPOTHESIS NUMBER 63      QUESTIONNAIRE NUMBER Q14.2

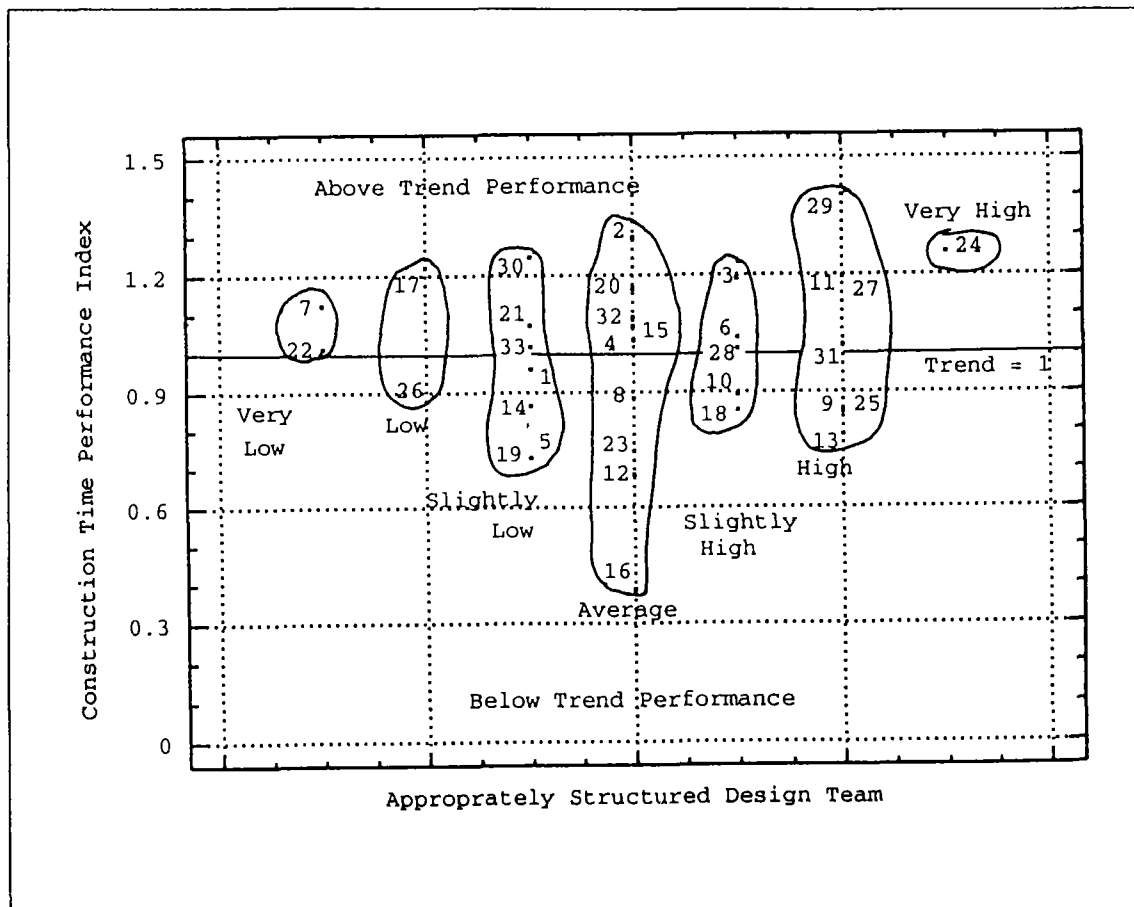
$H_0$  Construction time performance is **NOT** dependent upon an appropriate design team structure.

$H_1$  Construction time performance **IS** dependent upon an appropriate design team structure.

One-way ANOVA test results *measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.*

F-Ratio	Significance Level	Interpretation
0.527	0.7829	<b><math>H_0</math> ACCEPTED</b>

**Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)**



**SUB-HYPOTHESIS NUMBER 63**

**DATA ITEM: DESIGN TEAM'S ORGANISATIONAL STRUCTURE TO MANAGE RISK**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ the project design team's confidence in the CR contribution ( $C_s = 0.4937$ ; sig. = 0.0068);
- ☐ CR and design team communication effectiveness for decision making ( $C_s = 0.6178$ ; sig. = 0.0007).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ number of basement levels ( $C_s = 0.6462$ ; sig. = 0.0003);
- ☐ client organisation's confidence in the CR ( $C_s = 0.4982$ ; sig. = 0.0055);
- ☐ design coordination complexity ( $C_s = 0.5709$ ; sig. = 0.0012);
- ☐ general project complexity ( $C_s = 0.4481$ ; sig. = 0.0112);
- ☐ CR's organisational structure to manage risk ( $C_s = 0.4556$ ; sig. = 0.0100);
- ☐ task-orientation of the design team's management style ( $C_s = 0.5730$ ; sig. = 0.0020);
- ☐ direct use of power in the design team's management style ( $C_s = -0.4776$ ; sig. = 0.0193);
- ☐ decision making communication within the design team ( $C_s = 0.4628$ ; sig. = 0.0127);
- ☐ design team's decision making, communicating and actioning ( $C_s = 0.4785$ ; sig. = 0.0068).

## SUB-HYPOTHESIS NUMBER 64

## QUESTIONNAIRE NUMBER Q14.3

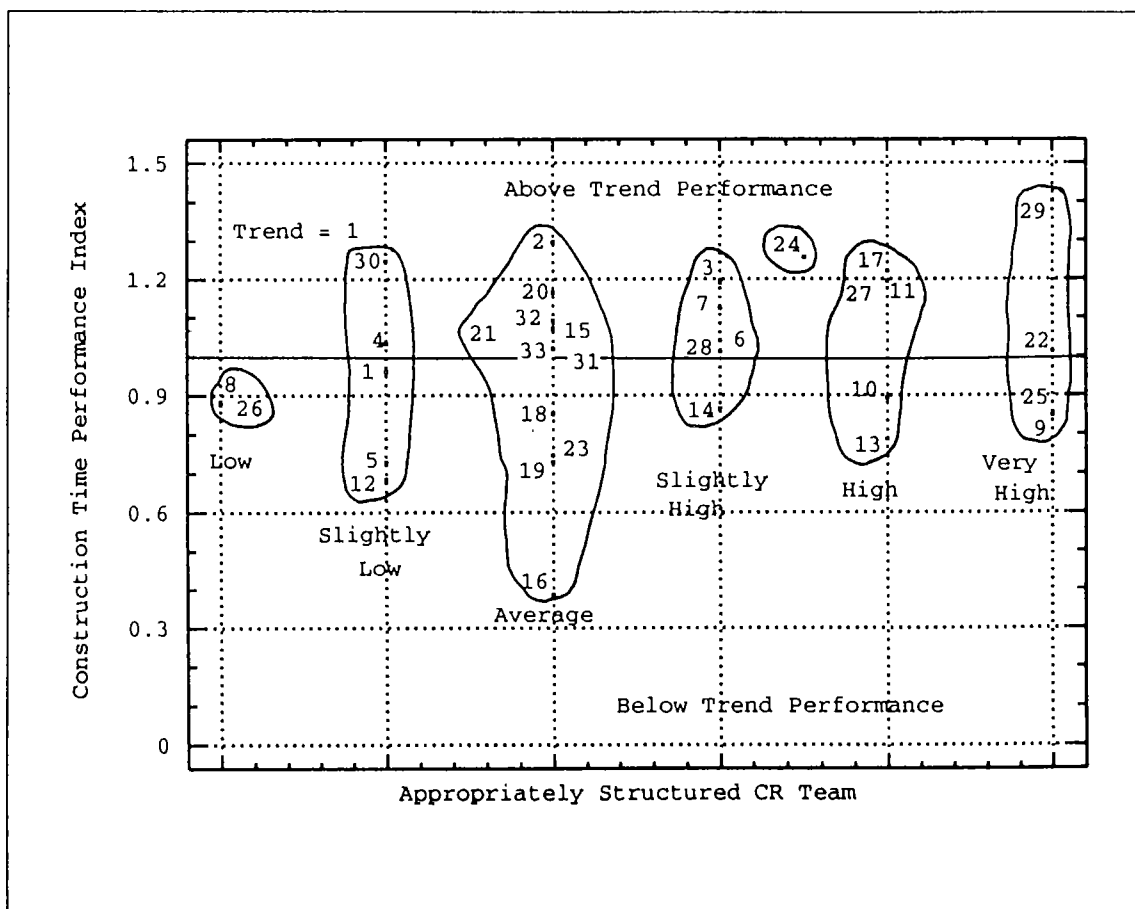
$H_0$  Construction time performance is **NOT** dependent upon an appropriate CR team structure.

$H_1$  Construction time performance **IS** dependent upon an appropriate CR team structure.

One-way ANOVA test results *measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.*

F-Ratio	Significance Level	Interpretation
0.594	0.7319	<b><math>H_0</math> ACCEPTED</b>

**Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)**



## SUB-HYPOTHESIS NUMBER 64

### DATA ITEM: CR'S ORGANISATIONAL STRUCTURE TO MANAGE RISK

#### Spearman Rank Correlation results for factors affecting CTP:

- ☐ *client/CR's time minimisation objective* ( $C_s = 0.5338$ ; sig. = 0.0025);
- ☐ *ability of the CR to contribute ideas to the design process* ( $C_s = 0.5113$ ; sig. = 0.0044);
- ☐ *ability of the CR to contribute ideas to the construction process* ( $C_s = 0.6531$ ; sig. = 0.0002);
- ☐ *the project design team's confidence in the CR contribution* ( $C_s = 0.4923$ ; sig. = 0.0070);
- ☐ **the construction team's confidence in the CR's contribution** ( $C_s = 0.8067$ ; sig. = 0.0000);
- ☐ *CR's willingness to contribute effective and positive ideas* ( $C_s = 0.6592$ ; sig. = 0.0002);
- ☐ **impact of CR/CM working relationship** ( $C_s = 0.7212$ ; sig. = 0.0000);
- ☐ *CM's forecasting planning data* ( $C_s = 0.4706$ ; sig. = 0.0088);
- ☐ *effectiveness of the construction team's planning* ( $C_s = 0.4804$ ; sig. = 0.0066);
- ☐ *CM's planning - responding to problems or opportunities* ( $C_s = 0.5132$ ; sig. = 0.0037);
- ☐ *CM's effectively coordinating resources* ( $C_s = 0.5622$ ; sig. = 0.0015);
- ☐ *CM's developing an organisational structure to maintain workflow* ( $C_s = 0.5267$ ; sig. = 0.0029);
- ☐ *effectiveness of the construction team's monitoring and control* ( $C_s = 0.6010$ ; sig. = 0.0007);
- ☐ *CM's organisational structure to manage risk* ( $C_s = 0.6886$ ; sig. = 0.0001);
- ☐ *CM's communication management to facilitate decision making* ( $C_s = 0.6025$ ; sig. = 0.0007);
- ☐ *CR and CM team communication effectiveness for decision making* ( $C_s = 0.4615$ ; sig. = 0.0090);
- ☐ *decision making communication within the CM team* ( $C_s = 0.4439$ ; sig. = 0.0120);
- ☐ *effectiveness of the CM team in managing the construction process* ( $C_s = 0.5196$ ; sig. = 0.0033);

#### Spearman Rank Correlation results for factors NOT affecting CTP:

- ☐ *CR's experience with the building procurement process* ( $C_s = 0.4691$ ; sig. = 0.0080);
- ☐ *client organisation's confidence in the CR* ( $C_s = 0.5822$ ; sig. = 0.0012);
- ☐ *stability of client/CR objectives* ( $C_s = 0.5811$ ; sig. = 0.0010);
- ☐ *clarity of communication of client/CR objectives* ( $C_s = 0.6924$ ; sig. = 0.0001);
- ☐ *complexity of CR's influence upon the project's management* ( $C_s = 0.6233$ ; sig. = 0.0004);
- ☐ **CR's ability to quickly make authoritative decisions** ( $C_s = 0.7931$ ; sig. = 0.0000);
- ☐ *CR's ability to effectively brief the design team* ( $C_s = 0.5767$ ; sig. = 0.016);
- ☐ *stability of CR decisions* ( $C_s = 0.6035$ ; sig. = 0.0006);
- ☐ *the CR's ability to mould shared project goals and aspirations* ( $C_s = 0.6099$ ; sig. = 0.0007);
- ☐ *the CR's willingness to accept effective and positive ideas* ( $C_s = 0.4632$ ; sig. = 0.0088);
- ☐ *the overall CR contribution to project team harmony* ( $C_s = 0.5498$ ; sig. = 0.0019);
- ☐ *CM's effectiveness in influencing the CR decision making process* ( $C_s = 0.5052$ ; sig. = 0.0043);
- ☐ *CM management systems and procedures* ( $C_s = 0.5309$ ; sig. = 0.0027);
- ☐ *design team's organisational structure to manage risk* ( $C_s = 0.4556$ ; sig. = 0.0100);
- ☐ *flexibility of the CR's management style* ( $C_s = 0.5032$ ; sig. = 0.0044);
- ☐ *direct use of power in the CR's management style* ( $C_s = -0.4558$ ; sig. = 0.0112);
- ☐ *decision making communication within the CR team* ( $C_s = 0.5088$ ; sig. = 0.0071);
- ☐ **CR decision making, communicating and actioning** ( $C_s = 0.6993$ ; sig. = 0.0001);
- ☐ *CR's effective use of information technologies* ( $C_s = 0.4458$ ; sig. = 0.0745).

## SUB-HYPOTHESIS NUMBER 65

## QUESTIONNAIRE NUMBER Q14.4

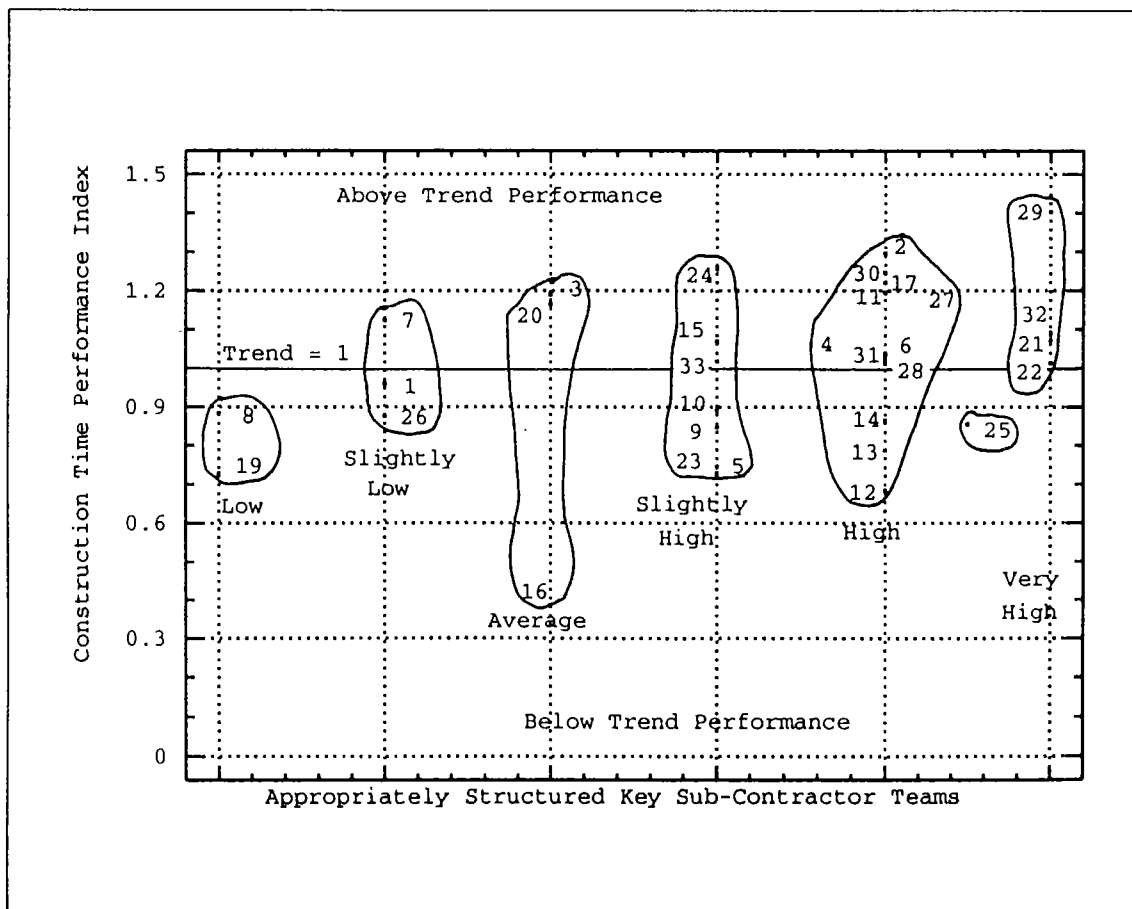
$H_0$  Construction time performance is NOT dependent upon an appropriate key sub-contractors team structure.

$H_1$  Construction time performance IS dependent upon an appropriate key sub-contractor team structure.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.917	0.4991	<b><math>H_0</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 65**

**DATA ITEM: KEY SUB-CONTRACTOR'S ORGANISATIONAL STRUCTURE TO MANAGE RISK**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *the project design team's confidence in the CR contribution ( $C_s = 0.5847$ ; sig. = 0.0016);*
- ☐ *the construction team's confidence in the CR's contribution ( $C_s = 0.5049$ ; sig. = 0.0049);*
- ☐ *impact of CR/CM working relationship ( $C_s = 0.5556$ ; sig. = 0.0020);*
- ☐ *effectiveness of the construction team's planning ( $C_s = 0.5850$ ; sig. = 0.0011);*
- ☐ *CM's monitoring and updating plans to reflect work status ( $C_s = 0.4971$ ; sig. = 0.0056);*
- ☐ *CM's planning - responding to problems or opportunities ( $C_s = 0.4556$ ; sig. = 0.0112);*
- ☐ *CM's effectively coordinating resources ( $C_s = 0.5164$ ; sig. = 0.0040);*
- ☐ *CM's developing an organisational structure to maintain workflow ( $C_s = 0.5802$ ; sig. = 0.0012);*
- ☐ *effectiveness of the construction team's monitoring and control ( $C_s = 0.5465$ ; sig. = 0.0023);*
- ☐ *key sub-contractor's task-oriented management style ( $C_s = 0.4806$ ; sig. = 0.0075);*
- ☐ *CM's communication management to facilitate decision making ( $C_s = 0.4873$ ; sig. = 0.0067);*
- ☐ *decision making communication within the CM team ( $C_s = 0.5400$ ; sig. = 0.0026);*
- ☐ *CM decision making, communicating and actioning ( $C_s = 0.5128$ ; sig. = 0.0043);*
- ☐ *CM's effective use of information technologies ( $C_s = 0.4815$ ; sig. = 0.0073);*
- ☐ *effectiveness of the CM team in managing the construction process ( $C_s = 0.4603$ ; sig. = 0.0104).*

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *clarity of communication of client/CR objectives ( $C_s = 0.4712$ ; sig. = 0.0087);*
- ☐ *complexity of CR's influence upon the project's management ( $C_s = 0.4944$ ; sig. = 0.0059);*
- ☐ *the CR's ability to mould shared project goals and aspirations ( $C_s = 0.5806$ ; sig. = 0.0015);*
- ☐ *CM management systems and procedures ( $C_s = 0.4665$ ; sig. = 0.0094);*
- ☐ *CM's analysing resource movement ( $C_s = 0.5909$ ; sig. = 0.0012);*
- ☐ *CM's analysing work sequencing to achieve and maintain workflow ( $C_s = 0.5358$ ; sig. = 0.0029);*
- ☐ *CM's effectiveness in team management to achieve synergy ( $C_s = 0.5727$ ; sig. = 0.0014);*
- ☐ *flexibility-of the CM's management style ( $C_s = 0.4514$ ; sig. = 0.0120);*
- ☐ *task-orientation of the CM's management style ( $C_s = 0.4478$ ; sig. = 0.0127);*
- ☐ *key sub-contractor's people-oriented management style ( $C_s = 0.4457$ ; sig. = 0.0131);*
- ☐ *decision making communication within the CR team ( $C_s = 0.4866$ ; sig. = 0.0115);*
- ☐ *CR's effective use of information technologies ( $C_s = 0.6241$ ; sig. = 0.0125).*



## SUB-HYPOTHESIS NUMBER 66

## QUESTIONNAIRE NUMBER Q15.1

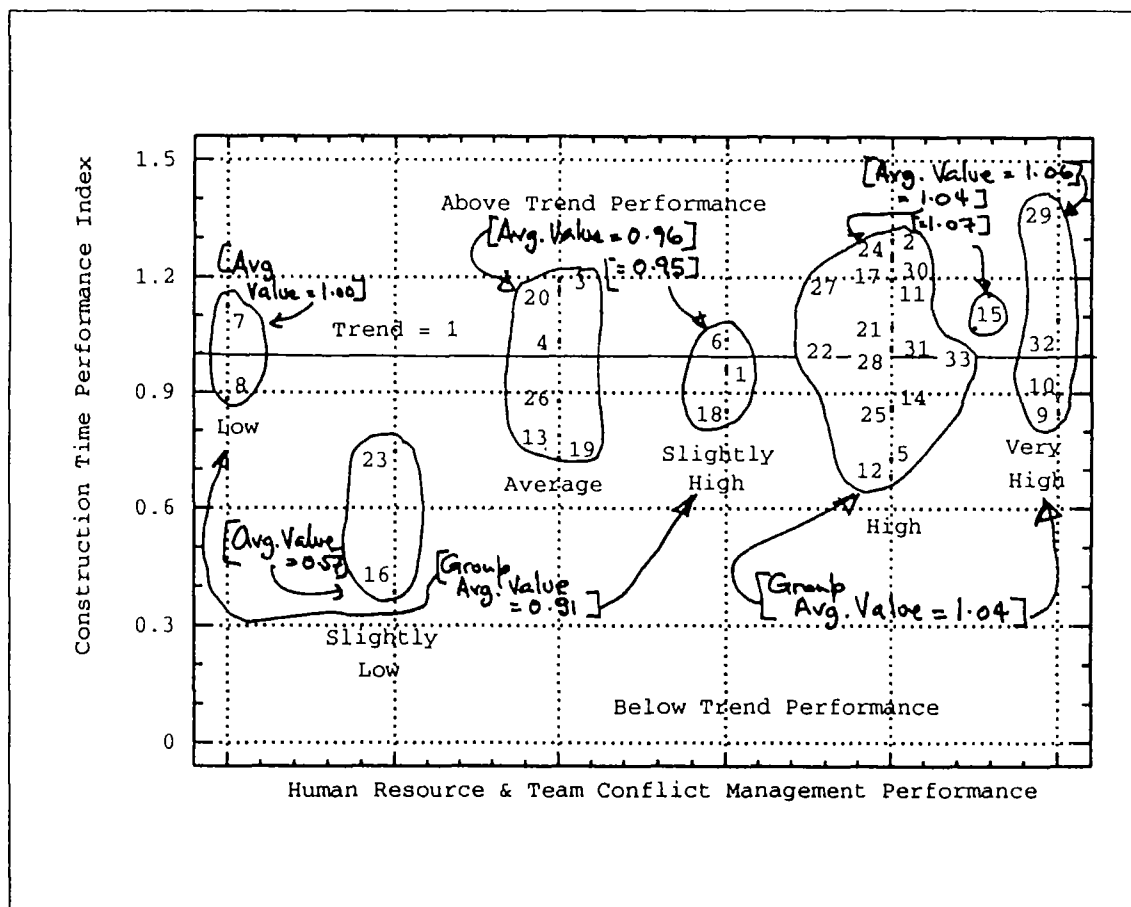
$H_0$  Construction time performance is NOT dependent upon CM team and human resources conflict management performance.

$H_1$  Construction time performance IS dependent upon CM team and human resources conflict management performance.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
1.872	0.1240	$H_0$ ACCEPTED

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 66**

**DATA ITEM: CM'S EFFECTIVENESS IN TEAM MANAGEMENT TO ACHIEVE SYNERGY**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ ability of the CR to contribute ideas to the design process ( $C_s = 0.4481$ ; sig. = 0.0126);
- ☐ CR's willingness to contribute effective and positive ideas ( $C_s = 0.4584$ ; sig. = 0.0095);
- ☐ *the project design team's confidence in the CR contribution* ( $C_s = 0.5615$ ; sig. = 0.0021);
- ☐ *the construction team's confidence in the CR's contribution* ( $C_s = 0.5023$ ; sig. = 0.0045);
- ☐ *impact of CR/CM working relationship* ( $C_s = 0.6831$ ; sig. = 0.0001);
- ☐ *CM's forecasting planning data* ( $C_s = 0.5110$ ; sig. = 0.0044);
- ☐ *CM's analysing construction methods* ( $C_s = 0.5993$ ; sig. = 0.0007);
- ☐ *effectiveness of the construction team's planning* ( $C_s = 0.6889$ ; sig. = 0.0001);
- ☐ *CM's monitoring and updating plans to reflect work status* ( $C_s = 0.6087$ ; sig. = 0.0006);
- ☐ *CM's planning - responding to problems or opportunities* ( $C_s = 0.6050$ ; sig. = 0.0006);
- ☐ **CM's effectively coordinating resources** ( $C_s = 0.7146$ ; sig. = 0.0001);
- ☐ *CM's developing an organisational structure to maintain workflow* ( $C_s = 0.6063$ ; sig. = 0.0006);
- ☐ **effectiveness of the construction team's monitoring and control** ( $C_s = 0.7351$ ; sig. = 0.0000);
- ☐ *key sub-contractor's task-oriented management style* ( $C_s = 0.5936$ ; sig. = 0.0008);
- ☐ *CM's communication management to facilitate decision making* ( $C_s = 0.6232$ ; sig. = 0.0004);
- ☐ *CR and design team communication effectiveness for decision making* ( $C_s = 0.5164$ ; sig. = 0.0047);
- ☐ *decision making communication within the CM team* ( $C_s = 0.6515$ ; sig. = 0.0002);
- ☐ **CM decision making, communicating and actioning** ( $C_s = 0.7595$ ; sig. = 0.0000);
- ☐ **effectiveness of the CM team in managing the construction process** ( $C_s = 0.6984$ ; sig. = 0.0001).

**SUB-HYPOTHESIS NUMBER 66**

**DATA ITEM: CM'S EFFECTIVENESS IN TEAM MANAGEMENT TO ACHIEVE SYNERGY**

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ ratio of EOT:actual construction time ( $C_s = -0.6219$ ; sig. = 0.0004);
- ☐ stability of client/CR objectives ( $C_s = 0.5537$ ; sig. = 0.017);
- ☐ clarity of communication of client/CR objectives ( $C_s = 0.4466$ ; sig. = 0.0115);
- ☐ the level of influence exercised on CTP by the CR ( $C_s = 0.4635$ ; sig. = 0.0087);
- ☐ CR's ability to quickly make authoritative decisions ( $C_s = 0.4849$ ; sig. = 0.0061);
- ☐ CR's ability to effectively brief the design team ( $C_s = 0.4887$ ; sig. = 0.0074);
- ☐ stability of CR decisions ( $C_s = 0.5287$ ; sig. = 0.0028);
- ☐ the CR's confidence in the construction team ( $C_s = 0.6279$ ; sig. = 0.0005);
- ☐ CM's effectiveness in influencing the CR decision making process ( $C_s = 0.6028$ ; sig. = 0.0006);
- ☐ CM management systems and procedures ( $C_s = 0.6532$ ; sig. = 0.0002);
- ☐ CM's analysing resource movement ( $C_s = 0.4706$ ; sig. = 0.0088);
- ☐ CM's analysing work sequencing to achieve and maintain workflow ( $C_s = 0.5986$ ; sig. = 0.0007);
- ☐ key sub-contractor's organisational structure to manage risk ( $C_s = 0.5727$ ; sig. = 0.0014);
- ☐ flexibility of the CR's management style ( $C_s = 0.5028$ ; sig. = 0.0044);
- ☐ task-orientation of the CR's management style ( $C_s = 0.4668$ ; sig. = 0.0094);
- ☐ flexibility of the CM's management style ( $C_s = 0.6314$ ; sig. = 0.0004);
- ☐ task-orientation of the CM's management style ( $C_s = 0.6464$ ; sig. = 0.0003);
- ☐ CM's people-oriented management style ( $C_s = 0.6582$ ; sig. = 0.0002);
- ☐ key sub-contractor's people-oriented management style ( $C_s = 0.5753$ ; sig. = 0.0011);
- ☐ decision making communication within the CR team ( $C_s = 0.6032$ ; sig. = 0.0014);
- ☐ design team's decision making, communicating and actioning ( $C_s = 0.5755$ ; sig. = 0.0011).

## SUB-HYPOTHESIS NUMBER 67

## QUESTIONNAIRE NUMBER Q15.2-CR

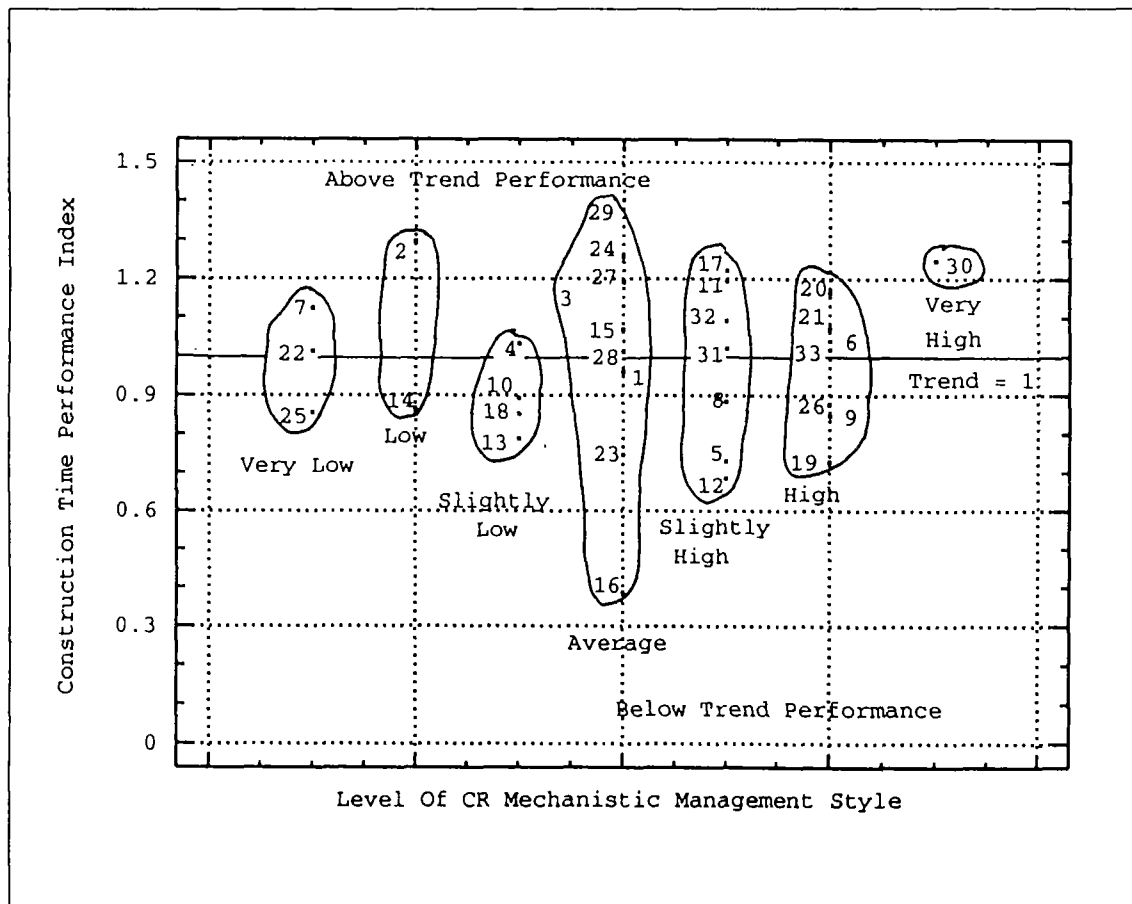
$H_0$  Construction time performance is **NOT** dependent upon a CR mechanistic management style.

$H_1$  Construction time performance **IS** dependent upon a CR mechanistic management style.

One-way ANOVA test results *measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.*

F-Ratio	Significance Level	Interpretation
0.456	0.8344	<b><math>H_0</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 67**

**DATA ITEM: CR'S MECHANISTIC-ORIENTED MANAGEMENT STYLE**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ no significant correlation.

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ CR's ability to effectively brief the design team ( $C_s = -0.4650$ ; sig. = 0.0109);
- ☐ design buildability complexity ( $C_s = -0.4640$ ; sig. = 0.0087);
- ☐ flexibility of the CR's management style ( $C_s = -0.4587$ ; sig. = 0.0095);
- ☐ *design team's mechanistic-oriented management style* ( $C_s = 0.5442$ ; sig. = 0.0024);

## SUB-HYPOTHESIS NUMBER 68

## QUESTIONNAIRE NUMBER Q15.2-CR

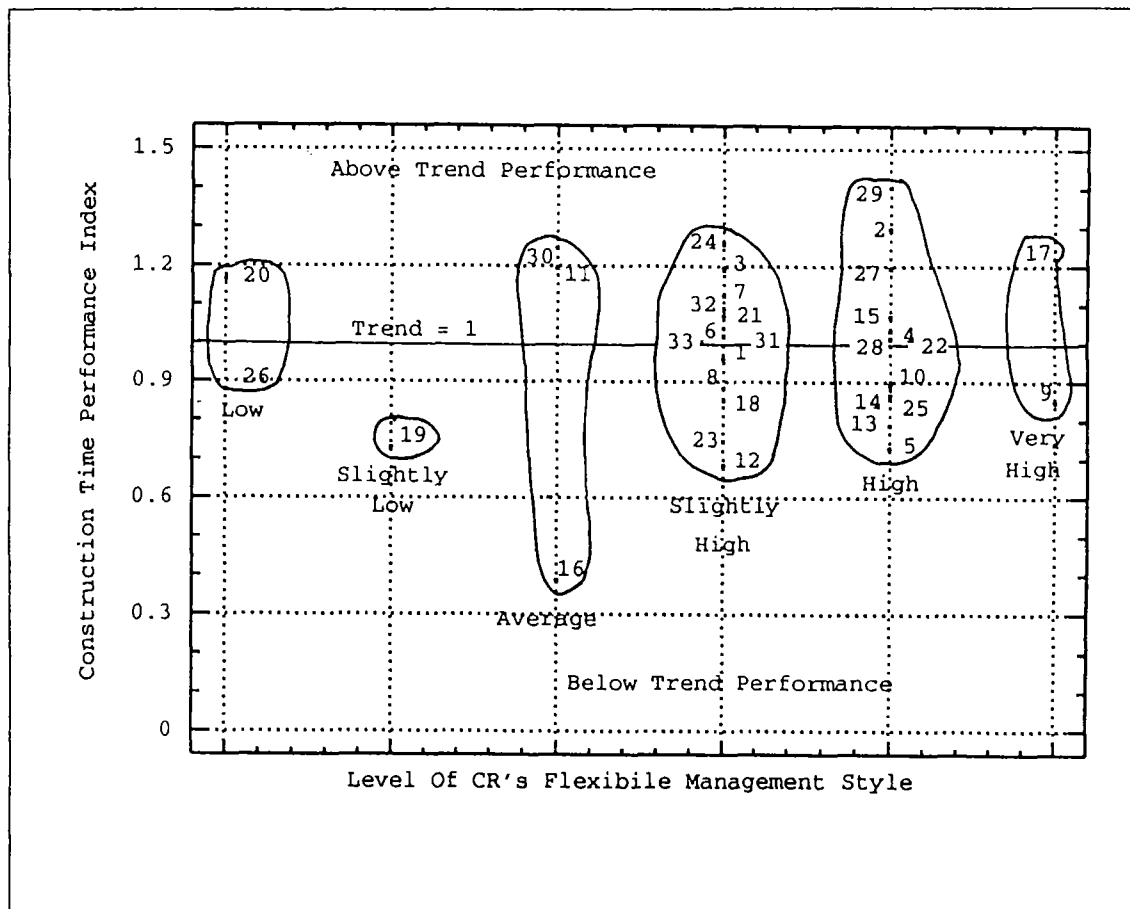
$H_0$  Construction time performance is **NOT** dependent upon a CR flexible management style.

$H_1$  Construction time performance **IS** dependent upon a CR flexible management style.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.343	0.8825	<b><math>H_0</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 68**

**DATA ITEM: FLEXIBILITY OF THE CR'S MANAGEMENT STYLE**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ ability of the CR to contribute ideas to the design process ( $C_s = 0.5618$ ; sig. = 0.0018);
- ☐ ability of the CR to contribute ideas to the construction process ( $C_s = 0.5030$ ; sig. = 0.0044);
- ☐ the project design team's confidence in the CR contribution ( $C_s = 0.4637$ ; sig. = 0.0111);
- ☐ the construction team's confidence in the CR's contribution ( $C_s = 0.6450$ ; sig. = 0.0003);
- ☐ CR's willingness to contribute effective and positive ideas ( $C_s = 0.6666$ ; sig. = 0.0002);
- ☐ impact of CR/CM working relationship ( $C_s = 0.5779$ ; sig. = 0.0011);
- ☐ CM's effectively coordinating resources ( $C_s = 0.5382$ ; sig. = 0.0023);
- ☐ effectiveness of the construction team's monitoring and control ( $C_s = 0.5129$ ; sig. = 0.0037);
- ☐ key sub-contractor's task-oriented management style ( $C_s = 0.5086$ ; sig. = 0.0040);
- ☐ CM's communication management to facilitate decision making ( $C_s = 0.5315$ ; sig. = 0.0026);
- ☐ CR and CM team communication effectiveness for decision making ( $C_s = 0.5464$ ; sig. = 0.0020);
- ☐ CR and design team communication effectiveness for decision making ( $C_s = 0.4822$ ; sig. = 0.0083);
- ☐ CM decision making, communicating and actioning ( $C_s = 0.5668$ ; sig. = 0.0013);
- ☐ effectiveness of the CM team in managing the construction process ( $C_s = 0.4736$ ; sig. = 0.0074).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ stability of client/CR objectives ( $C_s = 0.4667$ ; sig. = 0.0083);
- ☐ clarity of communication of client/CR objectives ( $C_s = 0.7326$ ; sig. = 0.0000);
- ☐ the level of influence exercised on CTP by the CR ( $C_s = 0.5044$ ; sig. = 0.0043);
- ☐ complexity of CR's influence upon the project's management ( $C_s = 0.5483$ ; sig. = 0.0019);
- ☐ CR's understanding the project's constraints ( $C_s = 0.4905$ ; sig. = 0.0055);
- ☐ CR's ability to quickly make authoritative decisions ( $C_s = 0.5362$ ; sig. = 0.0024);
- ☐ CR's ability to effectively brief the design team ( $C_s = 0.6180$ ; sig. = 0.0007);
- ☐ the CR's ability to mould shared project goals and aspirations ( $C_s = 0.5771$ ; sig. = 0.0013);
- ☐ the CR's willingness to accept effective and positive ideas ( $C_s = 0.5776$ ; sig. = 0.0011);
- ☐ the overall CR contribution to project team harmony ( $C_s = 0.5959$ ; sig. = 0.0007);
- ☐ CM's effectiveness in influencing the CR decision making process ( $C_s = 0.6417$ ; sig. = 0.0003);
- ☐ CM management systems and procedures ( $C_s = 0.4754$ ; sig. = 0.0072);
- ☐ CR's organisational structure to manage risk ( $C_s = 0.5032$ ; sig. = 0.0044);
- ☐ CM's effectiveness in team management to achieve synergy ( $C_s = 0.5028$ ; sig. = 0.0044);
- ☐ CR's mechanistic-oriented management style ( $C_s = -0.4587$ ; sig. = 0.0095);
- ☐ CR's people-oriented management style ( $C_s = 0.6390$ ; sig. = 0.0004);
- ☐ direct use of power in the CR's management style ( $C_s = -0.5472$ ; sig. = 0.0023);
- ☐ flexibility of design team's management style ( $C_s = 0.5872$ ; sig. = 0.0011);
- ☐ flexibility of the CR's management style ( $C_s = 0.5793$ ; sig. = 0.0010);
- ☐ task-orientation of the CM's management style ( $C_s = 0.5968$ ; sig. = 0.0007);
- ☐ CM's people-oriented management style ( $C_s = 0.5326$ ; sig. = 0.0026);
- ☐ CR decision making, communicating and actioning ( $C_s = 0.5141$ ; sig. = 0.0036).

## SUB-HYPOTHESIS NUMBER 69

## QUESTIONNAIRE NUMBER Q15.3-CR

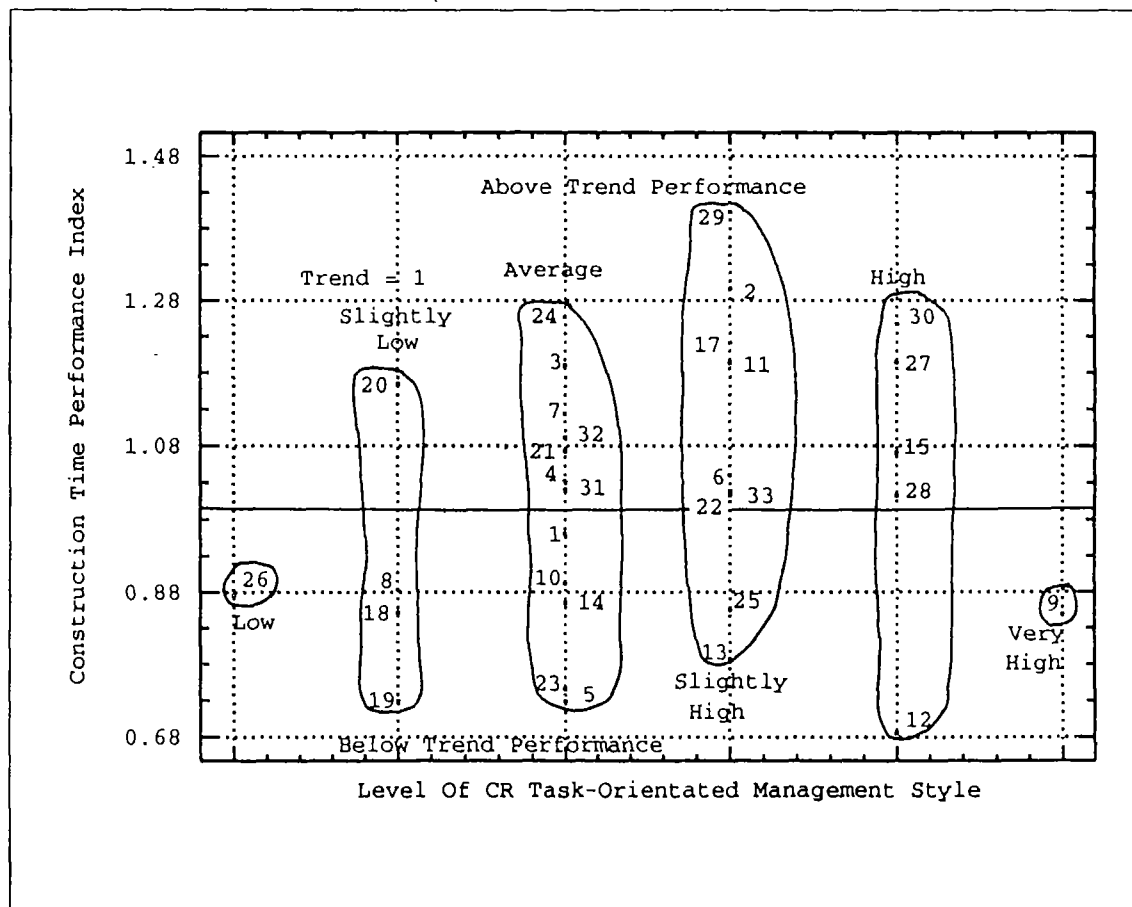
$H_0$  Construction time performance is **NOT** dependent upon a CR task oriented management style.

$H_1$  Construction time performance **IS** dependent upon a CR task oriented management style.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of *less than* 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.862	0.5198	<b><math>H_0</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*





**SUB-HYPOTHESIS NUMBER 69**

**DATA ITEM: TASK-ORIENTATION OF THE CR'S MANAGEMENT STYLE**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ ability of the CR to contribute ideas to the construction process ( $C_s = 0.4822$ ; sig. = 0.0073);
- ☐ CR's willingness to contribute effective and positive ideas ( $C_s = 0.5735$ ; sig. = 0.0014);
- ☐ the project design team's confidence in the CR contribution ( $C_s = 0.4773$ ; sig. = 0.0089);
- ☐ the construction team's confidence in the CR's contribution ( $C_s = 0.5253$ ; sig. = 0.0034);
- ☐ CM's organisational structure to manage risk ( $C_s = 0.4564$ ; sig. = 0.0111);
- ☐ key sub-contractor's task-oriented management style ( $C_s = 0.5269$ ; sig. = 0.0033);
- ☐ CR and design team communication effectiveness for decision making ( $C_s = 0.4642$ ; sig. = 0.1024);
- ☐ decision making communication within the CM team ( $C_s = 0.6045$ ; sig. = 0.0008);
- ☐ effectiveness of the CM team in managing the construction process ( $C_s = 0.5779$ ; sig. = 0.0013).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ project procurement method ( $C_s = 0.4912$ ; sig. = 0.0062);
- ☐ CR's experience with the building procurement process ( $C_s = 0.5248$ ; sig. = 0.0035);
- ☐ client organisation's confidence in the CR ( $C_s = 0.4920$ ; sig. = 0.0070);
- ☐ stability of client/CR objectives ( $C_s = 0.4908$ ; sig. = 0.0063);
- ☐ CR's understanding the project's constraints ( $C_s = 0.6693$ ; sig. = 0.0002);
- ☐ the construction team's confidence in the CR's contribution ( $C_s = 0.4592$ ; sig. = 0.0106);
- ☐ the CR's ability to mould shared project goals and aspirations ( $C_s = 0.5389$ ; sig. = 0.0032);
- ☐ quality management procedures used on-site ( $C_s = 0.4685$ ; sig. = 0.0103);
- ☐ impact of the IR environment ( $C_s = 0.4875$ ; sig. = 0.0066);
- ☐ impact of general environmental factors ( $C_s = 0.4540$ ; sig. = 0.0115);
- ☐ CM's effectiveness in team management to achieve synergy ( $C_s = 0.4668$ ; sig. = 0.0094);
- ☐ CR's people-oriented management style ( $C_s = 0.6380$ ; sig. = 0.0004);
- ☐ direct use of power in the CR's management style ( $C_s = -0.4973$ ; sig. = 0.0056);
- ☐ task-orientation of the design team's management style ( $C_s = 0.5272$ ; sig. = 0.0045);
- ☐ flexibility of the CM's management style ( $C_s = 0.5221$ ; sig. = 0.0037);
- ☐ task-orientation of the CM's management style ( $C_s = 0.5967$ ; sig. = 0.0009);
- ☐ CM's people-oriented management style ( $C_s = 0.6388$ ; sig. = 0.0004);
- ☐ flexibility of key sub-contractor's management style ( $C_s = 0.5142$ ; sig. = 0.0042).

## SUB-HYPOTHESIS NUMBER 70

## QUESTIONNAIRE NUMBER Q15.3-CR

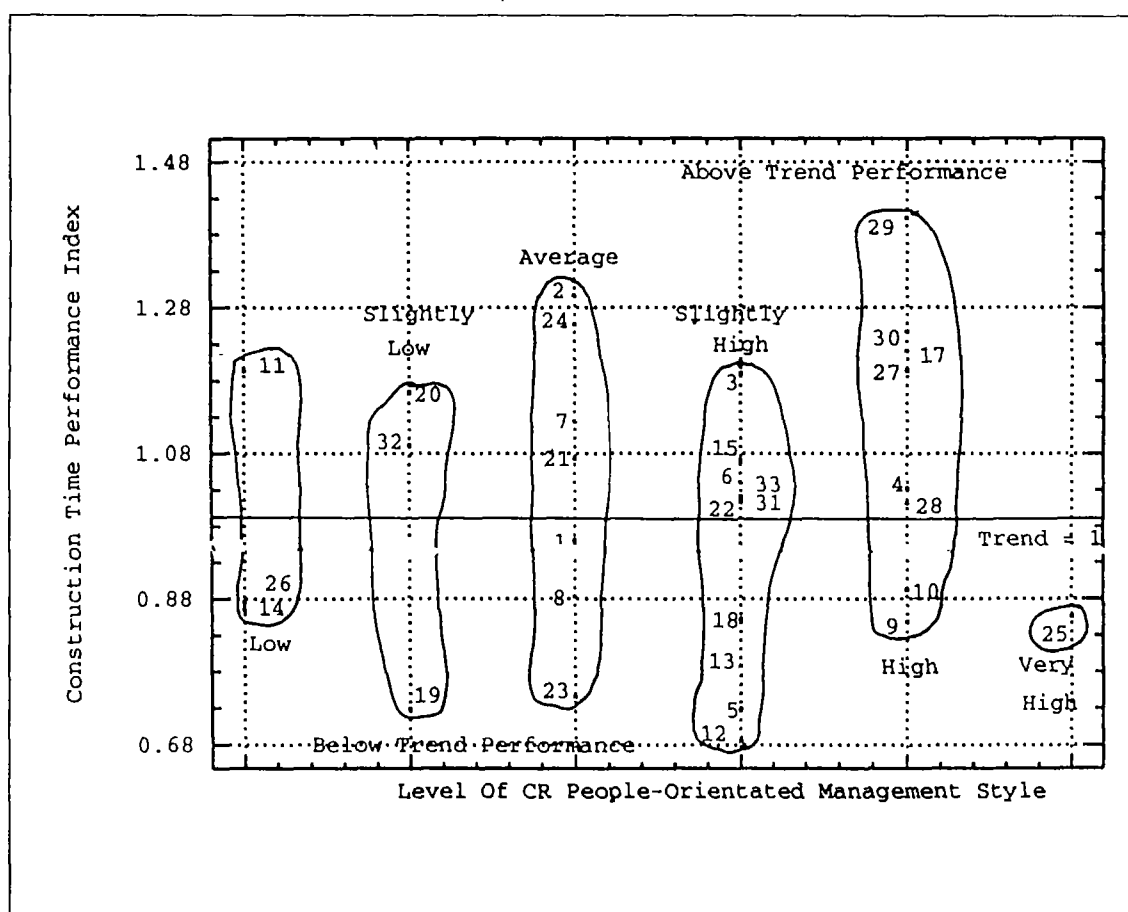
$H_0$  Construction time performance is **NOT** dependent upon a CR people oriented management style.

$H_1$  Construction time performance **IS** dependent upon a CR people oriented management style.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.907	0.4918	<b><math>H_0</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 70**

**DATA ITEM: CR'S PEOPLE-ORIENTED MANAGEMENT STYLE**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ ability of the CR to contribute ideas to the construction process ( $C_s = 0.4569$ ; sig. = 0.0110);
- ☐ the construction team's confidence in the CR's contribution ( $C_s = 0.6126$ ; sig. = 0.0006);
- ☐ **CR's willingness to contribute effective and positive ideas ( $C_s = 0.7695$ ; sig. = 0.0000);**
- ☐ impact of CR/CM working relationship ( $C_s = 0.4900$ ; sig. = 0.0064);
- ☐ CR and CM team communication effectiveness for decision making ( $C_s = 0.5637$ ; sig. = 0.0017);
- ☐ CR and design team communication effectiveness for decision making ( $C_s = 0.5429$ ; sig. = 0.0035);
- ☐ CM decision making, communicating and actioning ( $C_s = 0.5430$ ; sig. = 0.0025);

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ clarity of communication of client/CR objectives ( $C_s = 0.4524$ ; sig. = 0.0118);
- ☐ the level of influence exercised on CTP by the CR ( $C_s = 0.4535$ ; sig. = 0.0116);
- ☐ complexity of CR's influence upon the project's management ( $C_s = 0.4712$ ; sig. = 0.0087);
- ☐ CR's understanding the project's constraints ( $C_s = 0.5773$ ; sig. = 0.0013);
- ☐ CR's ability to effectively brief the design team ( $C_s = 0.4793$ ; sig. = 0.0099);
- ☐ the CR's confidence in the construction team ( $C_s = 0.5091$ ; sig. = 0.0046);
- ☐ the CR's ability to mould shared project goals and aspirations ( $C_s = 0.6210$ ; sig. = 0.0007);
- ☐ the CR's willingness to accept effective and positive ideas ( $C_s = 0.6051$ ; sig. = 0.0008);
- ☐ the overall CR contribution to project team harmony ( $C_s = 0.6501$ ; sig. = 0.0003);
- ☐ quality management procedures used on-site ( $C_s = 0.5531$ ; sig. = 0.0025);
- ☐ CM's effectiveness in influencing the CR decision making process ( $C_s = 0.6174$ ; sig. = 0.0006);
- ☐ flexibility of the CR's management style ( $C_s = 0.6390$ ; sig. = 0.0004);
- ☐ task-orientation of the CR's management style ( $C_s = 0.6380$ ; sig. = 0.0004);
- ☐ direct use of power in the CR's management style ( $C_s = -0.5689$ ; sig. = 0.0015);
- ☐ flexibility of design team's management style ( $C_s = 0.4463$ ; sig. = 0.0145);
- ☐ flexibility of the CM's management style ( $C_s = 0.5767$ ; sig. = 0.0013);
- ☐ task-orientation of the CM's management style ( $C_s = 0.6920$ ; sig. = 0.0001).

## SUB-HYPOTHESIS NUMBER 71

## QUESTIONNAIRE NUMBER Q15.4-CR

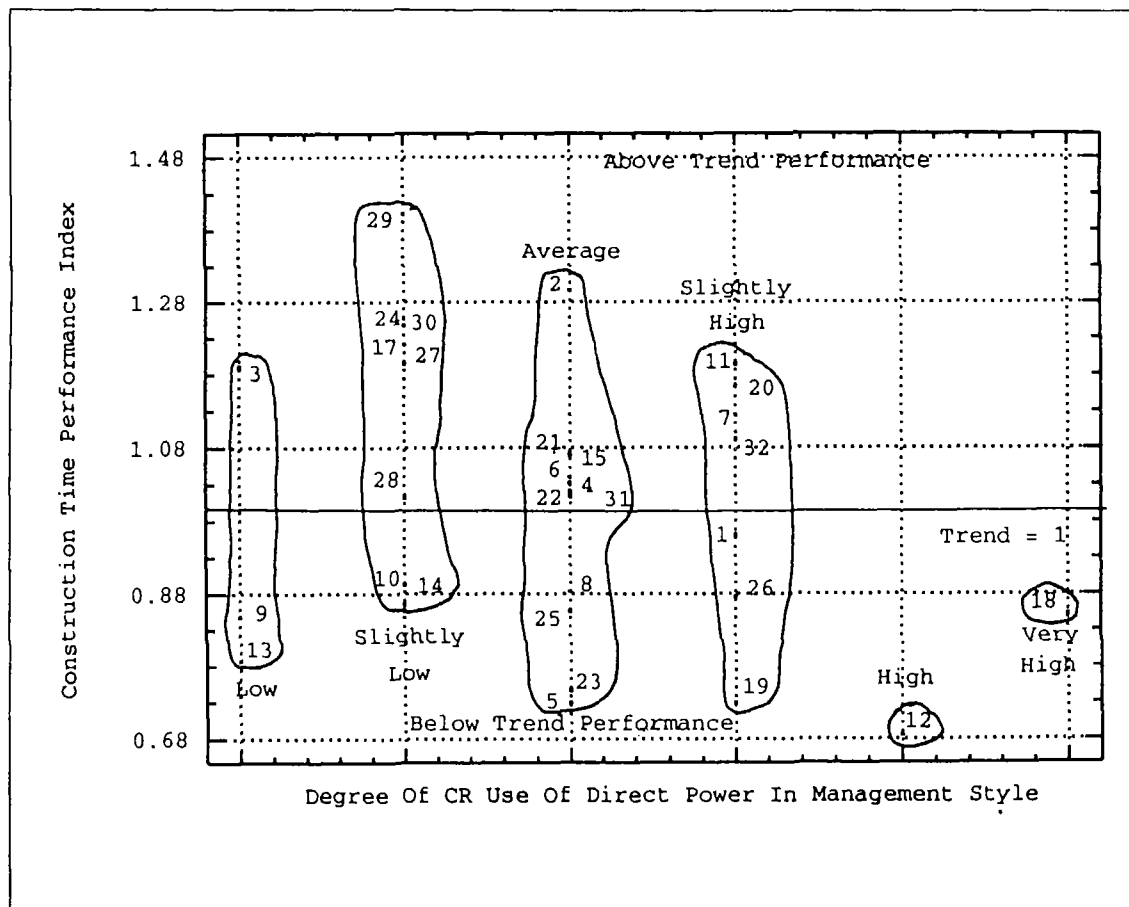
$H_0$  Construction time performance is **NOT** dependent upon a CR direct use of power as a management style.

$H_1$  Construction time performance **IS** dependent upon a CR direct use of power as a management style.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of *less than* 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
1.849	0.1382	$H_0$ ACCEPTED

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 71**

**DATA ITEM: DIRECT USE OF POWER IN THE CR'S MANAGEMENT STYLE**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ ability of the CR to contribute ideas to the design process ( $C_s = -0.4508$ ; sig. = 0.0135);
- ☐ ability of the CR to contribute ideas to the construction process ( $C_s = -0.4963$ ; sig. = 0.0057);
- ☐ the project design team's confidence in the CR contribution ( $C_s = -0.6297$ ; sig. = 0.0006);
- ☐ the construction team's confidence in the CR's contribution ( $C_s = -0.5915$ ; sig. = 0.0010);
- ☐ CR's willingness to contribute effective and positive ideas ( $C_s = -0.5433$ ; sig. = 0.0025);
- ☐ impact of CR/CM working relationship ( $C_s = -0.5603$ ; sig. = 0.0018);
- ☐ CM's communication management to facilitate decision making ( $C_s = -0.5219$ ; sig. = 0.0037);
- ☐ CR and CM team communication effectiveness for decision making ( $C_s = -0.6552$ ; sig. = 0.0003);
- ☐ CR and design team communication effectiveness for decision making ( $C_s = -0.5042$ ; sig. = 0.0066);
- ☐ CM decision making, communicating and actioning ( $C_s = -0.4539$ ; sig. = 0.0115).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ project procurement method ( $C_s = -0.4967$ ; sig. = 0.0057);
- ☐ clarity of communication of client/CR objectives ( $C_s = -0.4639$ ; sig. = 0.0098);
- ☐ complexity of CR's influence upon the project's management ( $C_s = -0.5389$ ; sig. = 0.0027);
- ☐ CR's understanding the project's constraints ( $C_s = -0.5744$ ; sig. = 0.0014);
- ☐ the CR's confidence in the construction team ( $C_s = -0.5358$ ; sig. = 0.0029);
- ☐ the CR's ability to mould shared project goals and aspirations ( $C_s = -0.6406$ ; sig. = 0.0005);
- ☐ the CR's willingness to accept effective and positive ideas ( $C_s = -0.6148$ ; sig. = 0.0006);
- ☐ the overall CR contribution to project team harmony ( $C_s = -0.8202$ ; sig. = 0.0000);
- ☐ quality management procedures used on-site ( $C_s = -0.5683$ ; sig. = 0.0019);
- ☐ CM's effectiveness in influencing the CR decision making process ( $C_s = -0.5156$ ; sig. = 0.0041);
- ☐ CR's organisational structure to manage risk ( $C_s = -0.4558$ ; sig. = 0.0112);
- ☐ flexibility of the CR's management style ( $C_s = -0.5472$ ; sig. = 0.0028);
- ☐ task-orientation of the CR's management style ( $C_s = -0.4973$ ; sig. = 0.0056);
- ☐ CR's people-oriented management style ( $C_s = -0.5689$ ; sig. = 0.0015);
- ☐ design team's people-oriented management style ( $C_s = -0.5122$ ; sig. = 0.0078);
- ☐ direct use of power in the design team's management style ( $C_s = 0.6092$ ; sig. = 0.0028);
- ☐ direct use of power in the CM's management style ( $C_s = 0.5506$ ; sig. = 0.0022).

## SUB-HYPOTHESIS NUMBER 72

## QUESTIONNAIRE NUMBER Q15.2-DES

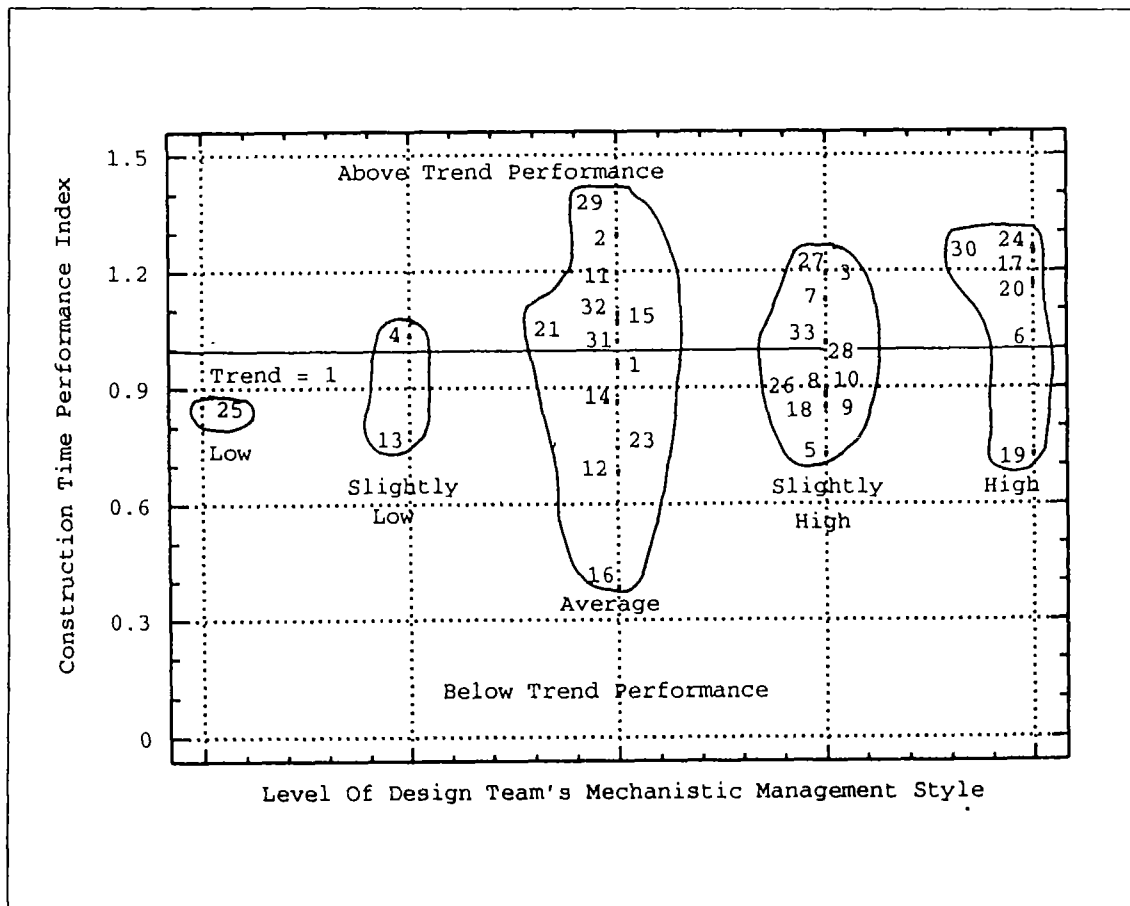
$H_0$  Construction time performance is **NOT** dependent upon a design team leader's mechanistic management style.

$H_1$  Construction time performance **IS** dependent upon a design team leader's mechanistic management style.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.629	0.6463	<b><math>H_0</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 72**

**DATA ITEM: DESIGN TEAM'S MECHANISTIC-ORIENTED MANAGEMENT STYLE**

**Spearman Rank Correlation results for factors affecting CTP:**

☐ no significant correlation.

**Spearman Rank Correlation results for factors NOT affecting CTP:**

☐ *CR's mechanistic-oriented management style ( $C_s = 0.5442$ ;  $sig. = 0.0024$ ).*

## SUB-HYPOTHESIS NUMBER 73

## QUESTIONNAIRE NUMBER Q15.2-DES

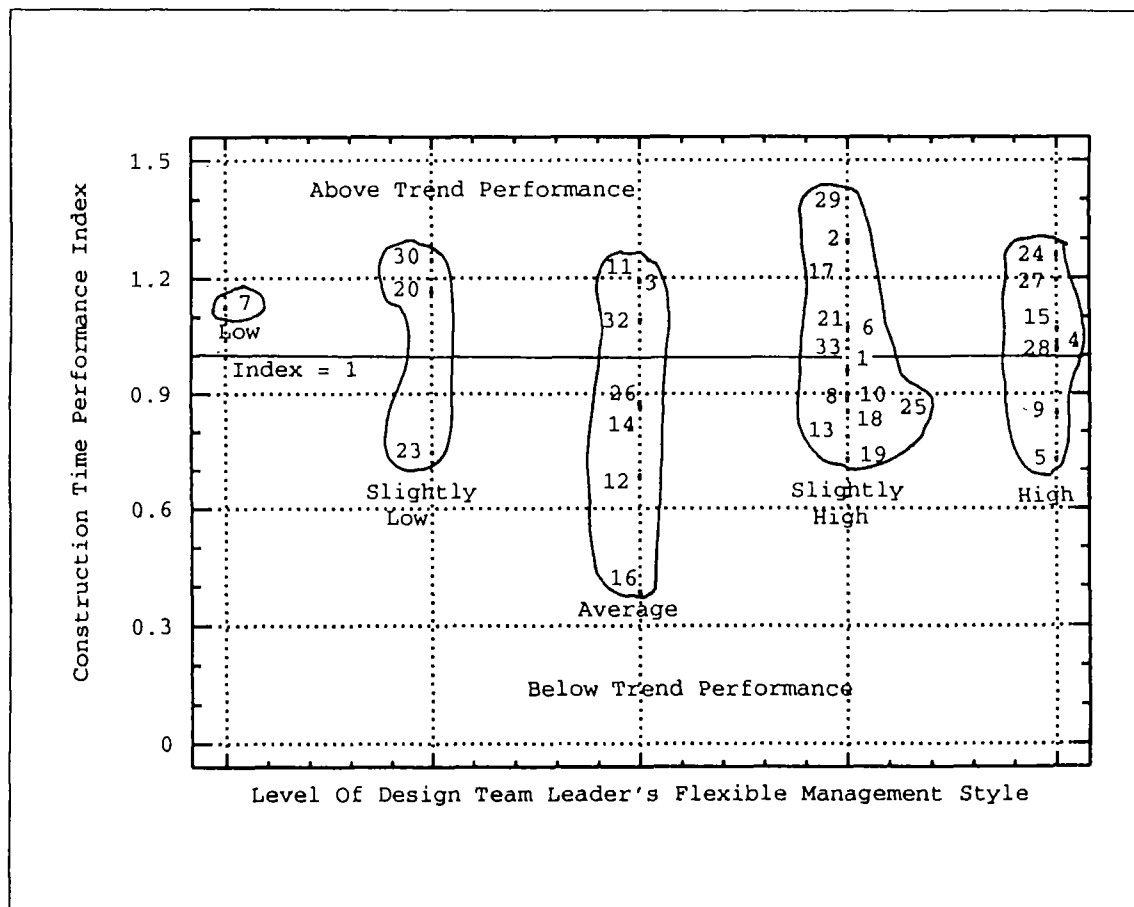
$H_0$  Construction time performance is **NOT** dependent upon a design team manager's flexible management style.

$H_1$  Construction time performance **IS** dependent upon a design team manager's flexible management style.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of *less than* 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.483	0.7479	<b><math>H_0</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*





**SUB-HYPOTHESIS NUMBER 73**

**DATA ITEM: FLEXIBILITY OF DESIGN TEAM'S MANAGEMENT STYLE**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ the project design team's confidence in the CR contribution ( $C_s = 0.4614$ ; sig. = 0.0130);
- ☐ CR and design team communication effectiveness for decision making ( $C_s = 0.5383$ ; sig. = 0.0037).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ ratio of EOT:actual construction time ( $C_s = -0.4665$ ; sig. = 0.0094);
- ☐ clarity of communication of client/CR objectives ( $C_s = 0.5075$ ; sig. = 0.0047);
- ☐ credibility of achieving goals established by the CR/Client ( $C_s = 0.5338$ ; sig. = 0.0030);
- ☐ complexity of CR's influence upon the project's management ( $C_s = 0.5114$ ; sig. = 0.0044);
- ☐ **CR's confidence in the project design team ( $C_s = 0.7467$ ; sig. = 0.0000);**
- ☐ the CR's willingness to accept effective and positive ideas ( $C_s = 0.5410$ ; sig. = 0.0026);
- ☐ the CR's ability to mould shared project goals and aspirations ( $C_s = 0.4851$ ; sig. = 0.0079);
- ☐ flexibility of the CR's management style ( $C_s = 0.5872$ ; sig. = 0.0011);
- ☐ CR's people-oriented management style ( $C_s = 0.4463$ ; sig. = 0.0145);
- ☐ **design team's people-oriented management style ( $C_s = 0.7250$ ; sig. = 0.0002);**
- ☐ direct use of power in the design team's management style ( $C_s = -0.5250$ ; sig. = 0.0101);
- ☐ task-orientation of the CM's management style ( $C_s = 0.5724$ ; sig. = 0.0014).

## SUB-HYPOTHESIS NUMBER 74

## QUESTIONNAIRE NUMBER Q15.3-DES

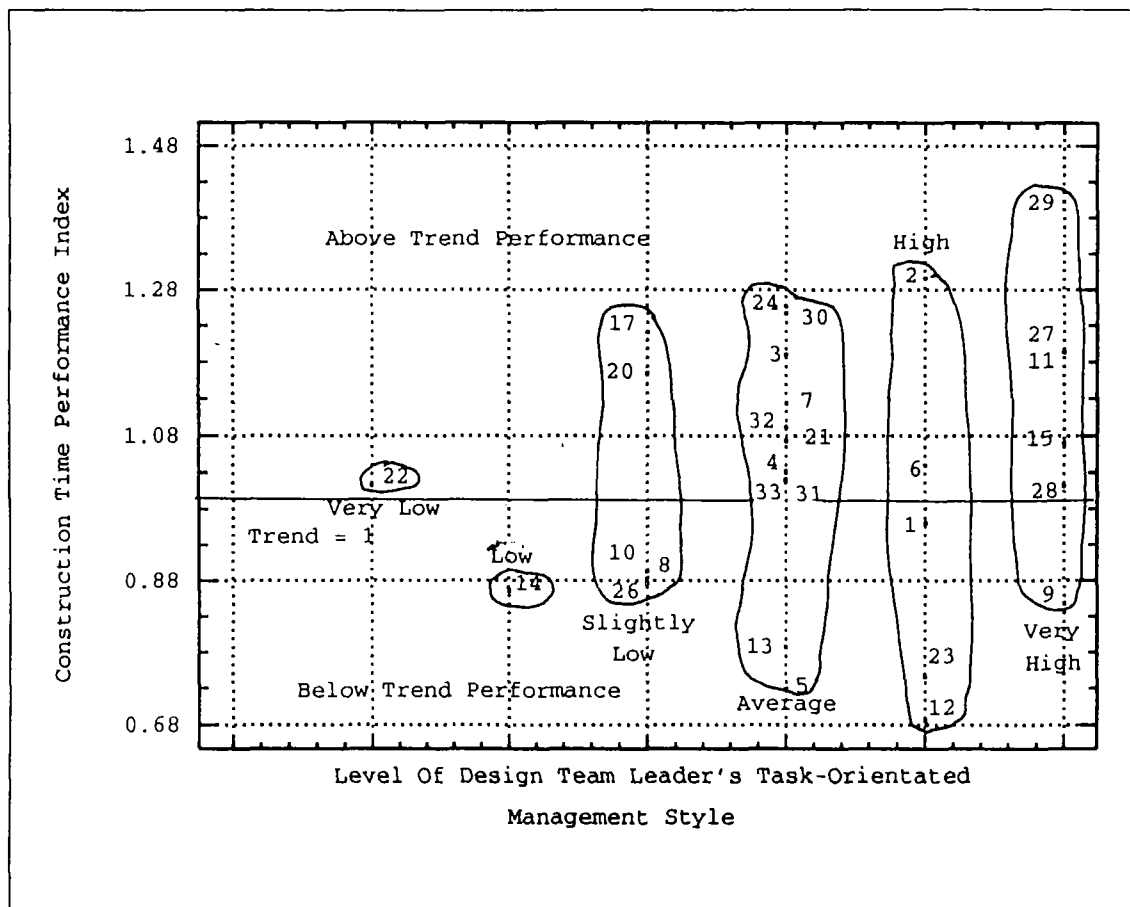
$H_0$  Construction time performance is NOT dependent upon a design team leader's task oriented management style.

$H_1$  Construction time performance IS dependent upon a design team leader's task oriented management style.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.592	0.7062	$H_0$ ACCEPTED

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 74**

**DATA ITEM: TASK-ORIENTATION OF THE DESIGN TEAM'S MANAGEMENT STYLE**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ the project design team's confidence in the CR contribution ( $C_s = 0.4503$ ; sig. = 0.0172);
- ☐ CR and CM team communication effectiveness for decision making ( $C_s = 0.5200$ ; sig. = 0.0069);
- ☐ effectiveness of the CM team in managing the construction process ( $C_s = 0.4651$ ; sig. = 0.0123).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ CR's confidence in the project design team ( $C_s = 0.5789$ ; sig. = 0.0018);
- ☐ design team's organisational structure to manage risk ( $C_s = 0.5730$ ; sig. = 0.0020);
- ☐ task-orientation of the CR's management style ( $C_s = 0.5272$ ; sig. = 0.0045);
- ☐ design team's people-oriented management style ( $C_s = 0.5313$ ; sig. = 0.0058);
- ☐ decision making communication within the design team ( $C_s = 0.5337$ ; sig. = 0.0056);
- ☐ design team's decision making, communicating and actioning ( $C_s = 0.5170$ ; sig. = 0.0054).

## SUB-HYPOTHESIS NUMBER 75

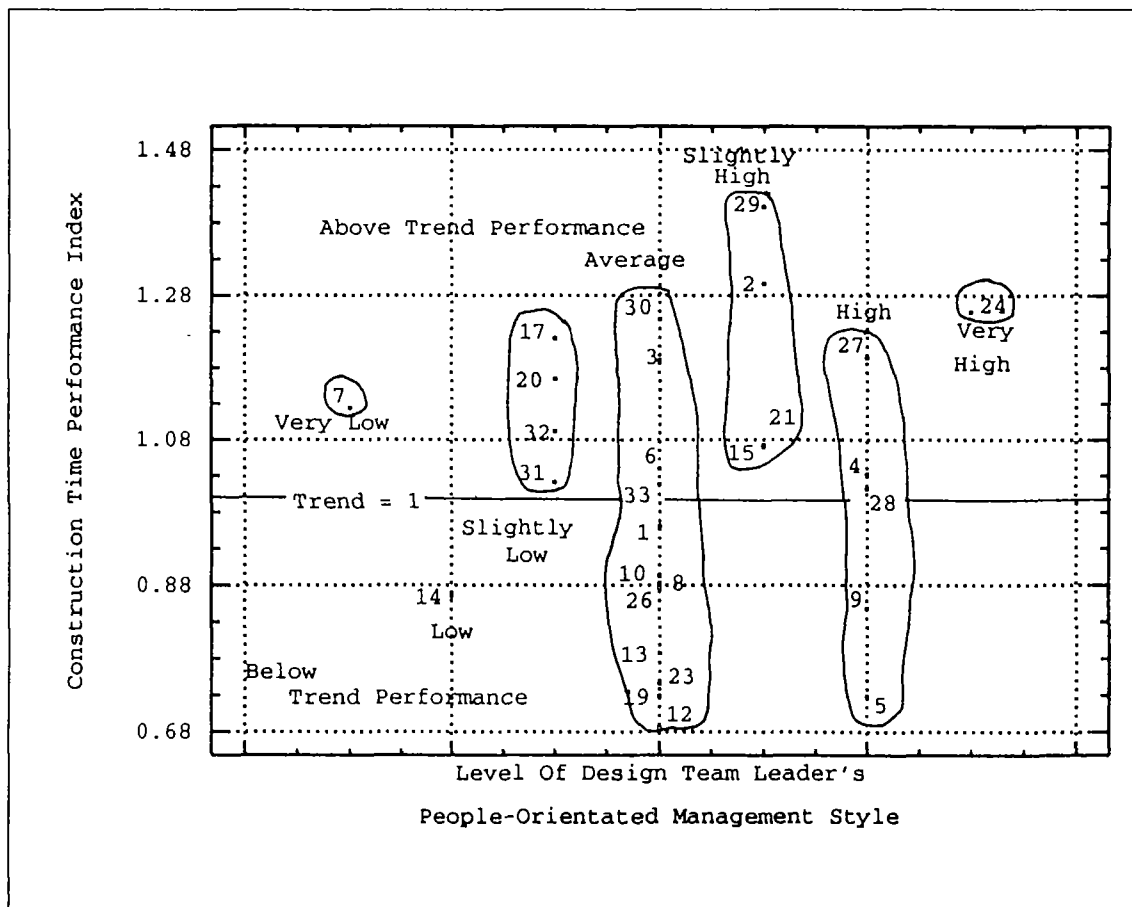
## QUESTIONNAIRE NUMBER Q15.3-DES

- $H_0$  Construction time performance is **NOT** dependent upon a design team manager's people oriented management style.
- $H_1$  Construction time performance **IS** dependent upon a design team manager's people oriented management style.

One-way ANOVA test results *measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.*

F-Ratio	Significance Level	Interpretation
2.473	0.0573	<b><math>H_0</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 75**

**DATA ITEM: DESIGN TEAM'S PEOPLE-ORIENTED MANAGEMENT STYLE**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ the project design team's confidence in the CR contribution ( $C_s = 0.4689$ ; sig. = 0.0168);
- ☐ CR and design team communication effectiveness for decision making ( $C_s = 0.6299$ ; sig. = 0.0166);
- ☐ CM and design team communication effectiveness for decision making ( $C_s = 0.5868$ ; sig. = 0.0023).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ credibility of achieving goals established by the CR/Client ( $C_s = 0.5031$ ; sig. = 0.0089);
- ☐ the CR's willingness to accept effective and positive ideas ( $C_s = 0.5319$ ; sig. = 0.0057);
- ☐ CR's confidence in the project design team ( $C_s = 0.6417$ ; sig. = 0.0009);
- ☐ design coordination complexity ( $C_s = 0.5606$ ; sig. = 0.0036);
- ☐ direct use of power in the CR's management style ( $C_s = -0.5122$ ; sig. = 0.0078);
- ☐ **flexibility of design team's management style ( $C_s = 0.7250$ ; sig. = 0.0002);**
- ☐ task-orientation of the design team's management style ( $C_s = 0.5313$ ; sig. = 0.0058);
- ☐ direct use of power in the design team's management style ( $C_s = -0.6276$ ; sig. = 0.0021);
- ☐ **decision making communication within the design team ( $C_s = 0.6973$ ; sig. = 0.0005).**

## SUB-HYPOTHESIS NUMBER 76

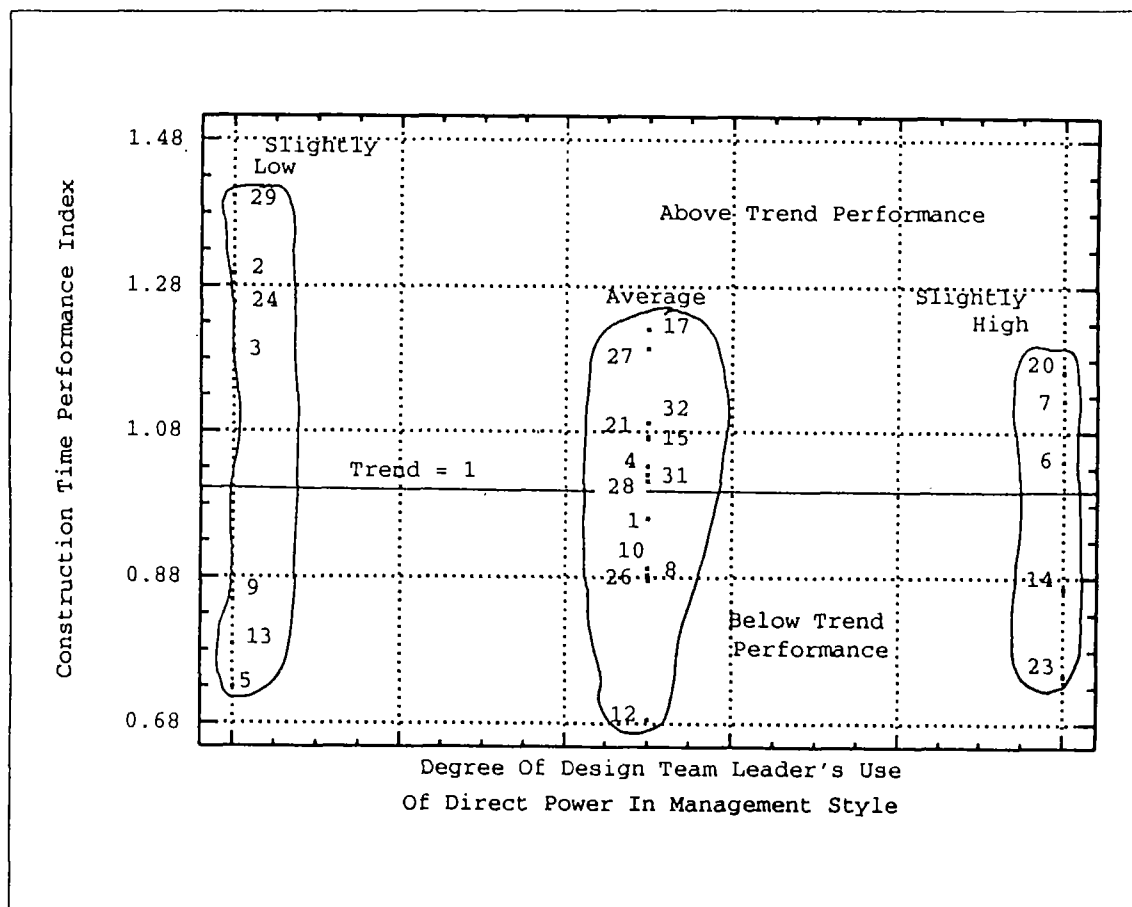
## QUESTIONNAIRE NUMBER Q15.4-DES

- $H_0$  Construction time performance is **NOT** dependent upon a design team manager's direct use of power as a management style.
- $H_1$  Construction time performance **IS** dependent upon a design team manager's direct use of power as a management style.

One-way ANOVA test results *measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.*

F-Ratio	Significance Level	Interpretation
0.392	0.6800	<b><math>H_0</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 76**

**DATA ITEM: DIRECT USE OF POWER IN THE DESIGN TEAM'S MANAGEMENT STYLE**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ ability of the CR to contribute ideas to the design process ( $C_s = -0.4812$ ; sig. = 0.0210);
- ☐ the project design team's confidence in the CR contribution ( $C_s = -0.5220$ ; sig. = 0.0123);
- ☐ impact of CR/CM working relationship ( $C_s = -0.4618$ ; sig. = 0.0237);
- ☐ CR and design team communication effectiveness for decision making ( $C_s = -0.6544$ ; sig. = 0.0021);
- ☐ CM and design team communication effectiveness for decision making ( $C_s = -0.4863$ ; sig. = 0.0172);

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ building end use ( $C_s = -0.4878$ ; sig. = 0.0169);
- ☐ credibility of achieving goals established by the CR/Client ( $C_s = -0.5138$ ; sig. = 0.0118);
- ☐ CR's confidence in the project design team ( $C_s = -0.5038$ ; sig. = 0.0136);
- ☐ the CR's willingness to accept effective and positive ideas ( $C_s = -0.5191$ ; sig. = 0.0110);
- ☐ the overall CR contribution to project team harmony ( $C_s = -0.4995$ ; sig. = 0.0144);
- ☐ design team's organisational structure to manage risk. ( $C_s = -0.4776$ ; sig. = 0.0193);
- ☐ direct use of power in the CR's management style ( $C_s = 0.6092$ ; sig. = 0.0028);
- ☐ flexibility of design team's management style ( $C_s = -0.5250$ ; sig. = 0.0101);
- ☐ design team's people-oriented management style ( $C_s = -0.6276$ ; sig. = 0.0021);

## SUB-HYPOTHESIS NUMBER 77

## QUESTIONNAIRE NUMBER Q15.2-CM

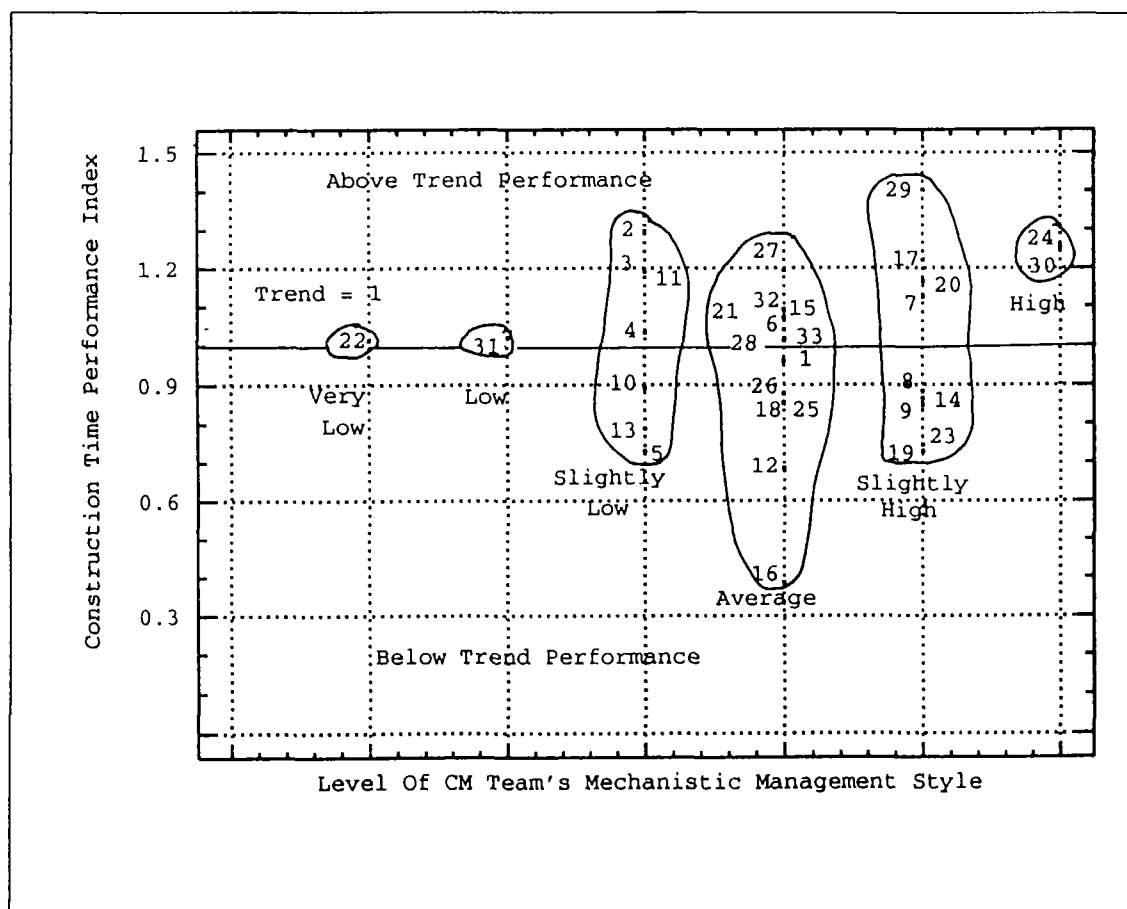
$H_0$  Construction time performance is **NOT** dependent upon a CM's mechanistic management style.

$H_1$  Construction time performance **IS** dependent upon a CM's mechanistic management style.

One-way ANOVA test results *measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.*

F-Ratio	Significance Level	Interpretation
0.803	0.5577	<b><math>H_0</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*





**SUB-HYPOTHESIS NUMBER 77**

**DATA ITEM: CM'S MECHANISTIC-ORIENTED MANAGEMENT STYLE**

**Spearman Rank Correlation results for factors affecting CTP:**

☐ no significant correlation.

**Spearman Rank Correlation results for factors NOT affecting CTP:**

☐ no significant correlation.

## SUB-HYPOTHESIS NUMBER 78

## QUESTIONNAIRE NUMBER Q15.2-CM

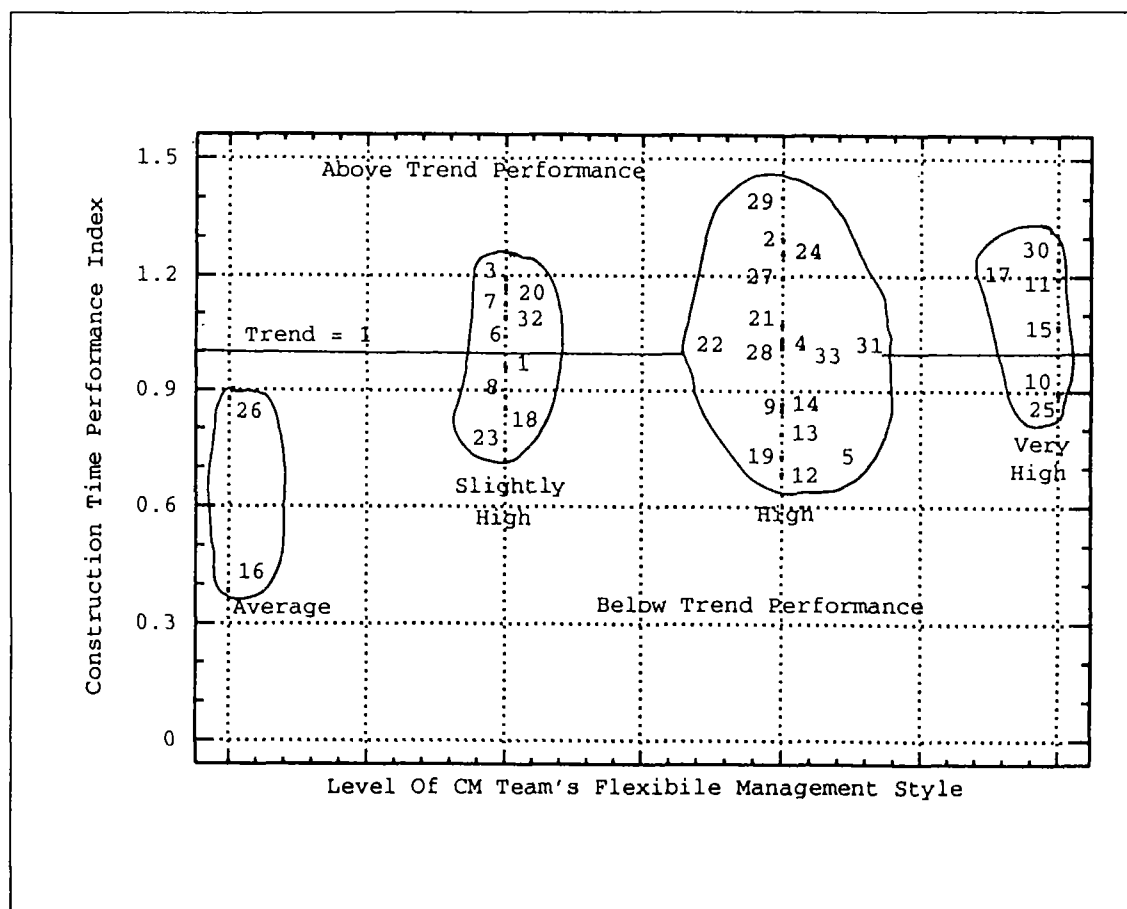
$H_0$  Construction time performance is NOT dependent upon a CM's flexible management style.

$H_1$  Construction time performance IS dependent upon a CM's flexible management style.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
2.601	0.0711	$H_0$ ACCEPTED

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



### SUB-HYPOTHESIS NUMBER 78

#### DATA ITEM: FLEXIBILITY OF THE CM'S MANAGEMENT STYLE

##### Spearman Rank Correlation results for factors affecting CTP:

- ☐ ability of the CR to contribute ideas to the construction process ( $C_s = 0.4604$ ; sig. = 0.0092);
- ☐ the project design team's confidence in the CR contribution ( $C_s = 0.5440$ ; sig. = 0.0028);
- ☐ the construction team's confidence in the CR's contribution ( $C_s = 0.6187$ ; sig. = 0.0005);
- ☐ CR's willingness to contribute effective and positive ideas ( $C_s = 0.5409$ ; sig. = 0.0022);
- ☐ impact of CR/CM working relationship ( $C_s = 0.5420$ ; sig. = 0.0022);
- ☐ CM's forecasting planning data ( $C_s = 0.4749$ ; sig. = 0.0082);
- ☐ CM's analysing construction methods ( $C_s = 0.5289$ ; sig. = 0.0028);
- ☐ effectiveness of the construction team's planning ( $C_s = 0.5373$ ; sig. = 0.0024);
- ☐ CM's monitoring and updating plans to reflect work status ( $C_s = 0.4796$ ; sig. = 0.0067);
- ☐ effectiveness of the construction team's monitoring and control ( $C_s = 0.4706$ ; sig. = 0.0078);
- ☐ CM's organisational structure to manage risk ( $C_s = 0.4650$ ; sig. = 0.0085);
- ☐ key sub-contractor's task-oriented management style ( $C_s = 0.5882$ ; sig. = 0.0009);
- ☐ CM's communication management to facilitate decision making ( $C_s = 0.5534$ ; sig. = 0.0017);
- ☐ CR and CM team communication effectiveness for decision making ( $C_s = 0.4958$ ; sig. = 0.0050);
- ☐ CR and design team communication effectiveness for decision making ( $C_s = 0.5991$ ; sig. = 0.0010);
- ☐ decision making communication within the CM team ( $C_s = 0.6120$ ; sig. = 0.0005);
- ☐ CM decision making, communicating and actioning ( $C_s = 0.6006$ ; sig. = 0.0007);
- ☐ effectiveness of the CM team in managing the construction process ( $C_s = 0.5733$ ; sig. = 0.0012).

##### Spearman Rank Correlation results for factors NOT affecting CTP:

- ☐ CR's experience with the building procurement process ( $C_s = 0.4833$ ; sig. = 0.0063);
- ☐ stability of client/CR objectives ( $C_s = 0.6004$ ; sig. = 0.0007);
- ☐ clarity of communication of client/CR objectives ( $C_s = 0.4554$ ; sig. = 0.0100);
- ☐ CR's understanding the project's constraints ( $C_s = 0.5265$ ; sig. = 0.0029);
- ☐ CR's ability to quickly make authoritative decisions ( $C_s = 0.4666$ ; sig. = 0.0083);
- ☐ CR's ability to effectively brief the design team ( $C_s = 0.5344$ ; sig. = 0.0034);
- ☐ the CR's ability to mould shared project goals and aspirations ( $C_s = 0.5283$ ; sig. = 0.0033);
- ☐ the overall CR contribution to project team harmony ( $C_s = 0.5083$ ; sig. = 0.0040);
- ☐ CM's effectiveness in influencing the CR decision making process ( $C_s = 0.4589$ ; sig. = 0.0094);
- ☐ key sub-contractor's organisational structure to manage risk ( $C_s = 0.4514$ ; sig. = 0.0120);
- ☐ CM's effectiveness in team management to achieve synergy ( $C_s = 0.6314$ ; sig. = 0.0004);
- ☐ flexibility of the CR's management style ( $C_s = 0.5793$ ; sig. = 0.0010);
- ☐ task-orientation of the CR's management style ( $C_s = 0.5221$ ; sig. = 0.0037);
- ☐ CR's people-oriented management style ( $C_s = 0.5767$ ; sig. = 0.0013);
- ☐ task-orientation of the CM's management style ( $C_s = 0.5945$ ; sig. = 0.0008);
- ☐ CM's people-oriented management style ( $C_s = 0.5409$ ; sig. = 0.0022);
- ☐ flexibility of key sub-contractor's management style ( $C_s = 0.5924$ ; sig. = 0.0008);
- ☐ direct use of power in key sub-contractor's management style ( $C_s = 0.4883$ ; sig. = 0.0057);
- ☐ CR decision making, communicating and actioning ( $C_s = 0.5305$ ; sig. = 0.0027);
- ☐ CR's effective use of information technologies ( $C_s = 0.6760$ ; sig. = 0.0068).

## SUB-HYPOTHESIS NUMBER 79

## QUESTIONNAIRE NUMBER Q15.3-CM

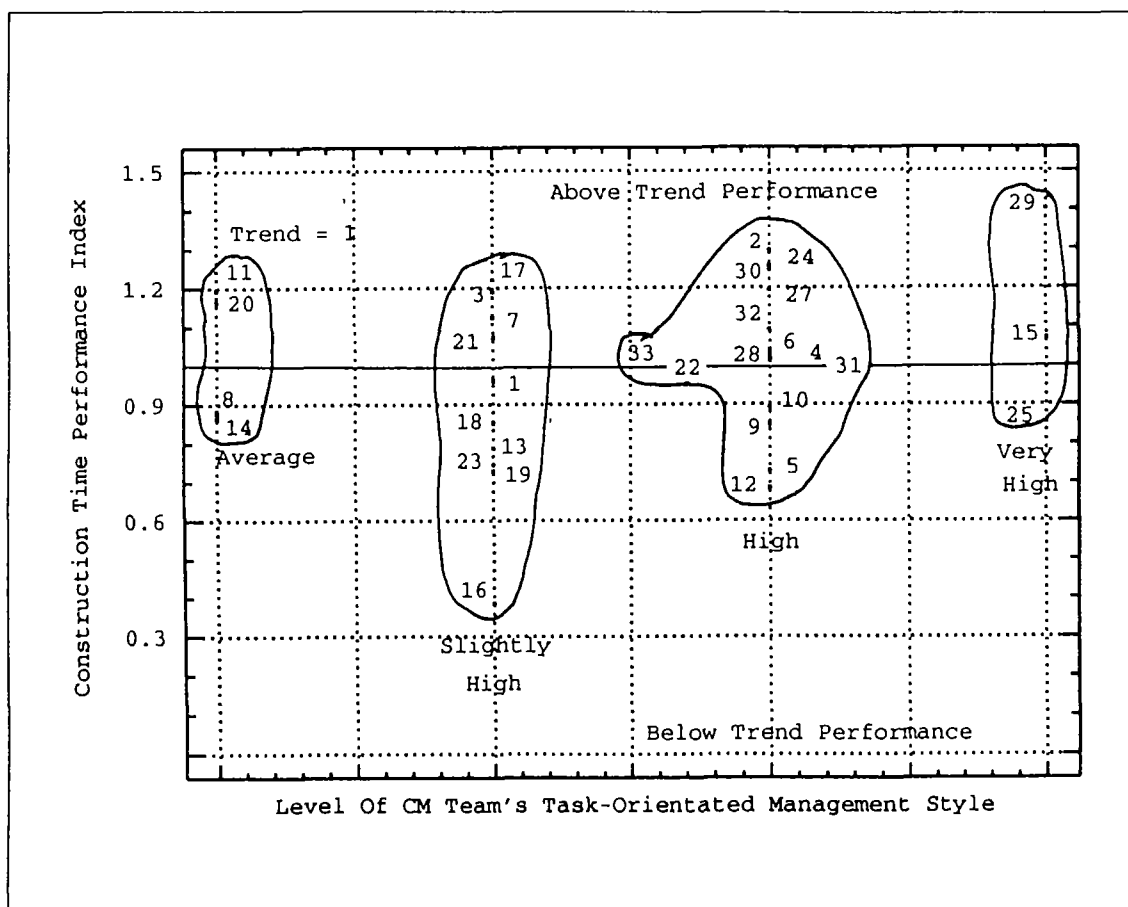
$H_0$  Construction time performance is **NOT** dependent upon a CM's task oriented management style.

$H_1$  Construction time performance **IS** dependent upon a CM's task oriented management style.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of *less than* 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.951	0.4289	<b><math>H_0</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



### SUB-HYPOTHESIS NUMBER 79

#### DATA ITEM: TASK-ORIENTATION OF THE CM'S MANAGEMENT STYLE

##### Spearman Rank Correlation results for factors affecting CTP:

- ☐ ability of the CR to contribute ideas to the design process ( $C_s = 0.4700$ ; sig. = 0.0089);
- ☐ the project design team's confidence in the CR contribution ( $C_s = 0.4626$ ; sig. = 0.0113);
- ☐ the construction team's confidence in the CR's contribution ( $C_s = 0.4611$ ; sig. = 0.0091);
- ☐ CR's willingness to contribute effective and positive ideas ( $C_s = 0.5991$ ; sig. = 0.0007);
- ☐ impact of CR/CM working relationship ( $C_s = 0.4687$ ; sig. = 0.0080);
- ☐ CM's forecasting planning data ( $C_s = 0.4809$ ; sig. = 0.0074);
- ☐ effectiveness of the construction team's planning ( $C_s = 0.4683$ ; sig. = 0.0081);
- ☐ CM's developing an organisational structure to maintain workflow ( $C_s = 0.4503$ ; sig. = 0.0109);
- ☐ effectiveness of the construction team's monitoring and control ( $C_s = 0.4548$ ; sig. = 0.0101);
- ☐ key sub-contractor's task-oriented management style ( $C_s = 0.6035$ ; sig. = 0.0006);
- ☐ CR and CM team communication effectiveness for decision making ( $C_s = 0.4562$ ; sig. = 0.0099);
- ☐ CR and design team communication effectiveness for decision making ( $C_s = 0.4918$ ; sig. = 0.0071);
- ☐ decision making communication within the CM team ( $C_s = 0.5195$ ; sig. = 0.0033);
- ☐ CM decision making, communicating and actioning ( $C_s = 0.6356$ ; sig. = 0.0003);
- ☐ effectiveness of the CM team in managing the construction process ( $C_s = 0.5505$ ; sig. = 0.0018).

##### Spearman Rank Correlation results for factors NOT affecting CTP:

- ☐ credibility of achieving goals established by the CR/Client ( $C_s = 0.4938$ ; sig. = 0.0052);
- ☐ the level of influence exercised on CTP by the CR ( $C_s = 0.4683$ ; sig. = 0.0081);
- ☐ CR's understanding the project's constraints ( $C_s = 0.4487$ ; sig. = 0.0111);
- ☐ the CR's confidence in the construction team ( $C_s = 0.6547$ ; sig. = 0.0003);
- ☐ the CR's ability to mould shared project goals and aspirations ( $C_s = 0.5131$ ; sig. = 0.0043);
- ☐ the CR's willingness to accept effective and positive ideas ( $C_s = 0.5488$ ; sig. = 0.0019);
- ☐ quality management procedures used on-site ( $C_s = 0.5625$ ; sig. = 0.0017);
- ☐ CM's effectiveness in influencing the CR decision making process ( $C_s = 0.5452$ ; sig. = 0.0020);
- ☐ CM management systems and procedures ( $C_s = 0.5067$ ; sig. = 0.0042);
- ☐ key sub-contractor's organisational structure to manage risk ( $C_s = 0.4478$ ; sig. = 0.0127);
- ☐ CM's effectiveness in team management to achieve synergy ( $C_s = 0.6464$ ; sig. = 0.0003);
- ☐ flexibility of the CR's management style ( $C_s = 0.5968$ ; sig. = 0.0007);
- ☐ task-orientation of the CR's management style ( $C_s = 0.5967$ ; sig. = 0.0009);
- ☐ CR's people-oriented management style ( $C_s = 0.6920$ ; sig. = 0.0001);
- ☐ flexibility of design team's management style ( $C_s = 0.5724$ ; sig. = 0.0014);
- ☐ flexibility of the CM's management style ( $C_s = 0.5945$ ; sig. = 0.0008);
- ☐ CM's people-oriented management style ( $C_s = 0.4807$ ; sig. = 0.0065);
- ☐ key sub-contractor's people-oriented management style ( $C_s = 0.5315$ ; sig. = 0.0026).

## SUB-HYPOTHESIS NUMBER 80

## QUESTIONNAIRE NUMBER Q15.3-CM

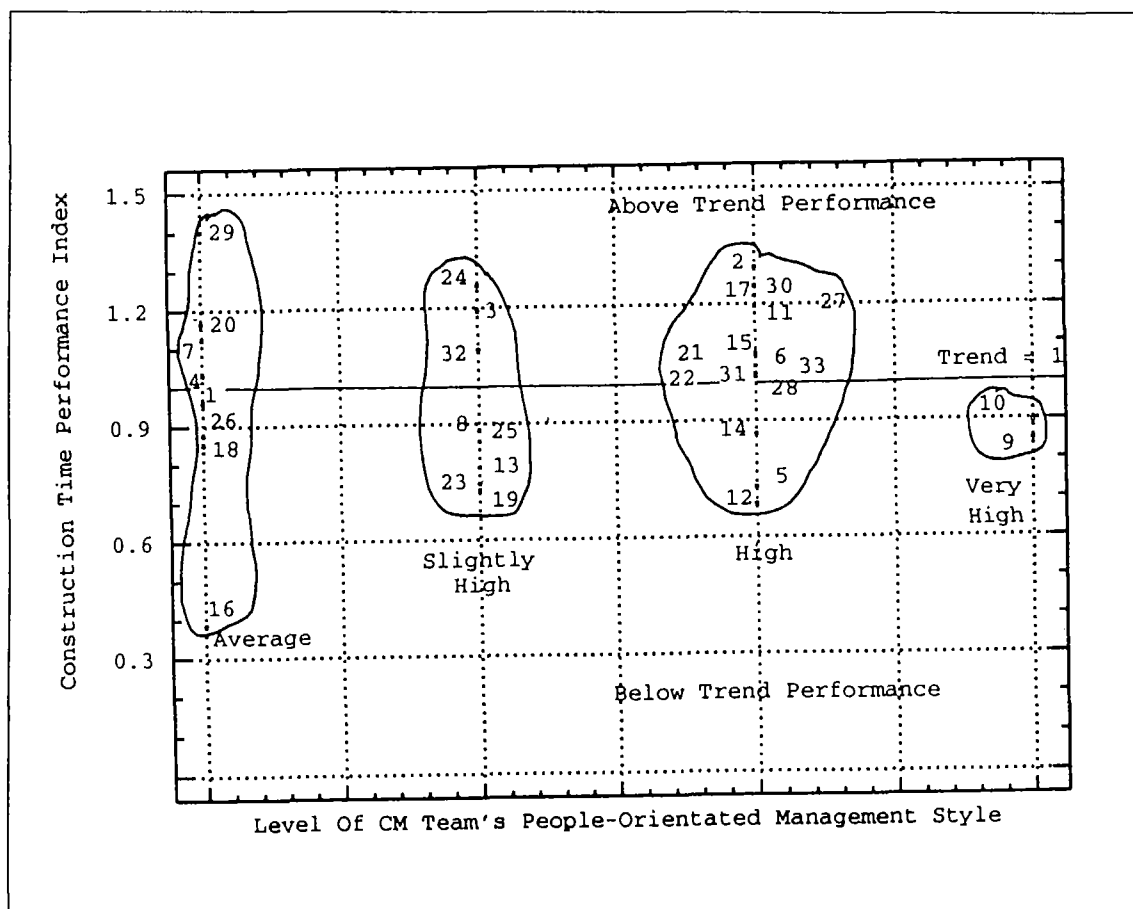
$H_0$  Construction time performance is NOT dependent upon a CM's people oriented management style.

$H_1$  Construction time performance IS dependent upon a CM's people oriented management style.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.665	0.5806	$H_0$ ACCEPTED

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 80**

**DATA ITEM: CM'S PEOPLE-ORIENTED MANAGEMENT STYLE**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ effectiveness of the construction team's planning ( $C_s = 0.4812$ ; sig. = 0.0065);
- ☐ CM's effectively coordinating resources ( $C_s = 0.5191$ ; sig. = 0.0033);
- ☐ CM's developing an organisational structure to maintain workflow ( $C_s = 0.4621$ ; sig. = 0.0089);
- ☐ effectiveness of the construction team's monitoring and control ( $C_s = 0.5310$ ; sig. = 0.0027);
- ☐ key sub-contractor's task-oriented management style ( $C_s = 0.5064$ ; sig. = 0.0042);
- ☐ CM's communication management to facilitate decision making ( $C_s = 0.4699$ ; sig. = 0.0079);
- ☐ CR and design team communication effectiveness for decision making ( $C_s = 0.4438$ ; sig. = 0.0151);
- ☐ decision making communication within the CM team ( $C_s = 0.5226$ ; sig. = 0.0031);
- ☐ CM decision making, communicating and actioning ( $C_s = 0.5820$ ; sig. = 0.0010);
- ☐ effectiveness of the CM team in managing the construction process ( $C_s = 0.6109$ ; sig. = 0.0005).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ stability of client/CR objectives ( $C_s = 0.5860$ ; sig. = 0.0009);
- ☐ the CR's confidence in the construction team ( $C_s = 0.4819$ ; sig. = 0.0073);
- ☐ CM management systems and procedures ( $C_s = 0.5997$ ; sig. = 0.0007);
- ☐ CM's effectiveness in team management to achieve synergy ( $C_s = 0.6582$ ; sig. = 0.0002);
- ☐ flexibility of the CR's management style ( $C_s = 0.5326$ ; sig. = 0.0026);
- ☐ task-orientation of the CR's management style ( $C_s = 0.6388$ ; sig. = 0.0004);
- ☐ flexibility of the CM's management style ( $C_s = 0.5409$ ; sig. = 0.0022);
- ☐ task-orientation of the CM's management style ( $C_s = 0.4807$ ; sig. = 0.0065);
- ☐ **key sub-contractor's people-oriented management style ( $C_s = 0.6966$ ; sig. = 0.0001);**
- ☐ CR decision making, communicating and actioning ( $C_s = 0.6136$ ; sig. = 0.0005).

## SUB-HYPOTHESIS NUMBER 81

## QUESTIONNAIRE NUMBER Q15.4-CM

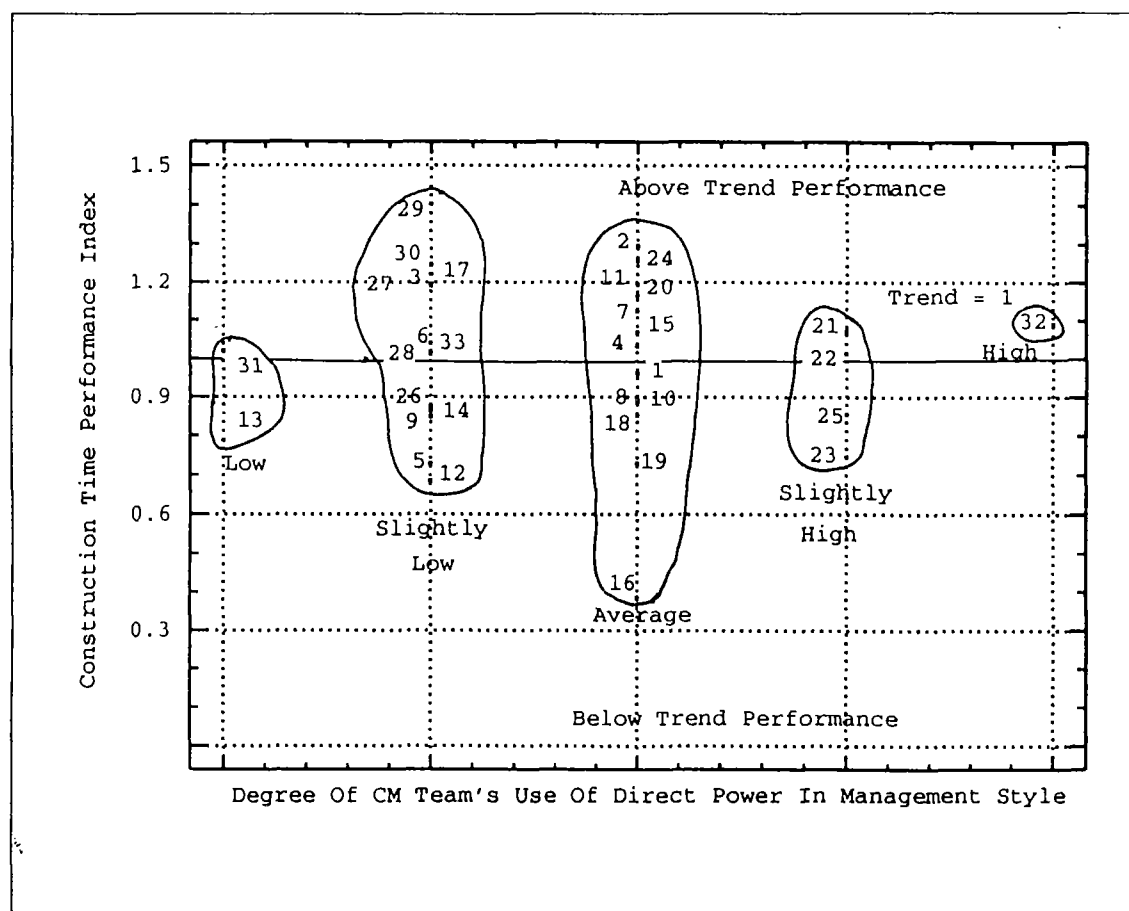
$H_0$  Construction time performance is **NOT** dependent upon a CM's direct use power as a management style.

$H_1$  Construction time performance **IS** dependent upon a CM's direct use of power as a management style.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.299	0.8759	<b><math>H_0</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*





**SUB-HYPOTHESIS NUMBER 81**

**DATA ITEM: DIRECT USE OF POWER IN THE CM'S MANAGEMENT STYLE**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ no significant correlation.

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ work type undertaken [fit-out etc.] ( $C_s = -0.4579$ ; sig. = 0.0096);
- ☐ *project procurement method* ( $C_s = -0.5707$ ; sig. = 0.0012);
- ☐ *direct use of power in the CR's management style* ( $C_s = 0.5506$ ; sig. = 0.0022);
- ☐ direct use of power in key sub-contractor's management style ( $C_s = 0.4735$ ; sig. = 0.0074).

## SUB-HYPOTHESIS NUMBER 82

## QUESTIONNAIRE NUMBER Q15.2-KEY

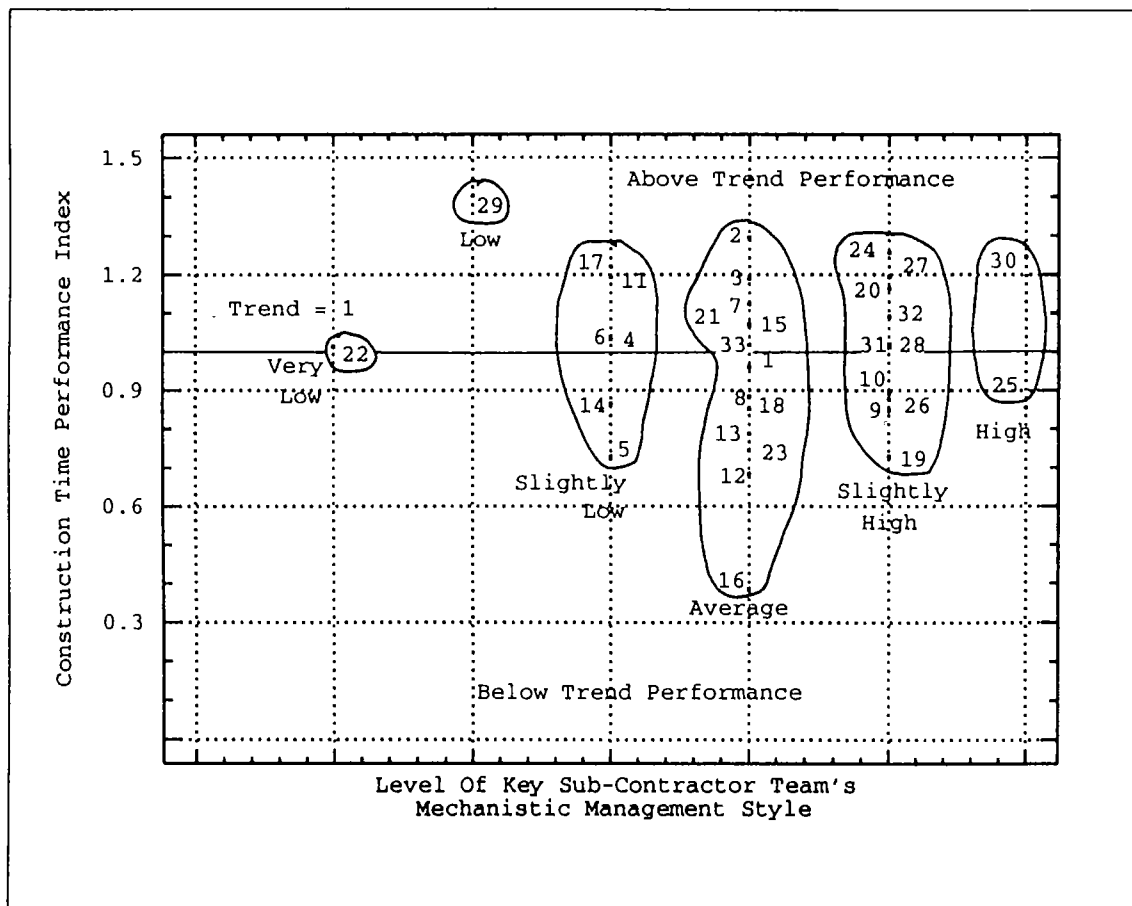
$H_0$  Construction time performance is **NOT** dependent upon key sub-contractor's mechanistic management style.

$H_1$  Construction time performance **IS** dependent upon key sub-contractor's mechanistic management style.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
1.034	0.4180	<b><math>H_0</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 82**

**DATA ITEM: KEY SUB-CONTRACTOR'S MECHANISTIC-ORIENTED MANAGEMENT STYLE**

**Spearman Rank Correlation results for factors affecting CTP:**

☐ no significant correlation.

**Spearman Rank Correlation results for factors NOT affecting CTP:**

☐ no significant correlation. ,

## SUB-HYPOTHESIS NUMBER 83

## QUESTIONNAIRE NUMBER Q15.2-KEY

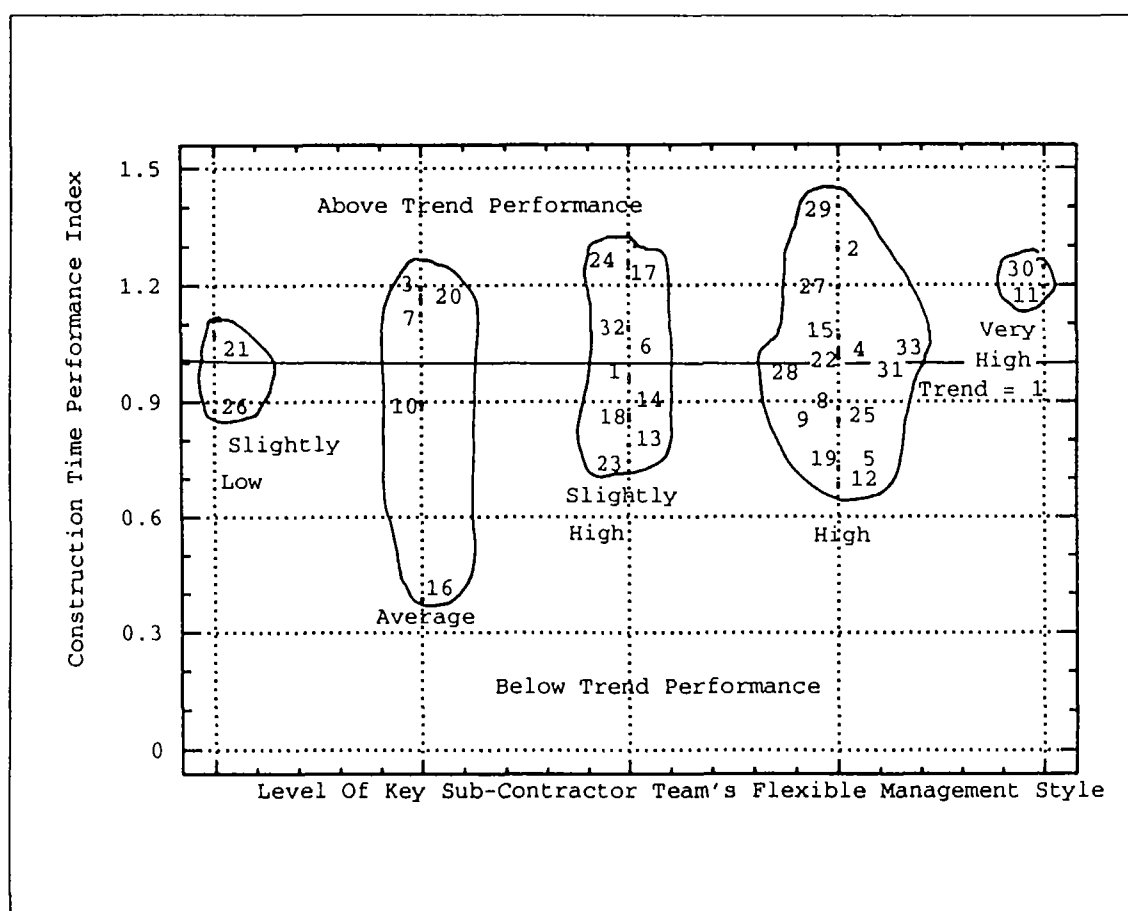
$H_0$  Construction time performance is **NOT** dependent upon key sub-contractor's flexible management style.

$H_1$  Construction time performance **IS** dependent upon key sub-contractor's flexible management style.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of *less than* 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.599	0.6666	<b><math>H_0</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 83**

**DATA ITEM: FLEXIBILITY OF KEY SUB-CONTRACTOR'S MANAGEMENT STYLE**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ no significant correlation.

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *impact of the IR environment ( $C_s = 0.4977$ ; sig. = 0.0049);*
- ☐ *impact of general environmental factors ( $C_s = 0.4819$ ; sig. = 0.0064);*
- ☐ *task-orientation of the CR's management style ( $C_s = 0.5142$ ; sig. = 0.0042);*
- ☐ *flexibility of the CM's management style ( $C_s = 0.5924$ ; sig. = 0.0008);*
- ☐ *decision making communication within the design team ( $C_s = 0.4490$ ; sig. = 0.0156);*
- ☐ *CR's effective use of information technologies ( $C_s = 0.4527$ ; sig. = 0.0702);*
- ☐ *design team's effective use of information technologies ( $C_s = 0.5842$ ; sig. = 0.0074).*

## SUB-HYPOTHESIS NUMBER 84

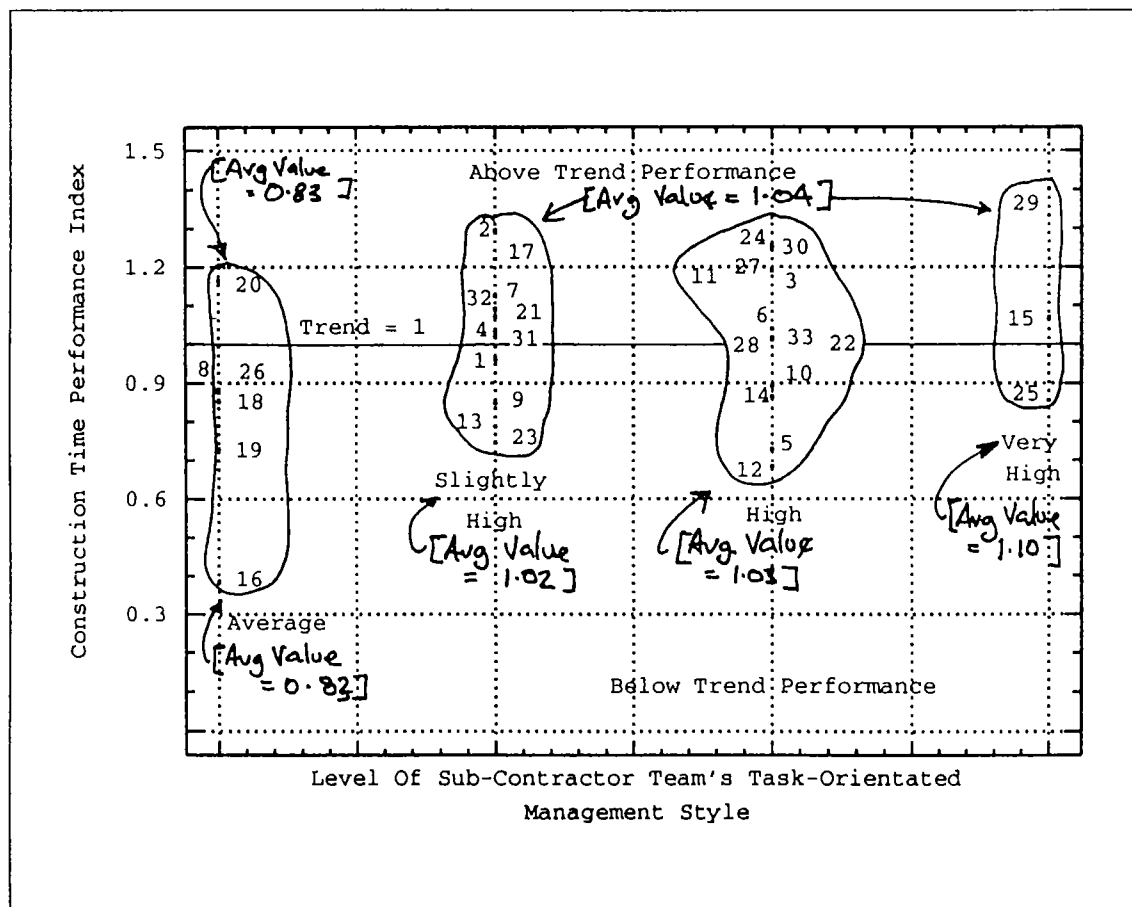
## QUESTIONNAIRE NUMBER Q15.3-KEY

- $H_0$  Construction time performance is **NOT** dependent upon a slightly high or greater level of key sub-contractor's task oriented management style.
- $H_1$  Construction time performance **IS** dependent upon a slightly high or greater level of key sub-contractor's task oriented management style.

One-way ANOVA test results *measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.*

F-Ratio	Significance Level	Interpretation
6.546	0.0156	<b><math>H_0</math> REJECTED: <math>H_1</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



### SUB-HYPOTHESIS NUMBER 84

#### DATA ITEM: KEY SUB-CONTRACTOR'S TASK-ORIENTED MANAGEMENT STYLE

##### Spearman Rank Correlation results for factors affecting CTP:

- ☐ ability of the CR to contribute ideas to the design process ( $C_s = 0.4782$ ; sig. = 0.0078);
- ☐ the construction team's confidence in the CR's contribution ( $C_s = 0.5023$ ; sig. = 0.0045);
- ☐ CR's willingness to contribute effective and positive ideas ( $C_s = 0.5660$ ; sig. = 0.0014);
- ☐ impact of CR/CM working relationship ( $C_s = 0.6008$ ; sig. = 0.0007);
- ☐ CM's forecasting planning data ( $C_s = 0.5184$ ; sig. = 0.0039);
- ☐ effectiveness of the construction team's planning ( $C_s = 0.5168$ ; sig. = 0.0035);
- ☐ CM's monitoring and updating plans to reflect work status ( $C_s = 0.5171$ ; sig. = 0.0034);
- ☐ CM's effectively coordinating resources ( $C_s = 0.5341$ ; sig. = 0.0025);
- ☐ CM's developing an organisational structure to maintain workflow ( $C_s = 0.4983$ ; sig. = 0.0048);
- ☐ effectiveness of the construction team's monitoring and control ( $C_s = 0.5802$ ; sig. = 0.0010);
- ☐ CM's organisational structure to manage risk ( $C_s = 0.5100$ ; sig. = 0.0039);
- ☐ CR and design team communication effectiveness for decision making ( $C_s = 0.4788$ ; sig. = 0.0087);
- ☐ decision making communication within the CM team ( $C_s = 0.5016$ ; sig. = 0.0045);
- ☐ CM decision making, communicating and actioning ( $C_s = 0.5296$ ; sig. = 0.0027);
- ☐ effectiveness of the CM team in managing the construction process ( $C_s = 0.6755$ ; sig. = 0.0001).

##### Spearman Rank Correlation results for factors NOT affecting CTP:

- ☐ ratio of EOT:actual construction time ( $C_s = -0.4706$ ; sig. = 0.0078);
- ☐ CR's experience with the building procurement process ( $C_s = 0.4704$ ; sig. = 0.0078);
- ☐ stability of client/CR objectives ( $C_s = 0.5367$ ; sig. = 0.0024);
- ☐ the CR's confidence in the construction team ( $C_s = 0.4490$ ; sig. = 0.0124);
- ☐ quality management procedures used on-site ( $C_s = 0.4540$ ; sig. = 0.0115);
- ☐ CM's effectiveness in influencing the CR decision making process ( $C_s = 0.5477$ ; sig. = 0.0019);
- ☐ CM management systems and procedures ( $C_s = 0.4716$ ; sig. = 0.0076);
- ☐ CM's analysing work sequencing to achieve and maintain workflow ( $C_s = 0.4652$ ; sig. = 0.0085);
- ☐ key sub-contractor's organisational structure to manage risk ( $C_s = 0.4806$ ; sig. = 0.0075);
- ☐ CM's effectiveness in team management to achieve synergy ( $C_s = 0.5936$ ; sig. = 0.0008);
- ☐ flexibility of the CR's management style ( $C_s = 0.5086$ ; sig. = 0.0040);
- ☐ task-orientation of the CR's management style ( $C_s = 0.5269$ ; sig. = 0.0033);
- ☐ flexibility of the CM's management style ( $C_s = 0.5882$ ; sig. = 0.0009);
- ☐ task-orientation of the CM's management style ( $C_s = 0.6035$ ; sig. = 0.0006);
- ☐ CM's people-oriented management style ( $C_s = 0.5064$ ; sig. = 0.0042);
- ☐ key sub-contractor's people-oriented management style ( $C_s = 0.6862$ ; sig. = 0.0001);
- ☐ CR decision making, communicating and actioning ( $C_s = 0.5799$ ; sig. = 0.0010);
- ☐ CR's effective use of information technologies ( $C_s = 0.4552$ ; sig. = 0.0686);
- ☐ design team's effective use of information technologies ( $C_s = 0.5246$ ; sig. = 0.0162).

SUB-HYPOTHESIS NUMBER 85

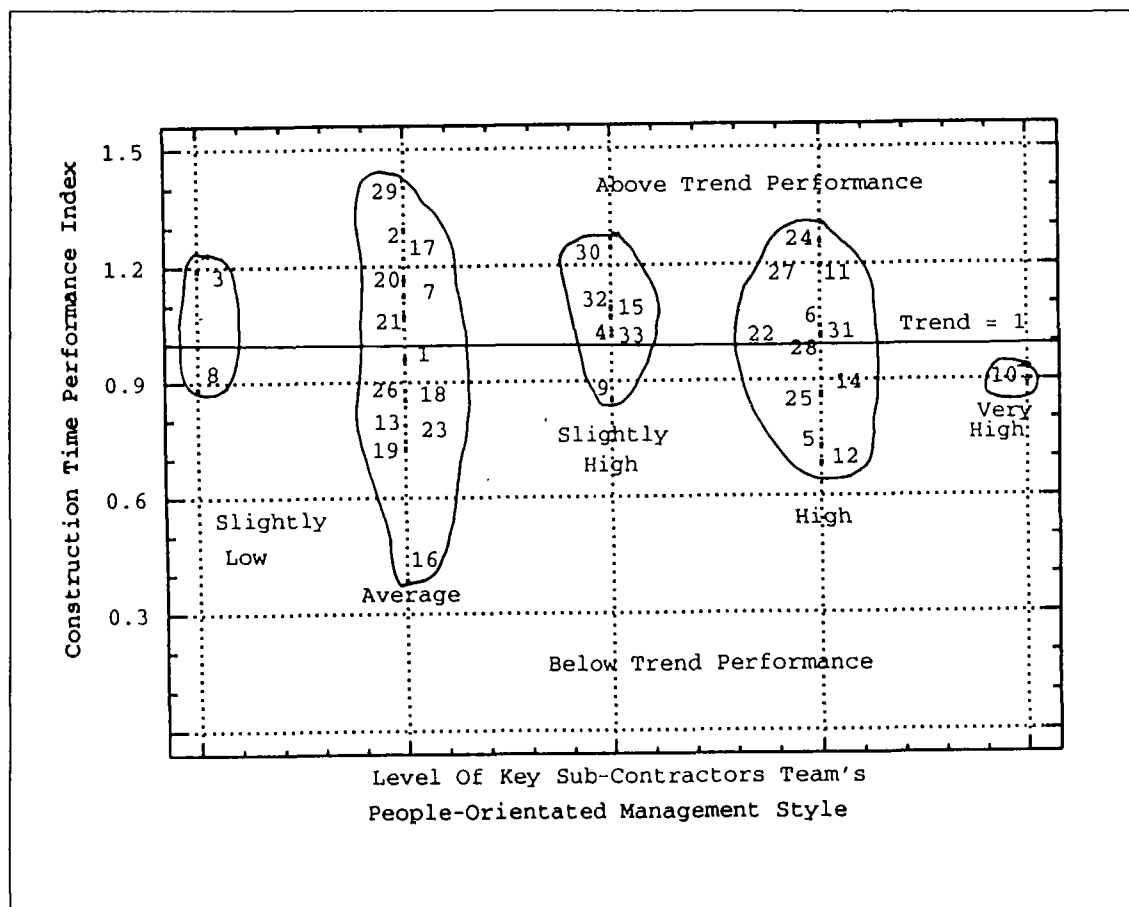
QUESTIONNAIRE NUMBER Q15.3-KEY

- $H_0$  Construction time performance is NOT dependent upon key sub-contractor's people oriented management style.
- $H_1$  Construction time performance IS dependent upon key sub-contractor's people oriented management style.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.204	0.9342	$H_0$ ACCEPTED

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)





**SUB-HYPOTHESIS NUMBER 85**

**DATA ITEM: KEY SUB-CONTRACTOR'S PEOPLE-ORIENTED MANAGEMENT STYLE**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ CM's effectively coordinating resources ( $C_s = 0.4615$ ; sig. = 0.0090);
- ☐ effectiveness of the construction team's monitoring and control ( $C_s = 0.5003$ );
- ☐ key sub-contractor's task-oriented management style ( $C_s = 0.6862$ ; sig. = 0.0001);
- ☐ effectiveness of the CM team in managing the construction process ( $C_s = 0.5553$ ; sig. = 0.0017).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ ratio of EOT:actual construction time ( $C_s = -0.5049$ ; sig. = 0.0043);
- ☐ stability of client/CR objectives ( $C_s = 0.5493$ ; sig. = 0.0019);
- ☐ CM management systems and procedures ( $C_s = 0.5293$ ; sig. = 0.0028);
- ☐ key sub-contractor's organisational structure to manage risk ( $C_s = 0.4457$ ; sig. = 0.0131);
- ☐ CM's effectiveness in team management to achieve synergy ( $C_s = 0.5753$ ; sig. = 0.0011);
- ☐ flexibility of the CM's management style ( $C_s = 0.4883$ ; sig. = 0.0057);
- ☐ task-orientation of the CM's management style ( $C_s = 0.5315$ ; sig. = 0.0026);
- ☐ **CM's people-oriented management style ( $C_s = 0.6966$ ; sig. = 0.0001);**
- ☐ direct use of power in key sub-contractor's management style ( $C_s = -0.5425$ ; sig. = 0.0021);
- ☐ CR decision making, communicating and actioning ( $C_s = 0.5392$ ; sig. = 0.0023);
- ☐ design team's effective use of information technologies ( $C_s = 0.5329$ ; sig. = 0.0146).

## SUB-HYPOTHESIS NUMBER 86

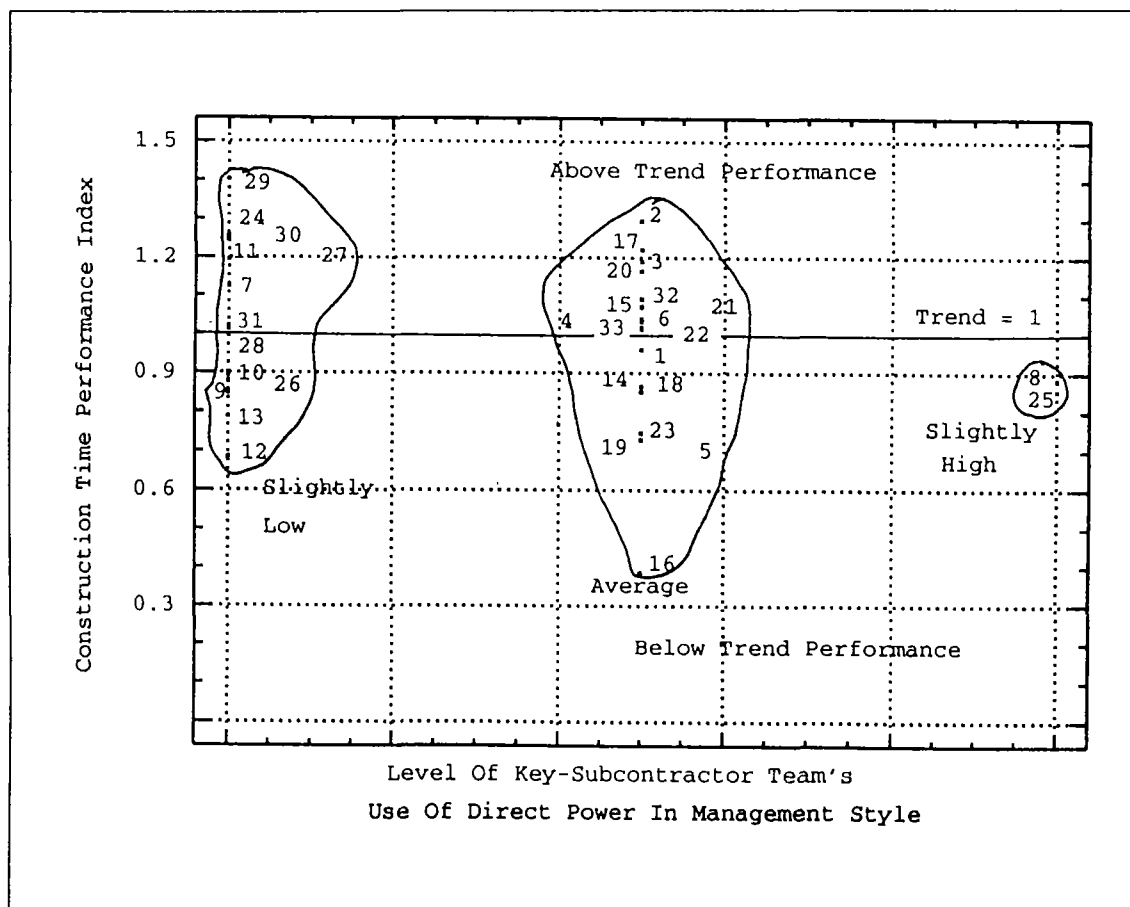
## QUESTIONNAIRE NUMBER Q15.4-KEY

- $H_0$  Construction time performance is **NOT** dependent upon key sub-contractor's direct use power as a management style.
- $H_1$  Construction time performance **IS** dependent upon key sub-contractor's direct use of power as a management style.

One-way ANOVA test results *measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.*

F-Ratio	Significance Level	Interpretation
0.754	0.4793	<b><math>H_0</math> ACCEPTED</b>

**Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)**



**SUB-HYPOTHESIS NUMBER 86**

**DATA ITEM: DIRECT USE OF POWER IN KEY SUB-CONTRACTOR'S MANAGEMENT STYLE**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ no significant correlation.

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *project procurement method* ( $C_s = -0.5189$ ; sig. = 0.0033)
- ☐ *stability of client/CR objectives* ( $C_s = -0.4906$ ; sig. = 0.0055);
- ☐ *direct use of power in the CM's management style* ( $C_s = 0.4735$ ; sig. = 0.0074);
- ☐ *key sub-contractor's people-oriented management style* ( $C_s = -0.5425$ ; sig. = 0.0021).

## SUB-HYPOTHESIS NUMBER 87

## QUESTIONNAIRE NUMBER Q16.1

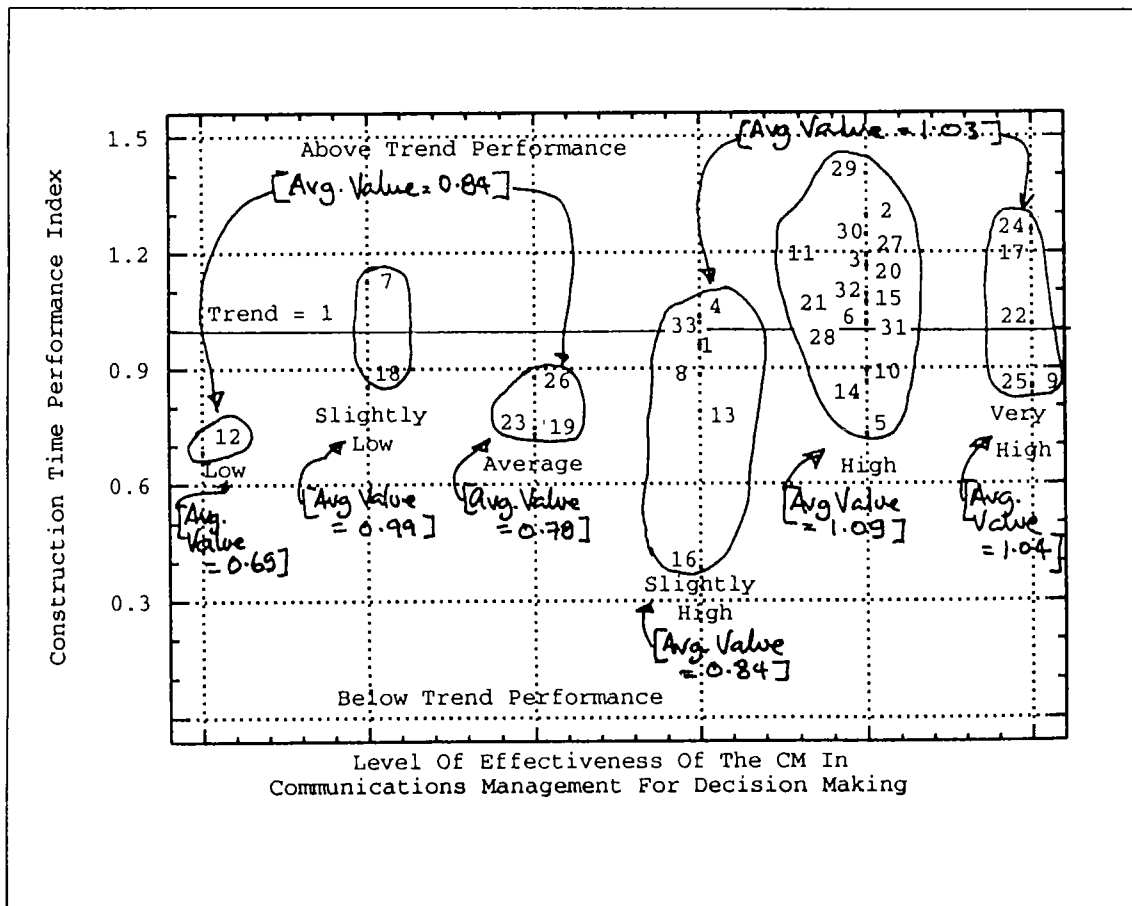
$H_0$  Construction time performance is **NOT** dependent upon the CM's effectiveness of communications management for decision making.

$H_1$  Construction time performance **IS** dependent upon the CM's effectiveness of communications management for decision making.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
3.061	0.0258	<b><math>H_0</math> REJECTED: <math>H_1</math> ACCEPTED</b>

**Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)**



**SUB-HYPOTHESIS NUMBER 87**

**DATA ITEM: CM'S COMMUNICATION MANAGEMENT TO FACILITATE DECISION MAKING**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ ability of the CR to contribute ideas to the design process ( $C_s = 0.5059$ ; sig. = 0.0049);
- ☐ ability of the CR to contribute ideas to the construction process ( $C_s = 0.4581$ ; sig. = 0.0096);
- ☐ the project design team's confidence in the CR contribution ( $C_s = 0.5746$ ; sig. = 0.0016);
- ☐ the construction team's confidence in the CR's contribution ( $C_s = 0.6577$ ; sig. = 0.0002);
- ☐ CR's willingness to contribute effective and positive ideas ( $C_s = 0.5224$ ; sig. = 0.0031);
- ☐ **impact of CR/CM working relationship ( $C_s = 0.7080$ ; sig. = 0.0001);**
- ☐ CM's forecasting planning data ( $C_s = 0.5417$ ; sig. = 0.0026);
- ☐ CM's analysing construction methods ( $C_s = 0.4947$ ; sig. = 0.0051);
- ☐ effectiveness of the construction team's planning ( $C_s = 0.6061$ ; sig. = 0.0006);
- ☐ CM's monitoring and updating plans to reflect work status ( $C_s = 0.6074$ ; sig. = 0.0006);
- ☐ CM's planning - responding to problems or opportunities ( $C_s = 0.6682$ ; sig. = 0.0002);
- ☐ **CM's effectively coordinating resources ( $C_s = 0.7153$ ; sig. = 0.0001);**
- ☐ CM's developing an organisational structure to maintain workflow ( $C_s = 0.5944$ ; sig. = 0.0008);
- ☐ **effectiveness of the construction team's monitoring and control ( $C_s = 0.7037$ ; sig. = 0.0001);**
- ☐ CM's organisational structure to manage risk ( $C_s = 0.6423$ ; sig. = 0.0003);
- ☐ CR and CM team communication effectiveness for decision making ( $C_s = 0.6642$ ; sig. = 0.0002);
- ☐ CR and design team communication effectiveness for decision making ( $C_s = 0.4893$ ; sig. = 0.0074);
- ☐ decision making communication within the CM team ( $C_s = 0.5439$ ; sig. = 0.0021)
- ☐ **CM decision making, communicating and actioning ( $C_s = 0.7727$ ; sig. = 0.0000);**
- ☐ effectiveness of the CM team in managing the construction process ( $C_s = 0.6266$ ; sig. = 0.0004);

**SUB-HYPOTHESIS NUMBER 87**

**DATA ITEM:CM'S COMMUNICATION MANAGEMENT TO FACILITATE DECISION MAKING**

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *building end use* ( $C_s = 0.5332$ ;  $\text{sig.} = 0.0026$ );
- ☐ *clarity of communication of client/CR objectives* ( $C_s = 0.5273$ ;  $\text{sig.} = 0.0029$ );
- ☐ *complexity of CR's influence upon the project's management* ( $C_s = 0.4479$ ;  $\text{sig.} = 0.0113$ );
- ☐ *CR's ability to quickly make authoritative decisions* ( $C_s = 0.4959$ ;  $\text{sig.} = 0.0050$ );
- ☐ *CR's ability to effectively brief the design team* ( $C_s = 0.5023$ ;  $\text{sig.} = 0.0059$ );
- ☐ *stability of CR decisions* ( $C_s = 0.5337$ ;  $\text{sig.} = 0.0025$ );
- ☐ *the CR's ability to mould shared project goals and aspirations* ( $C_s = 0.6137$ ;  $\text{sig.} = 0.0006$ );
- ☐ *the CR's willingness to accept effective and positive ideas* ( $C_s = 0.5425$ ;  $\text{sig.} = 0.0022$ );
- ☐ *the overall CR contribution to project team harmony* ( $C_s = 0.6119$ ;  $\text{sig.} = 0.0005$ );
- ☐ *CM's effectiveness in influencing the CR decision making process* ( $C_s = 0.5822$ ;  $\text{sig.} = 0.0010$ );
- ☐ *CM management systems and procedures* ( $C_s = 0.6083$ ;  $\text{sig.} = 0.0006$ );
- ☐ *CM's analysing resource movement* ( $C_s = 0.6329$ ;  $\text{sig.} = 0.0004$ );
- ☐ *CM's analysing work sequencing to achieve and maintain workflow* ( $C_s = 0.5692$ ;  $\text{sig.} = 0.0013$ );
- ☐ *CR's organisational structure to manage risk* ( $C_s = 0.6025$ ;  $\text{sig.} = 0.0007$ );
- ☐ *key sub-contractor's organisational structure to manage risk* ( $C_s = 0.4873$ ;  $\text{sig.} = 0.0067$ );
- ☐ *CM's effectiveness in team management to achieve synergy* ( $C_s = 0.6232$ ;  $\text{sig.} = 0.0004$ );
- ☐ *flexibility of the CR's management style* ( $C_s = 0.5315$ ;  $\text{sig.} = 0.0026$ );
- ☐ *direct use of power in the CR's management style* ( $C_s = -0.5219$ ;  $\text{sig.} = 0.0037$ );
- ☐ *flexibility of the CM's management style* ( $C_s = 0.5534$ ;  $\text{sig.} = 0.0017$ );
- ☐ *CM's people-oriented management style* ( $C_s = 0.4699$ ;  $\text{sig.} = 0.0079$ );
- ☐ *CR decision making, communicating and actioning* ( $C_s = 0.6451$ ;  $\text{sig.} = 0.0003$ ).

## SUB-HYPOTHESIS NUMBER 88

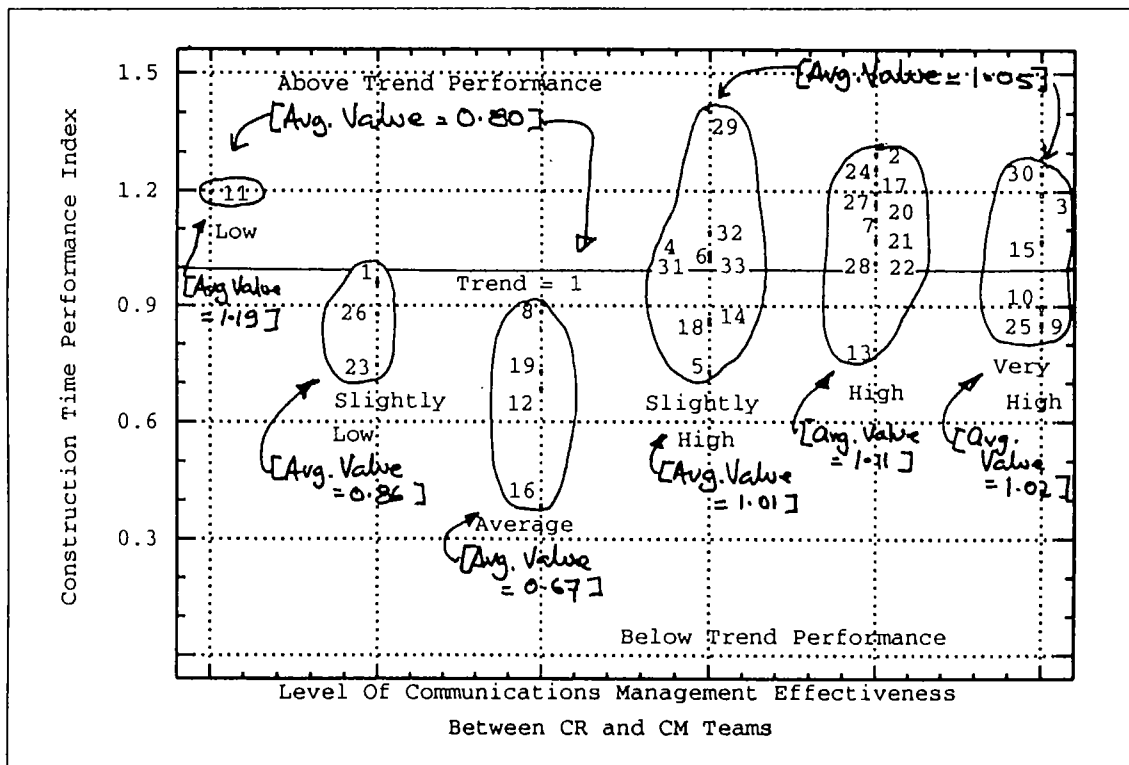
## QUESTIONNAIRE NUMBER Q16.2.1

- $H_0$  Construction time performance is **NOT** dependent upon better than average communications management for decision making between the CR and construction management teams.
- $H_1$  Construction time performance **IS** dependent upon better than average communications management for decision making between the CR and construction management teams.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
9.482	0.0043	<b><math>H_0</math> REJECTED: <math>H_1</math> ACCEPTED</b>

**Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)**



**SUB-HYPOTHESIS NUMBER 88**

**DATA ITEM: CR & CM TEAM COMMUNICATION FOR DECISION MAKING**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ client/CR's time minimisation objective ( $C_s = 0.4568$ ; sig. = 0.0098);
- ☐ ability of the CR to contribute ideas to the construction process ( $C_s = 0.5125$ ; sig. = 0.0037);
- ☐ the project design team's confidence in the CR contribution ( $C_s = 0.4483$ ; sig. = 0.0141);
- ☐ the construction team's confidence in the CR's contribution ( $C_s = 0.6560$ ; sig. = 0.0002);
- ☐ CR's willingness to contribute effective and positive ideas ( $C_s = 0.6636$ ; sig. = 0.0002);
- ☐ impact of CR/CM working relationship ( $C_s = 0.6394$ ; sig. = 0.0003);
- ☐ CM's planning - responding to problems or opportunities ( $C_s = 0.4758$ ; sig. = 0.0071);
- ☐ effectiveness of the construction team's monitoring and control ( $C_s = 0.5147$ ; sig. = 0.0036);
- ☐ CM's organisational structure to manage risk ( $C_s = 0.5437$ ; sig. = 0.0021);
- ☐ CM's communication management to facilitate decision making ( $C_s = 0.6642$ ; sig. = 0.0002);
- ☐ CR and design team communication effectiveness for decision making ( $C_s = 0.5490$ ; sig. = 0.0026);
- ☐ decision making communication within the CM team ( $C_s = 0.5101$ ; sig. = 0.0039);
- ☐ CM decision making, communicating and actioning ( $C_s = 0.6872$ ; sig. = 0.0001).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ clarity of communication of client/CR objectives ( $C_s = 0.4986$ ; sig. = 0.0048);
- ☐ complexity of CR's influence upon the project's management ( $C_s = 0.4639$ ; sig. = 0.0087);
- ☐ stability of CR decisions ( $C_s = 0.4467$ ; sig. = 0.0115);
- ☐ the CR's ability to mould shared project goals and aspirations ( $C_s = 0.5588$ ; sig. = 0.0019);
- ☐ the CR's willingness to accept effective and positive ideas ( $C_s = 0.7157$ ; sig. = 0.0001);
- ☐ the overall CR contribution to project team harmony ( $C_s = 0.7743$ ; sig. = 0.0000);
- ☐ quality management procedures used on-site ( $C_s = 0.5227$ ; sig. = 0.0036);
- ☐ CM's effectiveness in influencing the CR decision making process ( $C_s = 0.6386$ ; sig. = 0.0003);
- ☐ CR's organisational structure to manage risk ( $C_s = 0.4615$ ; sig. = 0.0090);
- ☐ flexibility of the CR's management style ( $C_s = 0.5464$ ; sig. = 0.0020);
- ☐ CR's people-oriented management style ( $C_s = 0.5637$ ; sig. = 0.0017);
- ☐ direct use of power in the CR's management style ( $C_s = -0.6552$ ; sig. = 0.0003);
- ☐ flexibility of the CM's management style ( $C_s = 0.4958$ ; sig. = 0.0050);
- ☐ task-orientation of the CM's management style ( $C_s = 0.4562$ ; sig. = 0.0099);
- ☐ decision making communication within the CM team ( $C_s = 0.5170$ ; sig. = 0.0062).



## SUB-HYPOTHESIS NUMBER 89

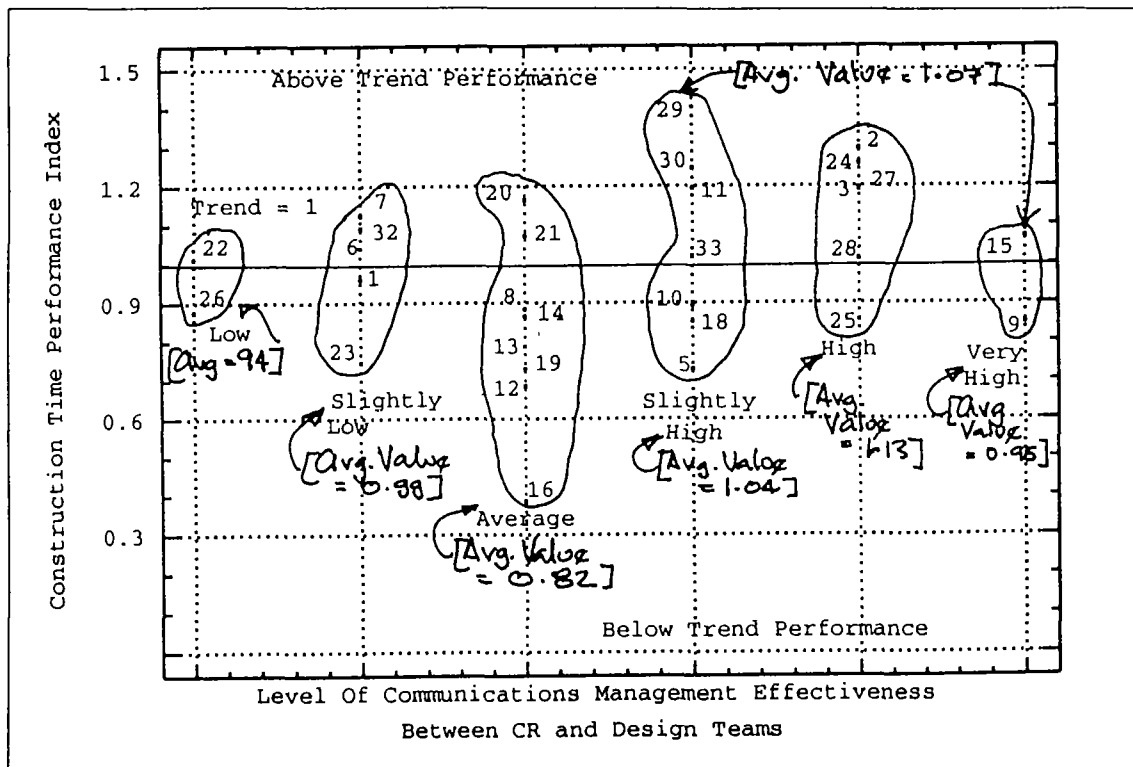
## QUESTIONNAIRE NUMBER Q16.2.2

- $H_0$  Construction time performance is **NOT** dependent upon better than average communications management for decision making between the CR and design teams.
- $H_1$  Construction time performance **IS** dependent upon better than average communications management for decision making between the CR and design teams.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
5.700	0.0237	<b><math>H_0</math> REJECTED: <math>H_1</math> ACCEPTED</b>

**Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)**



**SUB-HYPOTHESIS NUMBER 89**

**DATA ITEM: CR & DESIGN TEAM COMMUNICATION DECISION MAKING EFFECTIVENESS**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ ability of the CR to contribute ideas to the design process ( $C_s = 0.4892$ ; sig. = 0.0084);
- ☐ ability of the CR to contribute ideas to the construction process ( $C_s = 0.4865$ ; sig. = 0.0077);
- ☐ the project design team's confidence in the CR contribution ( $C_s = 0.6020$ ; sig. = 0.0014);
- ☐ the construction team's confidence in the CR's contribution ( $C_s = 0.5406$ ; sig. = 0.0031);
- ☐ CR's willingness to contribute effective and positive ideas ( $C_s = 0.4991$ ; sig. = 0.0063);
- ☐ impact of CR/CM working relationship ( $C_s = 0.5523$ ; sig. = 0.0025);
- ☐ key sub-contractor's task-oriented management style ( $C_s = 0.4788$ ; sig. = 0.0087);
- ☐ CM's communication management to facilitate decision making ( $C_s = 0.4893$ ; sig. = 0.0074);
- ☐ CR and CM team communication effectiveness for decision making ( $C_s = 0.5490$ ; sig. = 0.0026);
- ☐ CM and design team communication effectiveness for decision making ( $C_s = 0.5699$ ; sig. = 0.0018);
- ☐ decision making communication within the CM team ( $C_s = 0.4770$ ; sig. = 0.0090);
- ☐ effectiveness of the CM team in managing the construction process ( $C_s = 0.4897$ ; sig. = 0.0073).

**SUB-HYPOTHESIS NUMBER 89**

**DATA ITEM: CR & DESIGN TEAM COMMUNICATION DECISION MAKING EFFECTIVENESS**

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ CR's experience with the building procurement process ( $C_s = 0.5098$ ; sig. = 0.0052);
- ☐ client organisation's confidence in the CR ( $C_s = 0.4601$ ; sig. = 0.0132);
- ☐ credibility of achieving goals established by the CR/Client ( $C_s = 0.5289$ ; sig. = 0.0038);
- ☐ CR's understanding the project's constraints ( $C_s = 0.5448$ ; sig. = 0.0028);
- ☐ CR's ability to quickly make authoritative decisions ( $C_s = 0.4722$ ; sig. = 0.0097);
- ☐ CR's ability to effectively brief the design team ( $C_s = 0.6487$ ; sig. = 0.0006);
- ☐ stability of CR decisions ( $C_s = 0.5315$ ; sig. = 0.0036);
- ☐ CR's confidence in the project design team ( $C_s = 0.5782$ ; sig. = 0.0018);
- ☐ the CR's confidence in the construction team ( $C_s = 0.5065$ ; sig. = 0.0064);
- ☐ the CR's willingness to accept effective and positive ideas ( $C_s = 0.4700$ ; sig. = 0.0100);
- ☐ the overall CR contribution to project team harmony ( $C_s = 0.5366$ ; sig. = 0.0033);
- ☐ design coordination complexity ( $C_s = 0.4711$ ; sig. = 0.0099);
- ☐ design team's organisational structure to manage risk ( $C_s = 0.6178$ ; sig. = 0.0007);
- ☐ CM's effectiveness in team management to achieve synergy ( $C_s = 0.5164$ ; sig. = 0.0047);
- ☐ flexibility of the CR's management style ( $C_s = 0.4822$ ; sig. = 0.0083);
- ☐ task-orientation of the CR's management style ( $C_s = 0.4642$ ; sig. = 0.0124);
- ☐ CR's people-oriented management style ( $C_s = 0.5429$ ; sig. = 0.0035);
- ☐ direct use of power in the CR's management style ( $C_s = -0.5042$ ; sig. = 0.0066);
- ☐ flexibility of design team's management style ( $C_s = 0.5383$ ; sig. = 0.0037);
- ☐ task-orientation of the design team's management style ( $C_s = 0.5200$ ; sig. = 0.0069);
- ☐ design team's people-oriented management style ( $C_s = 0.6299$ ; sig. = 0.0016);
- ☐ direct use of power in the design team's management style ( $C_s = -0.6544$ ; sig. = 0.0021);
- ☐ flexibility of the CM's management style ( $C_s = 0.5991$ ; sig. = 0.0010);
- ☐ task-orientation of the CM's management style ( $C_s = 0.4918$ ; sig. = 0.0071);
- ☐ CM's people-oriented management style ( $C_s = 0.4438$ ; sig. = 0.0151);
- ☐ decision making communication within the design team ( $C_s = 0.6409$ ; sig. = 0.0009);
- ☐ CR decision making, communicating and actioning ( $C_s = 0.5170$ ; sig. = 0.0046);
- ☐ design team's decision making, communicating and actioning ( $C_s = 0.5335$ ; sig. = 0.0035);

## SUB-HYPOTHESIS NUMBER 90

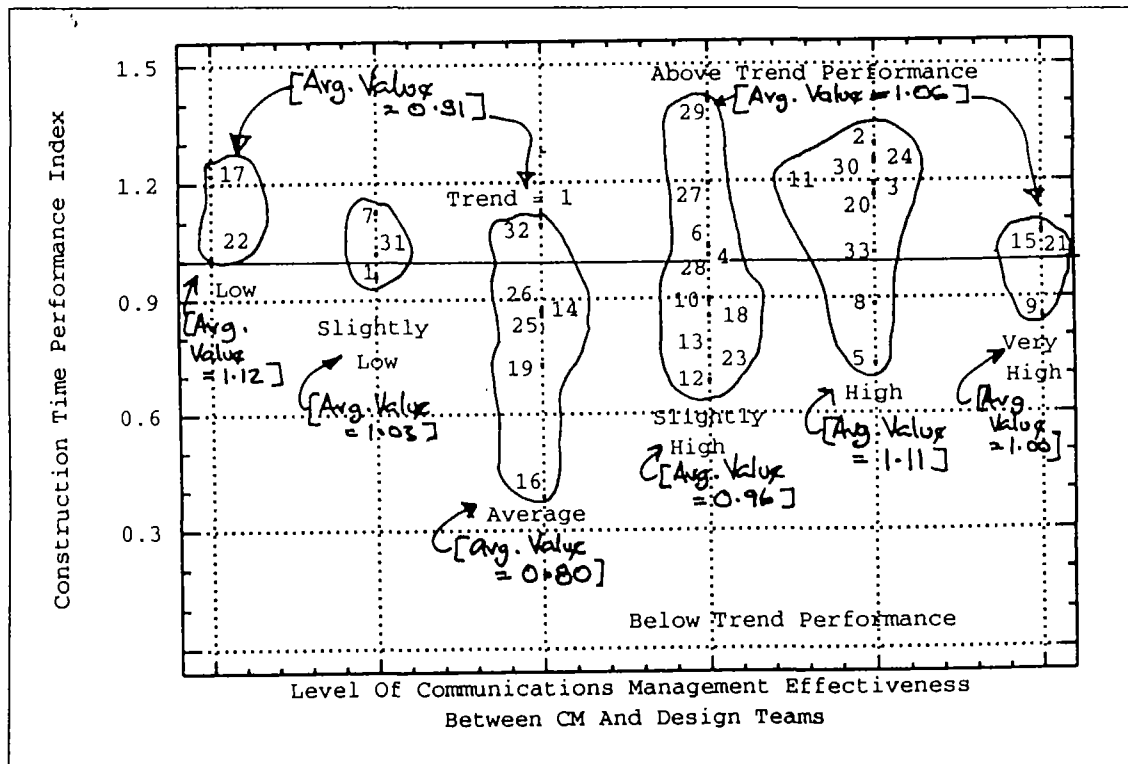
## QUESTIONNAIRE NUMBER Q16.2.3

- $H_0$  Construction time performance is **NOT** dependent upon better than average communications management for decision making between the CM and design teams.
- $H_1$  Construction time performance **IS** dependent upon better than average communications management for decision making between the CM and design teams.

One-way ANOVA test results *measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.*

F-Ratio	Significance Level	Interpretation
4.374	0.0448	<b><math>H_0</math> REJECTED: <math>H_1</math> ACCEPTED</b>

**Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)**



**SUB-HYPOTHESIS NUMBER 90**

**DATA ITEM: CM & DESIGN TEAM COMMUNICATION FOR DECISION MAKING**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *CR and design team communication effectiveness for decision making ( $C_s = 0.5699$ ; sig. = 0.0018).*

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *design team's people-oriented management style ( $C_s = 0.5868$ ; sig. = 0.0023);*
- ☐ *direct use of power in the design team's management style ( $C_s = -0.4863$ ; sig. = 0.0172);*
- ☐ *decision making communication within the design team ( $C_s = 0.5591$ ; sig. = 0.0026);*
- ☐ *design team's decision making, communicating and actioning ( $C_s = 0.5288$ ; sig. = 0.0028).*

## SUB-HYPOTHESIS NUMBER 91

## QUESTIONNAIRE NUMBER Q16.3.1

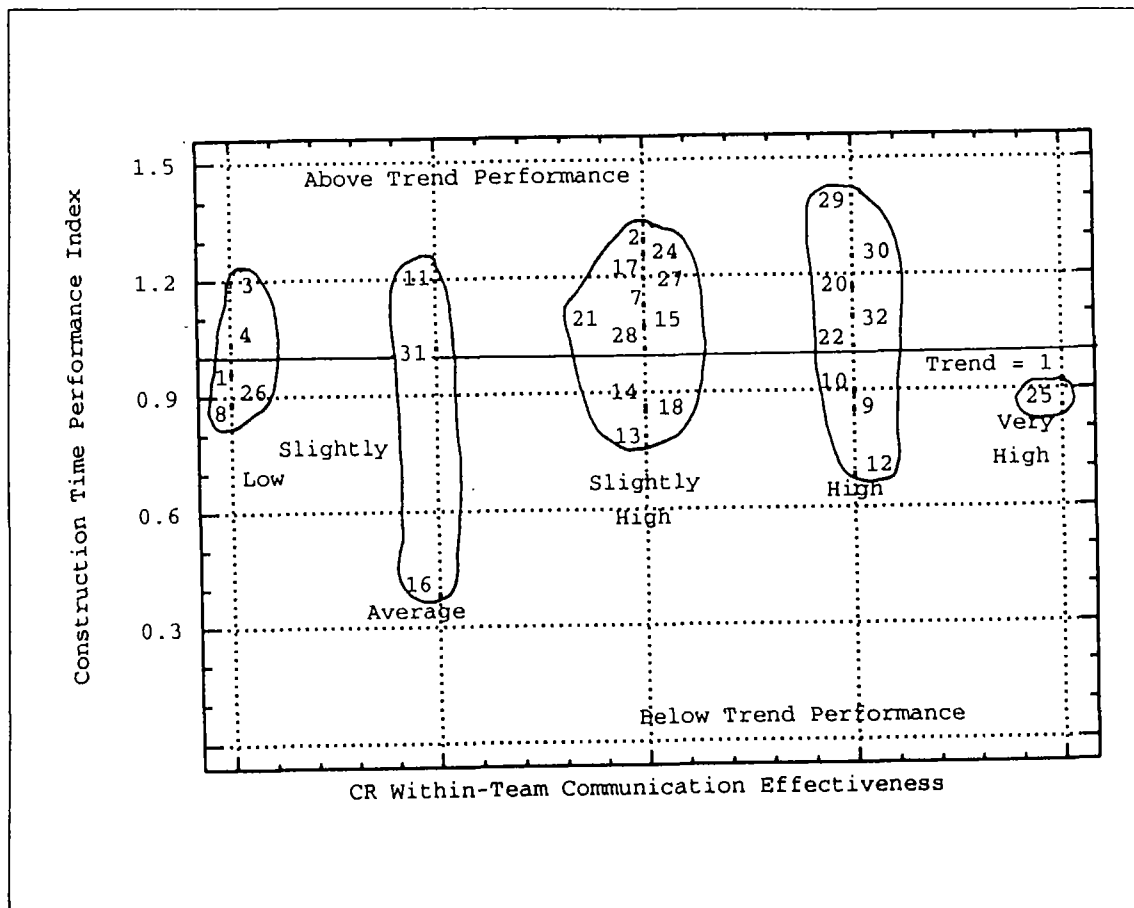
$H_0$  Construction time performance is NOT dependent upon CR within-team communication effectiveness.

$H_1$  Construction time performance IS dependent upon CR within-team communication effectiveness.

One-way ANOVA test results *measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.*

F-Ratio	Significance Level	Interpretation
0.614	0.6567	<b><math>H_0</math> ACCEPTED</b>

**Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)**



# SUB-HYPOTHESIS NUMBER 91

## DATA ITEM: DECISION MAKING COMMUNICATION WITHIN THE CR TEAM

### Spearman Rank Correlation results for factors affecting CTP:

- ☐ client/CR's time minimisation objective ( $C_s = 0.4621$ ; sig. = 0.0145);
- ☐ the construction team's confidence in the CR's contribution ( $C_s = 0.5452$ ; sig. = 0.0039);
- ☐ CR's willingness to contribute effective and positive ideas ( $C_s = 0.5494$ ; sig. = 0.0036);
- ☐ impact of CR/CM working relationship ( $C_s = 0.5610$ ; sig. = 0.0030);
- ☐ CM's forecasting planning data ( $C_s = 0.5404$ ; sig. = 0.0050);
- ☐ CM's analysing construction methods ( $C_s = 0.6185$ ; sig. = 0.0011);
- ☐ effectiveness of the construction team's planning ( $C_s = 0.6808$ ; sig. = 0.0003);
- ☐ CM's monitoring and updating plans to reflect work status ( $C_s = 0.5630$ ; sig. = 0.0029);
- ☐ CM's planning - responding to problems or opportunities ( $C_s = 0.6587$ ; sig. = 0.0005);
- ☐ CM's effectively coordinating resources ( $C_s = 0.6221$ ; sig. = 0.0010);
- ☐ CM's developing an organisational structure to maintain workflow ( $C_s = 0.6371$ ; sig. = 0.0007);
- ☐ **effectiveness of the construction team's monitoring and control ( $C_s = 0.7046$ ; sig. = 0.0002);**
- ☐ CM's organisational structure to manage risk ( $C_s = 0.4739$ ; sig. = 0.0121);
- ☐ CR and CM team communication effectiveness for decision making ( $C_s = 0.5170$ ; sig. = 0.0062);
- ☐ **decision making communication within the CM team ( $C_s = 0.7021$ ; sig. = 0.0002);**
- ☐ CM decision making, communicating and actioning ( $C_s = 0.6315$ ; sig. = 0.0008);
- ☐ effectiveness of the CM team in managing the construction process ( $C_s = 0.6233$ ; sig. = 0.0010);

### Spearman Rank Correlation results for factors NOT affecting CTP:

- ☐ CR's experience with the building procurement process ( $C_s = 0.4587$ ; sig. = 0.0152);
- ☐ client organisation's confidence in the CR ( $C_s = 0.6562$ ; sig. = 0.0007);
- ☐ stability of client/CR objectives ( $C_s = 0.4509$ ; sig. = 0.0170);
- ☐ CR's ability to quickly make authoritative decisions ( $C_s = 0.4856$ ; sig. = 0.0102);
- ☐ stability of CR decisions ( $C_s = 0.4773$ ; sig. = 0.0115);
- ☐ the CR's confidence in the construction team ( $C_s = 0.4820$ ; sig. = 0.0123);
- ☐ the CR's ability to mould shared project goals and aspirations ( $C_s = 0.4601$ ; sig. = 0.0149);
- ☐ physical environmental complexity ( $C_s = 0.4626$ ; sig. = 0.0144);
- ☐ **CM's effectiveness in influencing the CR decision making process ( $C_s = 0.6954$ ; sig. = 0.0002);**
- ☐ CM management systems and procedures ( $C_s = 0.5585$ ; sig. = 0.0031);
- ☐ CM's analysing resource movement ( $C_s = 0.5156$ ; sig. = 0.0074);
- ☐ CM's analysing work sequencing to achieve and maintain workflow ( $C_s = 0.6896$ ; sig. = 0.0003);
- ☐ CR's organisational structure to manage risk ( $C_s = 0.5088$ ; sig. = 0.0071);
- ☐ key sub-contractor's organisational structure to manage risk ( $C_s = 0.4866$ ; sig. = 0.0115);
- ☐ CM's effectiveness in team management to achieve synergy ( $C_s = 0.6032$ ; sig. = 0.0014);
- ☐ task-orientation of the CM's management style ( $C_s = 0.5477$ ; sig. = 0.0038).

## SUB-HYPOTHESIS NUMBER 92

## QUESTIONNAIRE NUMBER Q16.3.2

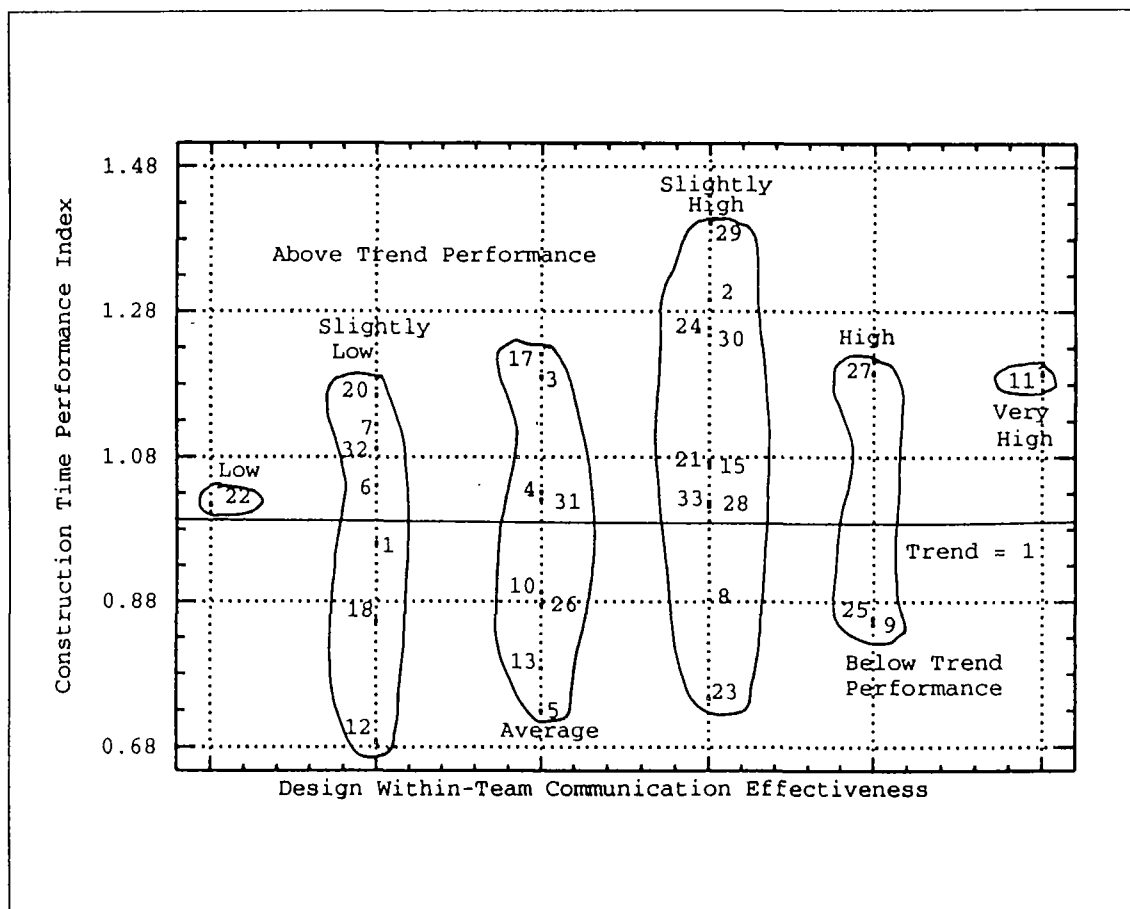
$H_0$  Construction time performance is **NOT** dependent upon design team within-team communication effectiveness.

$H_1$  Construction time performance **IS** dependent upon design team within-team communication effectiveness.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.747	0.5962	$H_0$ ACCEPTED

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*





**SUB-HYPOTHESIS NUMBER 92**

**DATA ITEM: DECISION MAKING COMMUNICATION WITHIN THE DESIGN TEAM**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *the project design team's confidence in the CR contribution ( $C_s = 0.5705$ ; sig. = 0.0025);*
- ☐ *CR and design team communication effectiveness for decision making ( $C_s = 0.6409$ ; sig. = 0.0009);*
- ☐ *CM and design team communication effectiveness for decision making ( $C_s = 0.5591$ ; sig. = 0.0026);*

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *CR's confidence in the project design team ( $C_s = 0.4681$ ; sig. = 0.0117);*
- ☐ *access to and within site ( $C_s = 0.5055$ ; sig. = 0.0065);*
- ☐ *general project complexity ( $C_s = 0.5266$ ; sig. = 0.0046);*
- ☐ *impact of the IR environment ( $C_s = 0.5037$ ; sig. = 0.0067);*
- ☐ *impact of general environmental factors ( $C_s = 0.4591$ ; sig. = 0.0134);*
- ☐ *design team's organisational structure to manage risk ( $C_s = 0.4628$ ; sig. = 0.0127);*
- ☐ *task-orientation of the design team's management style ( $C_s = 0.5337$ ; sig. = 0.0056);*
- ☐ **design team's people-oriented management style ( $C_s = 0.6973$ ; sig. = 0.0005);**
- ☐ *flexibility of key sub-contractor's management style ( $C_s = 0.4490$ ; sig. = 0.0156);*
- ☐ *design team's decision making, communicating and actioning ( $C_s = 0.6181$ ; sig. = 0.0009);*
- ☐ *CR's effective use of information technologies ( $C_s = 0.5034$ ; sig. = 0.0441).*

## SUB-HYPOTHESIS NUMBER 93

## QUESTIONNAIRE NUMBER Q16.3.3

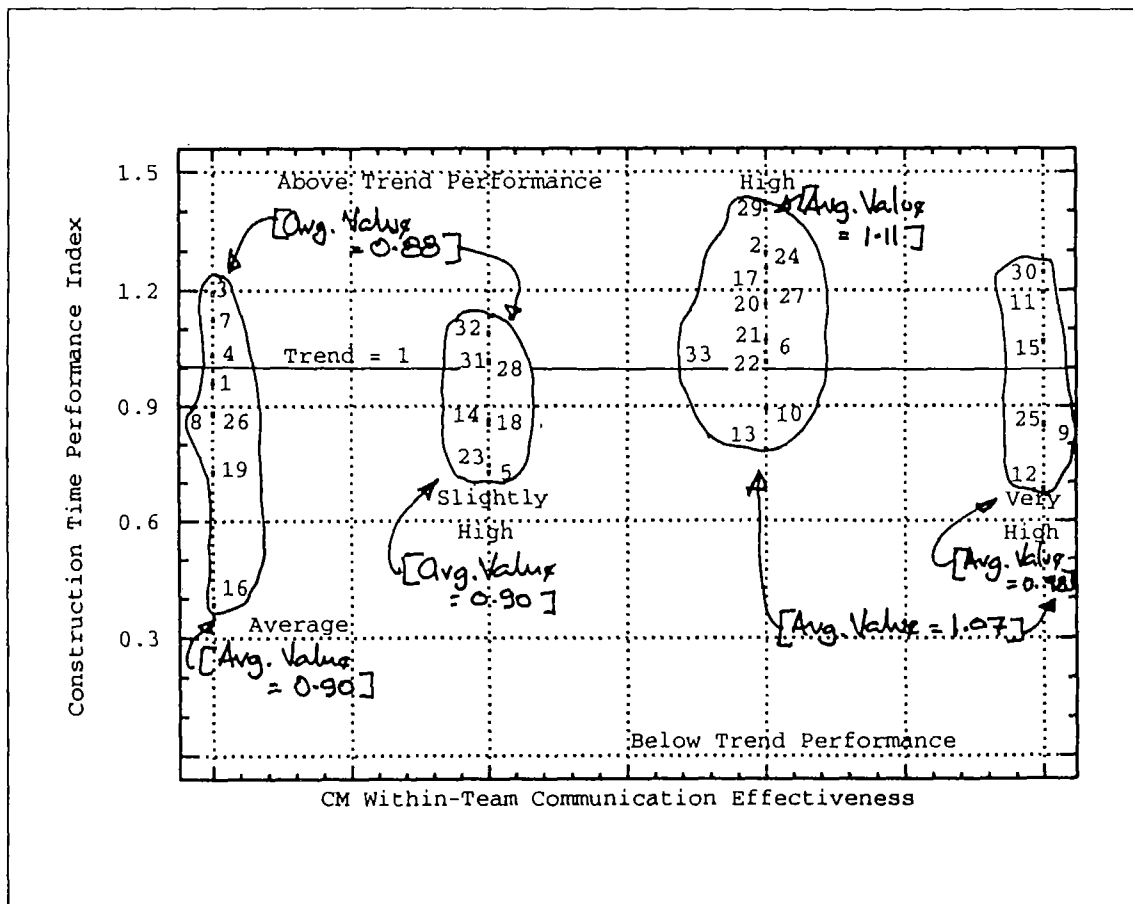
$H_0$  Construction time performance is **NOT** dependent upon better than slightly high CM within-team communication effectiveness.

$H_1$  Construction time performance **IS** dependent upon better than slightly high CM within-team communication effectiveness.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of *less than* 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
7.676	0.0094	<b><math>H_0</math> REJECTED: <math>H_1</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 93**

**DATA ITEM: DECISION MAKING COMMUNICATION WITHIN THE CM TEAM**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ the project design team's confidence in the CR contribution ( $C_s = 0.4462$ ; sig. = 0.0145);
- ☐ the construction team's confidence in the CR's contribution ( $C_s = 0.6095$ ; sig. = 0.0006);
- ☐ CR's willingness to contribute effective and positive ideas ( $C_s = 0.4690$ ; sig. = 0.0080);
- ☐ economic environmental complexity ( $C_s = 0.5176$ ; sig. = 0.0034);
- ☐ impact of CR/CM working relationship ( $C_s = 0.6355$ ; sig. = 0.0003);
- ☐ CM's forecasting planning data ( $C_s = 0.4992$ ; sig. = 0.0054);
- ☐ CM's analysing construction methods ( $C_s = 0.5967$ ; sig. = 0.0007);
- ☐ effectiveness of the construction team's planning ( $C_s = 0.6486$ ; sig. = 0.0002);
- ☐ CM's monitoring and updating plans to reflect work status ( $C_s = 0.5727$ ; sig. = 0.0012);
- ☐ CM's planning - responding to problems or opportunities ( $C_s = 0.5091$ ; sig. = 0.0040);
- ☐ CM's effectively coordinating resources ( $C_s = 0.4794$ ; sig. = 0.0067);
- ☐ CM's developing an organisational structure to maintain workflow ( $C_s = 0.5359$ ; sig. = 0.0024);
- ☐ effectiveness of the construction team's monitoring and control ( $C_s = 0.5230$ ; sig. = 0.0031);
- ☐ CM's organisational structure to manage risk ( $C_s = 0.4580$ ; sig. = 0.0096);
- ☐ key sub-contractor's task-oriented management style ( $C_s = 0.5106$ ; sig. = 0.0045);
- ☐ CM's communication management to facilitate decision making ( $C_s = 0.5439$ ; sig. = 0.0021);
- ☐ CR and CM team communication effectiveness for decision making ( $C_s = 0.5101$ ; sig. = 0.0039);
- ☐ CR and design team communication effectiveness for decision making ( $C_s = 0.4770$ ; sig. = 0.0090);
- ☐ CM decision making, communicating and actioning ( $C_s = 0.6033$ ; sig. = 0.0006);
- ☐ CM's effective use of information technologies ( $C_s = 0.4838$ ; sig. = 0.0062);
- ☐ effectiveness of the CM team in managing the construction process ( $C_s = 0.6835$ ; sig. = 0.0001).

**SUB-HYPOTHESIS NUMBER 93**

**DATA ITEM: DECISION MAKING COMMUNICATION WITHIN THE CM TEAM**

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *CR's experience with the building procurement process ( $C_s = 0.6224$ ; sig. = 0.0004);*
- ☐ *client organisation's confidence in the CR ( $C_s = 0.5502$ ; sig. = 0.0022);*
- ☐ *stability of client/CR objectives ( $C_s = 0.5312$ ; sig. = 0.0027);*
- ☐ *CR's ability to quickly make authoritative decisions ( $C_s = 0.4776$ ; sig. = 0.0069);*
- ☐ *the CR's ability to mould shared project goals and aspirations ( $C_s = 0.4829$ ; sig. = 0.0072);*
- ☐ *socio-political environmental complexity ( $C_s = 0.5210$ ; sig. = 0.0032);*
- ☐ *impact of the IR environment ( $C_s = 0.5208$ ; sig. = 0.0032);*
- ☐ *impact of general environmental factors ( $C_s = 0.5010$ ; sig. = 0.0046);*
- ☐ *CM's effectiveness in influencing the CR decision making process ( $C_s = 0.5591$ ; sig. = 0.0016);*
- ☐ *CM management systems and procedures ( $C_s = 0.4889$ ; sig. = 0.0057);*
- ☐ *CM's analysing resource movement ( $C_s = 0.4740$ ; sig. = 0.0083);*
- ☐ *CM's analysing work sequencing to achieve and maintain workflow ( $C_s = 0.6187$ ; sig. = 0.0005);*
- ☐ *CR's organisational structure to manage risk ( $C_s = 0.4439$ ; sig. = 0.0120);*
- ☐ *key sub-contractor's organisational structure to manage risk ( $C_s = 0.5400$ ; sig. = 0.0026);*
- ☐ *CM's effectiveness in team management to achieve synergy ( $C_s = 0.6515$ ; sig. = 0.0002);*
- ☐ *task-orientation of the CR's management style ( $C_s = 0.6045$ ; sig. = 0.0008);*
- ☐ *flexibility of the CM's management style ( $C_s = 0.6120$ ; sig. = 0.0005);*
- ☐ *task-orientation of the CM's management style ( $C_s = 0.5195$ ; sig. = 0.0033);*
- ☐ *CM's people-oriented management style ( $C_s = 0.5226$ ; sig. = 0.0031);*
- ☐ **decision making communication within the CR team ( $C_s = 0.7021$ ; sig. = 0.0002);**
- ☐ *CR decision making, communicating and actioning ( $C_s = 0.4950$ ; sig. = 0.0051);*
- ☐ *CR's effective use of information technologies ( $C_s = 0.6408$ ; sig. = 0.0104).*

## SUB-HYPOTHESIS NUMBER 94

## QUESTIONNAIRE NUMBER Q16.4.1

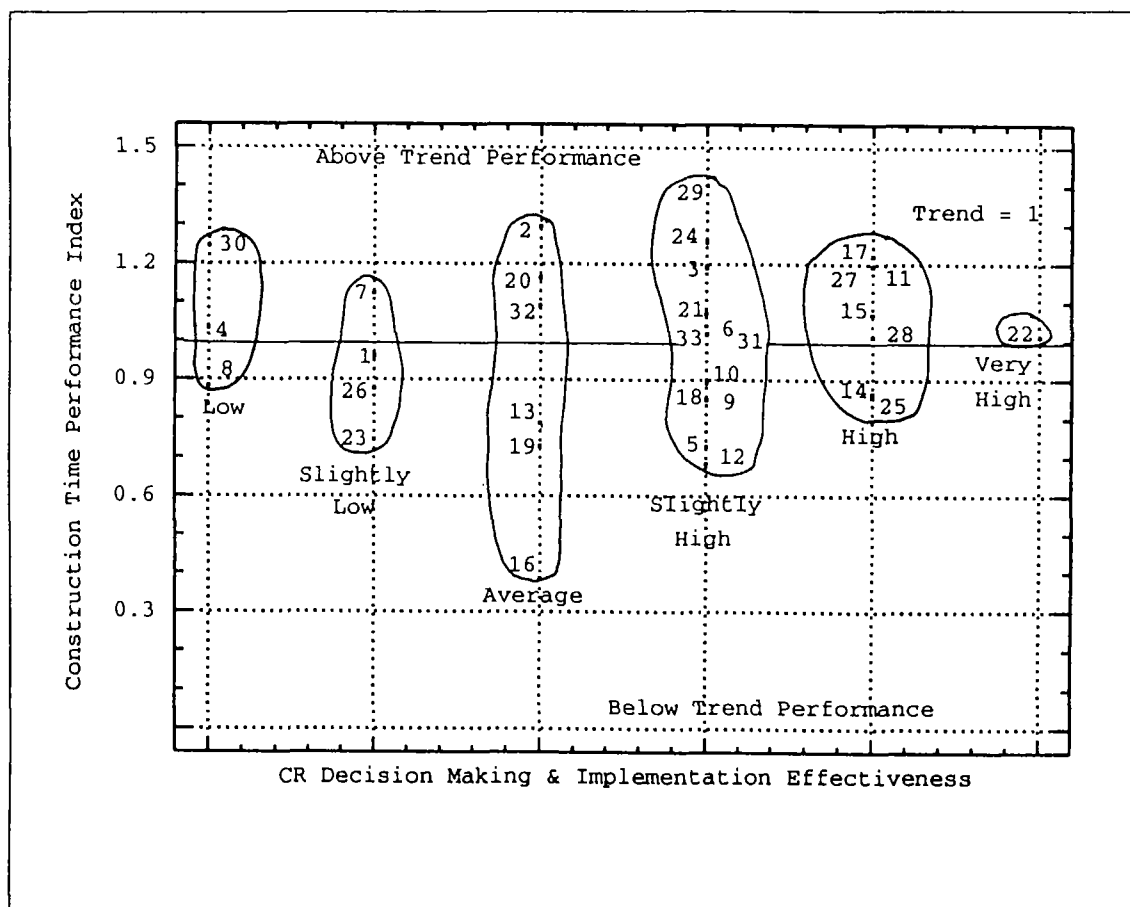
$H_0$  Construction time performance is **NOT** dependent upon CR decision making and implementation effectiveness.

$H_1$  Construction time performance **IS** dependent upon CR decision making and implementation effectiveness.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.408	0.8388	<b><math>H_0</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 94**

**DATA ITEM: CR DECISION MAKING, COMMUNICATING AND ACTIONING**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *ability of the CR to contribute ideas to the construction process ( $C_s = 0.5461$ ; sig. = 0.0020);*
- ☐ *the construction team's confidence in the CR's contribution ( $C_s = 0.6616$ ; sig. = 0.0002);*
- ☐ *CR's willingness to contribute effective and positive ideas ( $C_s = 0.5260$ ; sig. = 0.0029);*
- ☐ *impact of CR/CM working relationship ( $C_s = 0.5961$ ; sig. = 0.0007);*
- ☐ *CM's forecasting planning data ( $C_s = 0.5484$ ; sig. = 0.0023);*
- ☐ *CM's analysing construction methods ( $C_s = 0.5777$ ; sig. = 0.0011);*
- ☐ *effectiveness of the construction team's planning ( $C_s = 0.5682$ ; sig. = 0.0013);*
- ☐ *CM's monitoring and updating plans to reflect work status ( $C_s = 0.5601$ ; sig. = 0.0015);*
- ☐ *CM's planning - responding to problems or opportunities ( $C_s = 0.5373$ ; sig. = 0.0024);*
- ☐ *CM's effectively coordinating resources ( $C_s = 0.6501$ ; sig. = 0.0002);*
- ☐ *CM's developing an organisational structure to maintain workflow ( $C_s = 0.5172$ ; sig. = 0.0034);*
- ☐ *effectiveness of the construction team's monitoring and control ( $C_s = 0.6227$ ; sig. = 0.0004);*
- ☐ *CM's organisational structure to manage risk ( $C_s = 0.6207$ ; sig. = 0.0004);*
- ☐ *key sub-contractor's task-oriented management style ( $C_s = 0.5799$ ; sig. = 0.0010);*
- ☐ *CM's communication management to facilitate decision making ( $C_s = 0.6451$ ; sig. = 0.0003);*
- ☐ *CR and design team communication effectiveness for decision making ( $C_s = 0.5170$ ; sig. = 0.0046);*
- ☐ *decision making communication within the CM team ( $C_s = 0.4950$ ; sig. = 0.0051);*
- ☐ *CM decision making, communicating and actioning ( $C_s = 0.5637$ ; sig. = 0.0014);*
- ☐ *effectiveness of the CM team in managing the construction process ( $C_s = 0.6300$ ; sig. = 0.0004).*

**SUB-HYPOTHESIS NUMBER 94**

**DATA ITEM: CR DECISION MAKING, COMMUNICATING AND ACTIONING**

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ CR's experience with the building procurement process ( $C_s = 0.4989$ ; sig. = 0.0048);
- ☐ stability of client/CR objectives ( $C_s = 0.6008$ ; sig. = 0.0007);
- ☐ clarity of communication of client/CR objectives ( $C_s = 0.6296$ ; sig. = 0.0004);
- ☐ the level of influence exercised on CTP by the CR ( $C_s = 0.4706$ ; sig. = 0.0078);
- ☐ complexity of CR's influence upon the project's management ( $C_s = 0.4987$ ; sig. = 0.0048);
- ☐ CR's ability to quickly make authoritative decisions ( $C_s = 0.5680$ ; sig. = 0.0013);
- ☐ CR's ability to effectively brief the design team ( $C_s = 0.5783$ ; sig. = 0.0015);
- ☐ stability of CR decisions ( $C_s = 0.5797$ ; sig. = 0.0010);
- ☐ the CR's ability to mould shared project goals and aspirations ( $C_s = 0.5183$ ; sig. = 0.0039);
- ☐ CM's effectiveness in influencing the CR decision making process ( $C_s = 0.5051$ ; sig. = 0.0043);
- ☐ CM management systems and procedures ( $C_s = 0.6686$ ; sig. = 0.0002);
- ☐ CM's analysing resource movement ( $C_s = 0.4477$ ; sig. = 0.0127);
- ☐ CM's analysing work sequencing to achieve and maintain workflow ( $C_s = 0.4741$ ; sig. = 0.0073);
- ☐ **CR's organisational structure to manage risk ( $C_s = 0.6993$ ; sig. = 0.0001);**
- ☐ CM's effectiveness in team management to achieve synergy ( $C_s = 0.5755$ ; sig. = 0.0011);
- ☐ flexibility of the CR's management style ( $C_s = 0.5141$ ; sig. = 0.0036);
- ☐ flexibility of the CM's management style ( $C_s = 0.5305$ ; sig. = 0.0027);
- ☐ CM's people-oriented management style ( $C_s = 0.6136$ ; sig. = 0.0005);
- ☐ key sub-contractor's people-oriented management style ( $C_s = 0.5392$ ; sig. = 0.0023);
- ☐ CR's effective use of information technologies ( $C_s = 0.5402$ ; sig. = 0.0307).

## SUB-HYPOTHESIS NUMBER 95

## QUESTIONNAIRE NUMBER Q16.4.2

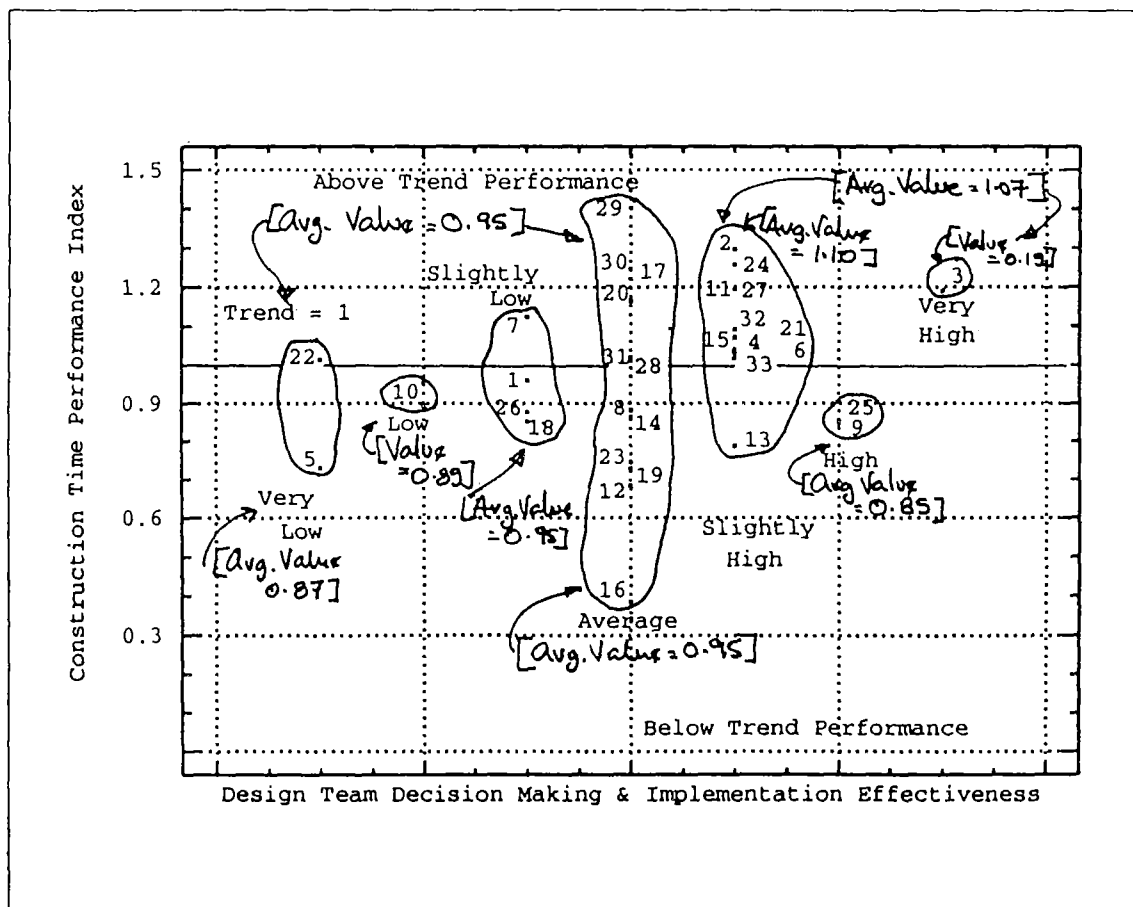
$H_0$  Construction time performance is **NOT** dependent upon design team decision making and implementation effectiveness.

$H_1$  Construction time performance **IS** dependent upon design team decision making and implementation effectiveness.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.968	0.4661	<b><math>H_0</math> ACCEPTED</b>

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)





**SUB-HYPOTHESIS NUMBER 95**

**DATA ITEM: DESIGN TEAM'S DECISION MAKING, COMMUNICATING AND ACTIONING**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ the project design team's confidence in the CR contribution ( $C_s = 0.4786$ ; sig. = 0.0088);
- ☐ economic environmental complexity ( $C_s = 0.4784$ ; sig. = 0.0068);
- ☐ *CR and design team communication effectiveness for decision making* ( $C_s = 0.5335$ ; sig. = 0.0035);
- ☐ *CM and design team communication effectiveness for decision making* ( $C_s = 0.5288$ ; sig. = 0.0028).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ design team's organisational structure to manage risk ( $C_s = 0.4785$ ; sig. = 0.0068);
- ☐ *task-orientation of the design team's management style* ( $C_s = 0.5170$ ; sig. = 0.0054);
- ☐ *decision making communication within the design team* ( $C_s = 0.6181$ ; sig. = 0.0009);

## SUB-HYPOTHESIS NUMBER 96

## QUESTIONNAIRE NUMBER Q16.4.3

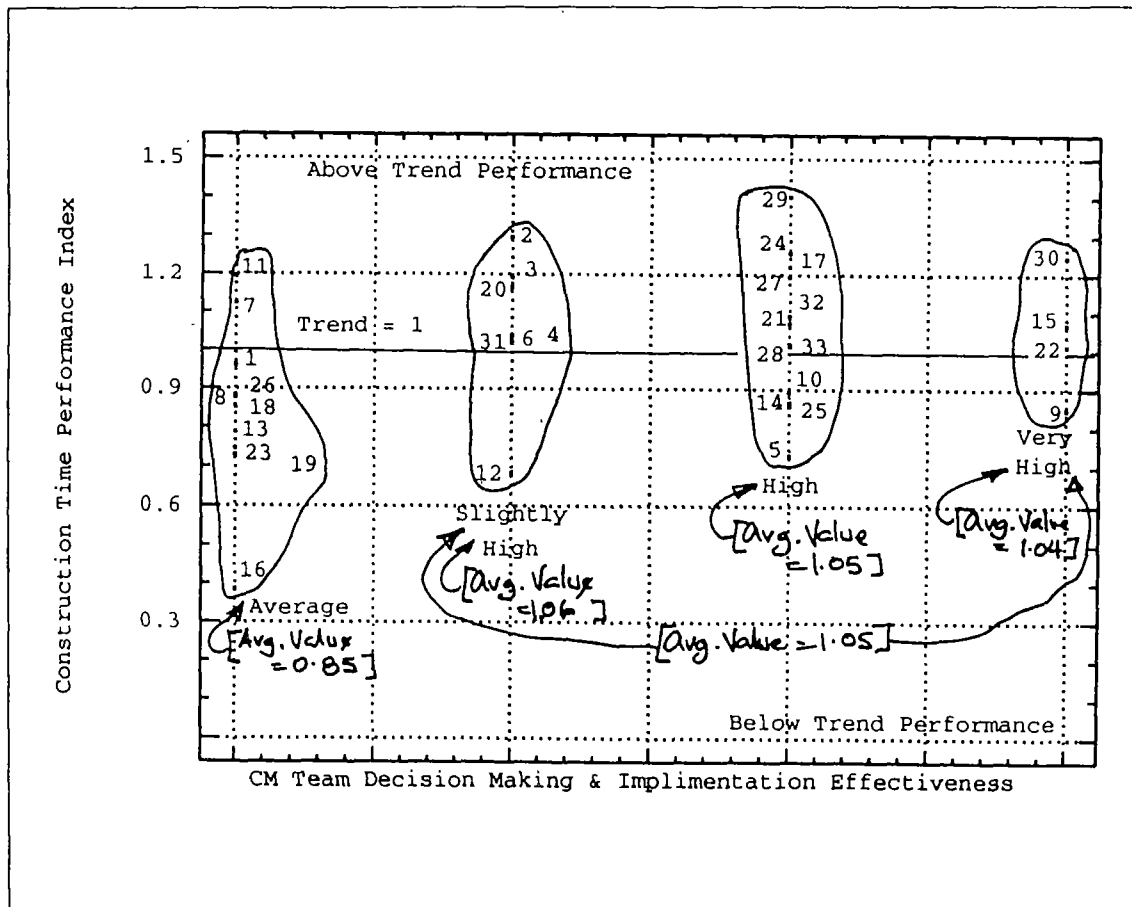
$H_0$  Construction time performance is **NOT** dependent upon a better than slightly high level of construction team decision making and implementation effectiveness.

$H_1$  Construction time performance **IS** dependent upon a better than slightly high level of construction team decision making and implementation effectiveness.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
7.265	0.0113	$H_0$ REJECTED: $H_1$ ACCEPTED

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 96**

**DATA ITEM: CM DECISION MAKING, COMMUNICATING AND ACTIONING**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *client/CR's time minimisation objective* ( $C_s = 0.4959$ ; sig. = 0.0050);
- ☐ *ability of the CR to contribute ideas to the design process* ( $C_s = 0.6066$ ; sig. = 0.0007);
- ☐ *the project design team's confidence in the CR contribution* ( $C_s = 0.4841$ ; sig. = 0.0080);
- ☐ *the construction team's confidence in the CR's contribution* ( $C_s = 0.5982$ ; sig. = 0.0007);
- ☐ *CR's willingness to contribute effective and positive ideas* ( $C_s = 0.5919$ ; sig. = 0.0008);
- ☐ *impact of CR/CM working relationship* ( $C_s = 0.6273$ ; sig. = 0.0004);
- ☐ *CM's forecasting planning data* ( $C_s = 0.6328$ ; sig. = 0.0004);
- ☐ *CM's analysing construction methods* ( $C_s = 0.6570$ ; sig. = 0.0002);
- ☐ **effectiveness of the construction team's planning** ( $C_s = 0.7338$ ; sig. = 0.0000);
- ☐ *CM's monitoring and updating plans to reflect work status* ( $C_s = 0.6447$ ; sig. = 0.0003);
- ☐ *CM's planning - responding to problems or opportunities* ( $C_s = 0.6801$ ; sig. = 0.0001);
- ☐ **CM's effectively coordinating resources** ( $C_s = 0.7226$ ; sig. = 0.0000);
- ☐ **CM's developing an organisational structure to maintain workflow** ( $C_s = 0.7103$ ; sig. = 0.0001);
- ☐ **effectiveness of the construction team's monitoring and control** ( $C_s = 0.7522$ ; sig. = 0.0000);
- ☐ *CM's organisational structure to manage risk* ( $C_s = 0.5974$ ; sig. = 0.0007);
- ☐ *key sub-contractor's task-oriented management style* ( $C_s = 0.5296$ ; sig. = 0.0027);
- ☐ **CM's communication management to facilitate decision making** ( $C_s = 0.7727$ ; sig. = 0.0000);
- ☐ *CR and CM team communication effectiveness for decision making* ( $C_s = 0.6872$ ; sig. = 0.0001);
- ☐ *CR and design team communication effectiveness for decision making* ( $C_s = 0.4472$ ; sig. = 0.0143);
- ☐ *decision making communication within the CM team* ( $C_s = 0.6033$ ; sig. = 0.0006);
- ☐ *effectiveness of the CM team in managing the construction process* ( $C_s = 0.6739$ ; sig. = 0.0001).

**SUB-HYPOTHESIS NUMBER 96**

**DATA ITEM: CM DECISION MAKING, COMMUNICATING AND ACTIONING**

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *stability of client/CR objectives ( $C_s = 0.5193$ ; sig. = 0.0033);*
- ☐ *clarity of communication of client/CR objectives ( $C_s = 0.5344$ ; sig. = 0.0025);*
- ☐ *the level of influence exercised on CTP by the CR ( $C_s = 0.4532$ ; sig. = 0.0104);*
- ☐ *complexity of CR's influence upon the project's management ( $C_s = 0.5293$ ; sig. = 0.0028);*
- ☐ *CR's ability to effectively brief the design team ( $C_s = 0.5116$ ; sig. = 0.0051);*
- ☐ *stability of CR decisions ( $C_s = 0.5517$ ; sig. = 0.0018);*
- ☐ *the CR's confidence in the construction team ( $C_s = 0.6318$ ; sig. = 0.0004);*
- ☐ *the CR's ability to mould shared project goals and aspirations ( $C_s = 0.6073$ ; sig. = 0.0007);*
- ☐ *the CR's willingness to accept effective and positive ideas ( $C_s = 0.5979$ ; sig. = 0.0007);*
- ☐ *the overall CR contribution to project team harmony ( $C_s = 0.5710$ ; sig. = 0.0012);*
- ☐ *quality management procedures used on-site ( $C_s = 0.4963$ ; sig. = 0.0057)*
- ☐ **CM's effectiveness in influencing the CR decision making process ( $C_s = 0.7630$ ; sig. = 0.0000);**
- ☐ *CM management systems and procedures ( $C_s = 0.6630$ ; sig. = 0.0002);*
- ☐ *CM's analysing resource movement ( $C_s = 0.6498$ ; sig. = 0.0003);*
- ☐ **CM's analysing work sequencing to achieve and maintain workflow ( $C_s = 0.7247$ ; sig. = 0.0000);**
- ☐ *key sub-contractor's organisational structure to manage risk ( $C_s = 0.5128$ ; sig. = 0.0043);*
- ☐ **CM's effectiveness in team management to achieve synergy ( $C_s = 0.7595$ ; sig. = 0.0000);**
- ☐ *flexibility of the CR's management style ( $C_s = 0.5668$ ; sig. = 0.0013);*
- ☐ *CR's people-oriented management style ( $C_s = 0.5430$ ; sig. = 0.0025);*
- ☐ *direct use of power in the CR's management style ( $C_s = -0.4539$ ; sig. = 0.0115);*
- ☐ *flexibility of the CM's management style ( $C_s = 0.6006$ ; sig. = 0.0007);*
- ☐ *task-orientation of the CM's management style ( $C_s = 0.6356$ ; sig. = 0.0003);*
- ☐ *CM's people-oriented management style ( $C_s = 0.5820$ ; sig. = 0.0010);*
- ☐ *decision making communication within the CM team ( $C_s = 0.6315$ ; sig. = 0.0008);*
- ☐ *CR decision making, communicating and actioning ( $C_s = 0.5637$ ; sig. = 0.0014);*

## SUB-HYPOTHESIS NUMBER 97

## QUESTIONNAIRE NUMBER Q16.6CR

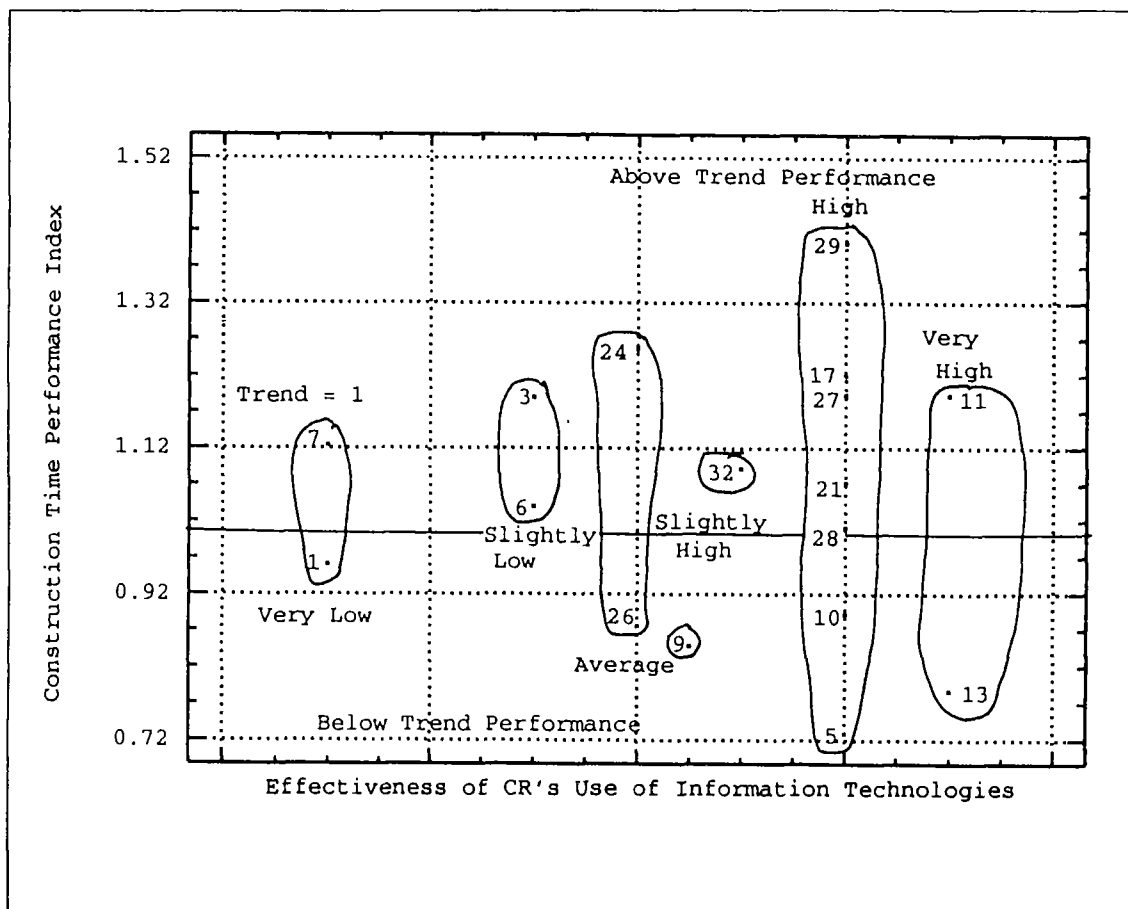
$H_0$  Construction time performance is **NOT** dependent upon the CR's effective use of information technologies.

$H_1$  Construction time performance **IS** dependent upon the CR's effective use of information technologies.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.218	0.9622	<b><math>H_0</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 97**

**DATA ITEM: CR'S EFFECTIVE USE OF INFORMATION TECHNOLOGIES**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *the project design team's confidence in the CR contribution* ( $C_s = 0.5568$ ; sig. = 0.0259);
- ☐ *impact of CR/CM working relationship* ( $C_s = 0.4573$ ; sig. = 0.0674);
- ☐ *CM's analysing construction methods* ( $C_s = 0.4763$ ; sig. = 0.0568);
- ☐ *effectiveness of the construction team's planning* ( $C_s = 0.4518$ ; sig. = 0.0707);
- ☐ *CM's monitoring and updating plans to reflect work status* ( $C_s = 0.5207$ ; sig. = 0.0373);
- ☐ *key sub-contractor's task-oriented management style* ( $C_s = 0.4552$ ; sig. = 0.0686);
- ☐ *decision making communication within the CM team* ( $C_s = 0.6408$ ; sig. = 0.0104);
- ☐ **CM's effective use of information technologies** ( $C_s = 0.7648$ ; sig. = 0.0022).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *project procurement method* ( $C_s = 0.5350$ ; sig. = 0.0324);
- ☐ *CR's experience with the building procurement process* ( $C_s = 0.5950$ ; sig. = 0.0173);
- ☐ *client organisation's confidence in the CR* ( $C_s = 0.4876$ ; sig. = 0.0590);
- ☐ *stability of client/CR objectives* ( $C_s = 0.4689$ ; sig. = 0.0607);
- ☐ *CR's ability to quickly make authoritative decisions* ( $C_s = 0.4895$ ; sig. = 0.0502);
- ☐ *CM's analysing resource movement* ( $C_s = 0.5962$ ; sig. = 0.0209);
- ☐ *CM's analysing work sequencing to achieve and maintain workflow* ( $C_s = 0.4805$ ; sig. = 0.0546);
- ☐ *CR's organisational structure to manage risk* ( $C_s = 0.4458$ ; sig. = 0.0745);
- ☐ *key sub-contractor's organisational structure to manage risk* ( $C_s = 0.6241$ ; sig. = 0.0125);
- ☐ *flexibility of the CM's management style* ( $C_s = 0.6760$ ; sig. = 0.0068);
- ☐ *flexibility of key sub-contractor's management style* ( $C_s = 0.4527$ ; sig. = 0.0702);
- ☐ *decision making communication within the design team* ( $C_s = 0.5034$ ; sig. = 0.0441);
- ☐ *CR decision making, communicating and actioning* ( $C_s = 0.5402$ ; sig. = 0.0307);

## SUB-HYPOTHESIS NUMBER 98

## QUESTIONNAIRE NUMBER Q16.6DES

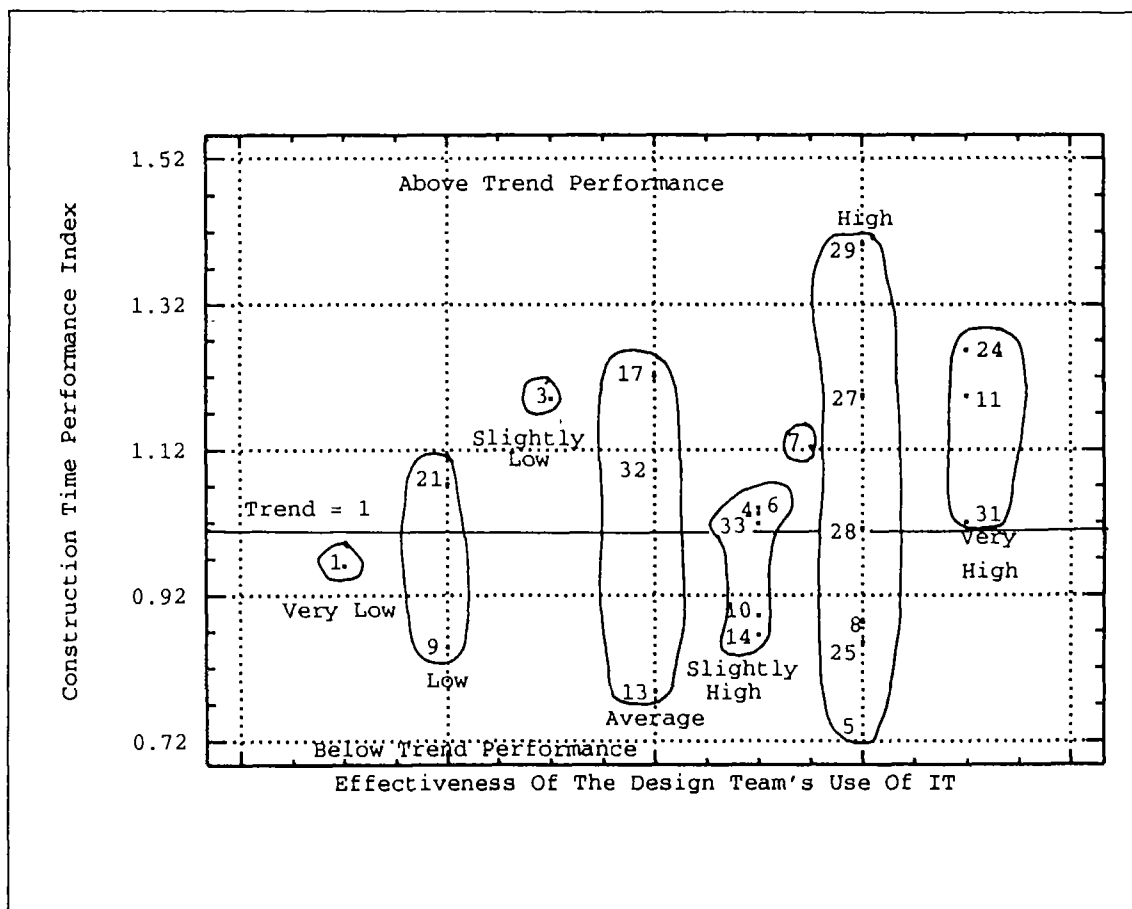
$H_0$  Construction time performance is **NOT** dependent upon the design team's effective use of information technologies.

$H_1$  Construction time performance **IS** dependent upon the design team's effective use of information technologies.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of **less than** 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
0.479	0.8341	<b><math>H_0</math> ACCEPTED</b>

**Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)**



**SUB-HYPOTHESIS NUMBER 98**

**DATA ITEM: DESIGN TEAM'S EFFECTIVE USE OF INFORMATION TECHNOLOGIES**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *key sub-contractor's task-oriented management style ( $C_s = 0.5246$ ; sig. = 0.0162).*

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *client organisation's experience with the building procurement process ( $C_s = 0.5011$ ; sig. = 0.0217);*
- ☐ *flexibility of key sub-contractor's management style ( $C_s = 0.5842$ ; sig. = 0.0074);*
- ☐ *key sub-contractor's people-oriented management style ( $C_s = 0.5329$ ; sig. = 0.0146).*



## SUB-HYPOTHESIS NUMBER 99

## QUESTIONNAIRE NUMBER Q16.6CM

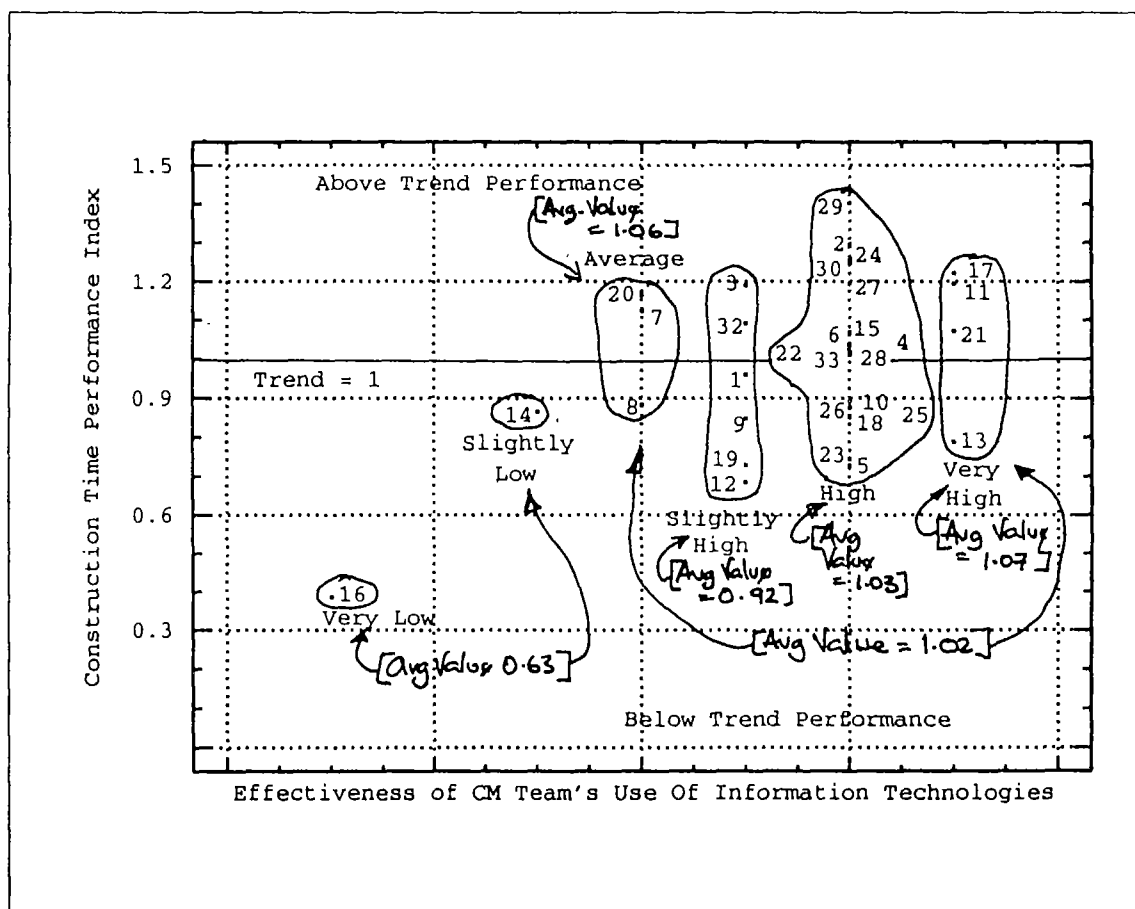
$H_0$  Construction time performance is **NOT** dependent upon the construction team's effective use of information technologies.

$H_1$  Construction time performance **IS** dependent upon the construction team's effective use of information technologies.

One-way ANOVA test results *measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.*

F-Ratio	Significance Level	Interpretation
2.646	0.0452	<b><math>H_0</math> REJECTED: <math>H_1</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*



**SUB-HYPOTHESIS NUMBER 99**

**DATA ITEM: CM'S EFFECTIVE USE OF INFORMATION TECHNOLOGIES**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ construction time estimate plus approved EOT being within 5% of actual construction time ( $C_s = 0.4461$ ; sig. = 0.0116);
- ☐ the construction team's confidence in the CR's contribution ( $C_s = 0.4660$ ; sig. = 0.0084);
- ☐ impact of CR/CM working relationship ( $C_s = 0.4509$ ; sig. = 0.0107);
- ☐ CM's forecasting planning data ( $C_s = 0.4544$ ; sig. = 0.0114);
- ☐ decision making communication within the CM team ( $C_s = 0.4838$ ; sig. = 0.0062).

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ CR's ability to quickly make authoritative decisions ( $C_s = 0.4602$ ; sig. = 0.0092);
- ☐ key sub-contractor's organisational structure to manage risk ( $C_s = 0.4815$ ; sig. = 0.0073);
- ☐ CR's effective use of information technologies ( $C_s = 0.7648$ ; sig. = 0.0022).

## SUB-HYPOTHESIS NUMBER 100

## QUESTIONNAIRE NUMBER Q17.1

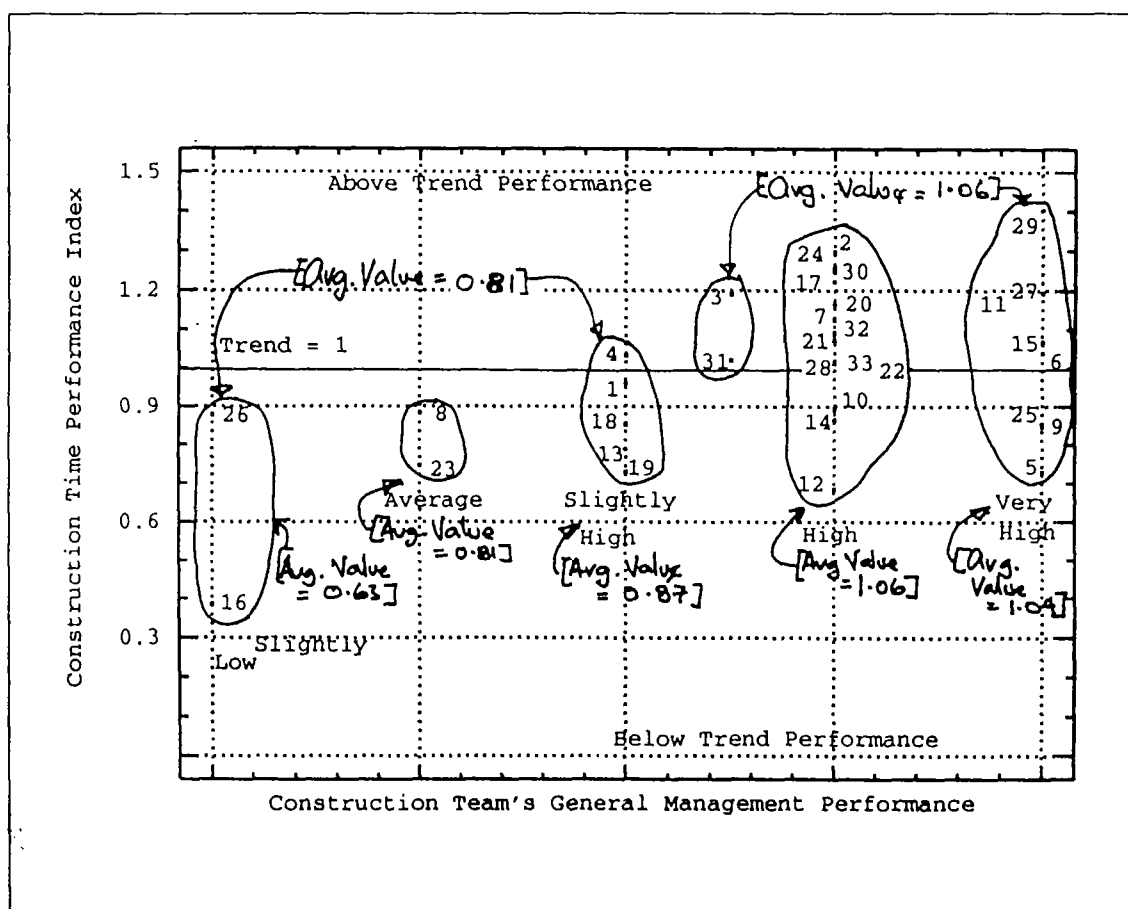
$H_0$  Construction time performance is NOT dependent upon the construction team's management performance.

$H_1$  Construction time performance IS dependent upon the construction team's management performance.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
3.017	0.0273	$H_0$ REJECTED: $H_1$ ACCEPTED

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 100**

**DATA ITEM: CM TEAM MANAGING THE CONSTRUCTION PROCESS**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ *client/CR's quality performance objective* ( $C_s = 0.6020$ ; sig. = 0.0007);
- ☐ *ability of the CR to contribute ideas to the design process* ( $C_s = 0.5729$ ; sig. = 0.0014);
- ☐ *the construction team's confidence in the CR's contribution* ( $C_s = 0.5560$ ; sig. = 0.0017);
- ☐ *CR's willingness to contribute effective and positive ideas* ( $C_s = 0.5653$ ; sig. = 0.0014);
- ☐ *impact of CR/CM working relationship* ( $C_s = 0.5939$ ; sig. = 0.0008);
- ☐ **CM's forecasting planning data** ( $C_s = 0.7968$ ; sig. = 0.0000);
- ☐ *CM's analysing construction methods* ( $C_s = 0.5870$ ; sig. = 0.0009);
- ☐ **effectiveness of the construction team's planning** ( $C_s = 0.7215$ ; sig. = 0.0000);
- ☐ *CM's monitoring and updating plans to reflect work status* ( $C_s = 0.6264$ ; sig. = 0.0004);
- ☐ *CM's planning - responding to problems or opportunities* ( $C_s = 0.6716$ ; sig. = 0.6716);
- ☐ *CM's effectively coordinating resources* ( $C_s = 0.6941$ ; sig. = 0.00001);
- ☐ **CM's developing an organisational structure to maintain workflow** ( $C_s = 0.7544$ ; sig. = 0.0000);
- ☐ **effectiveness of the construction team's monitoring and control** ( $C_s = 0.7525$ ; sig. = 0.0000);
- ☐ *CM's organisational structure to manage risk* ( $C_s = 0.6522$ ; sig. = 0.0002);
- ☐ *key sub-contractor's task-oriented management style* ( $C_s = 0.6755$ ; sig. = 0.0001);
- ☐ *CM's communication management to facilitate decision making* ( $C_s = 0.6266$ ; sig. = 0.0004);
- ☐ *CR and design team communication effectiveness for decision making* ( $C_s = 0.4897$ ; sig. = 0.0073);
- ☐ *CM decision making, communicating and actioning* ( $C_s = 0.6739$ ; sig. = 0.0001).

**SUB-HYPOTHESIS NUMBER 100**

**DATA ITEM: CM TEAM MANAGING THE CONSTRUCTION PROCESS**

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ ratio of EOT:actual construction time ( $C_s = -0.4941$ ; sig. = 0.0052);
- ☐ CR's experience with the building procurement process ( $C_s = 0.4948$ ; sig. = 0.0051);
- ☐ *stability of client/CR objectives* ( $C_s = 0.6808$ ; sig. = 0.0001);
- ☐ clarity of communication of client/CR objectives ( $C_s = 0.4866$ ; sig. = 0.0059);
- ☐ the CR's confidence in the construction team ( $C_s = 0.4645$ ; sig. = 0.0097);
- ☐ the CR's ability to mould shared project goals and aspirations ( $C_s = 0.4489$ ; sig. = 0.0124);
- ☐ CM's effectiveness in influencing the CR decision making process ( $C_s = 0.4849$ ; sig. = 0.0061);
- ☐ **CM management systems and procedures** ( $C_s = 0.7035$ ; sig. = 0.0001);
- ☐ CM's analysing resource movement ( $C_s = 0.4639$ ; sig. = 0.0098);
- ☐ *CM's analysing work sequencing to achieve and maintain workflow* ( $C_s = 0.6717$ ; sig. = 0.0001);
- ☐ *CR's organisational structure to manage risk* ( $C_s = 0.5196$ ; sig. = 0.0033);
- ☐ key sub-contractor's organisational structure to manage risk ( $C_s = 0.4603$ ; sig. = 0.0104);
- ☐ **CM's effectiveness in team management to achieve synergy** ( $C_s = 0.6984$ ; sig. = 0.0001);
- ☐ flexibility of the CR's management style ( $C_s = 0.4736$ ; sig. = 0.0074);
- ☐ *task-orientation of the CR's management style* ( $C_s = 0.5779$ ; sig. = 0.0013).
- ☐ task-orientation of the design team's management style ( $C_s = 0.4651$ ; sig. = 0.0123);
- ☐ *flexibility of the CM's management style* ( $C_s = 0.5733$ ; sig. = 0.0012);
- ☐ *task-orientation of the CM's management style* ( $C_s = 0.5505$ ; sig. = 0.0018);
- ☐ *CM's people-oriented management style* ( $C_s = 0.6109$ ; sig. = 0.0005);
- ☐ *key sub-contractor's people-oriented management style* ( $C_s = 0.5553$ ; sig. = 0.0017);
- ☐ *decision making communication within the CR team* ( $C_s = 0.6233$ ; sig. = 0.0010);
- ☐ *CR decision making, communicating and actioning* ( $C_s = 0.6300$ ; sig. = 0.0004).

## SUB-HYPOTHESIS NUMBER 101      QUESTIONNAIRE NUMBER Q15.5.3

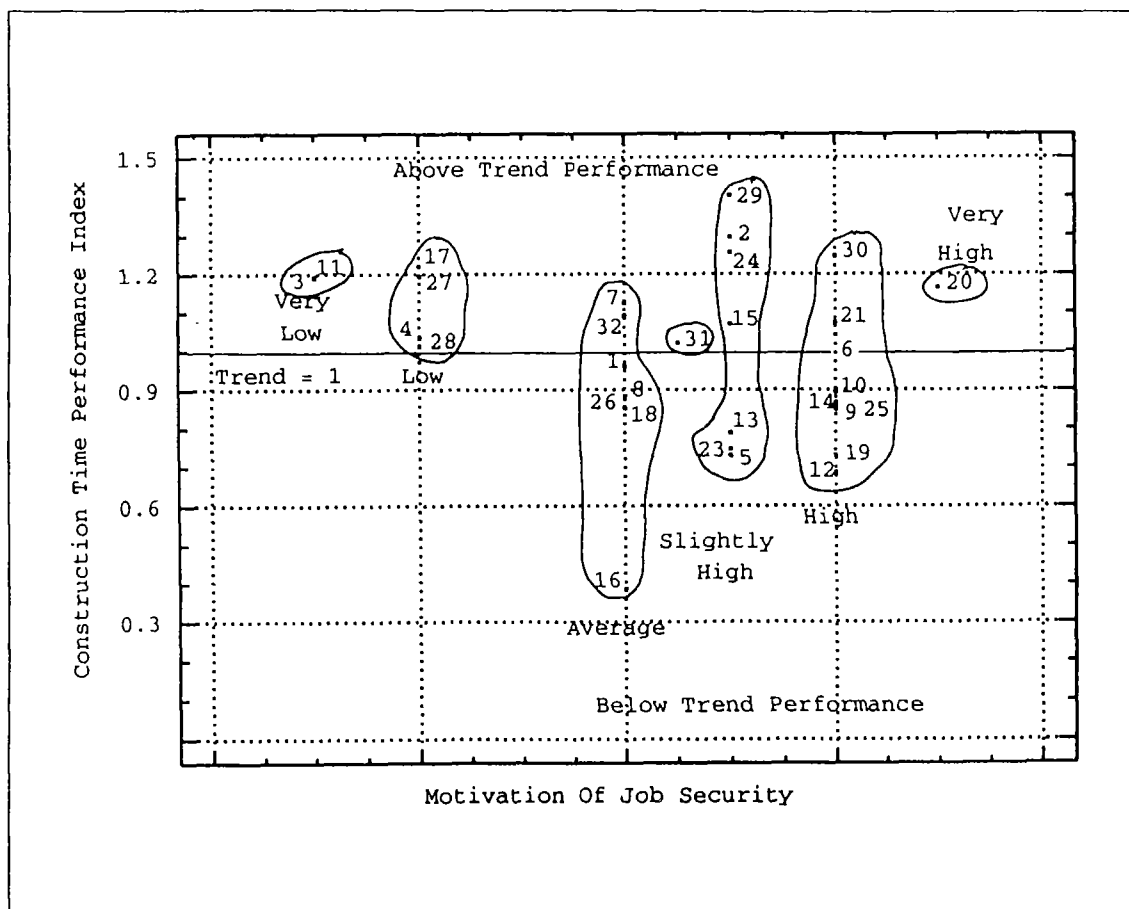
$H_0$  Construction time performance is NOT dependent upon the CM team's motivation from job security.

$H_1$  Construction time performance IS dependent upon the CM team's motivation from job security.

One-way ANOVA test results measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.

F-Ratio	Significance Level	Interpretation
1.437	0.2457	$H_0$ ACCEPTED

Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)



**SUB-HYPOTHESIS NUMBER 101**

**DATA ITEM: CM TEAM'S MOTIVATION FROM JOB SECURITY**

**Spearman Rank Correlation results for factors affecting CTP:**

☐ no significant correlation.

**Spearman Rank Correlation results for factors NOT affecting CTP:**

☐ *decision making communication within the CR team ( $C_s = 0.6809$ ; sig. = 0.0005).*

## SUB-HYPOTHESIS NUMBER 102

## QUESTIONNAIRE NUMBER Q15.5.9

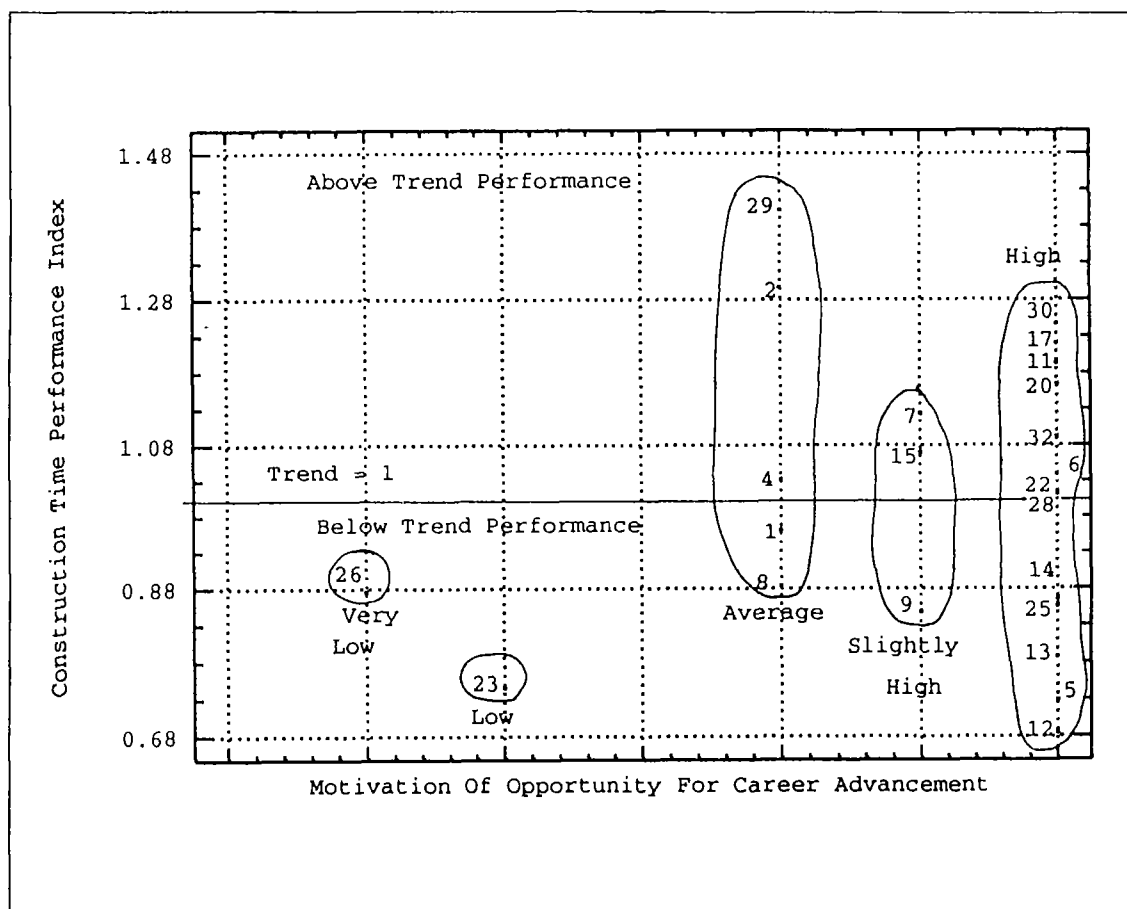
$H_0$  Construction time performance is **NOT** dependent upon the CM team's motivation from opportunity for career advancement.

$H_1$  Construction time performance **IS** dependent upon the CM team's motivation from opportunity for career advancement.

One-way ANOVA test results *measure variability among the different factors categorised in the dependent variable data set. F-ratio is the between group Mean Square divided by the within group Mean Square value. A significance level measure of less than 0.05 indicates that the variable differs significantly across the levels of the dependent classification variable. In this situation the  $H_0$  sub-hypothesis is rejected and the alternative sub-hypothesis,  $H_1$ , is accepted.*

F-Ratio	Significance Level	Interpretation
0.308	0.8698	<b><math>H_0</math> ACCEPTED</b>

*Graph of construction time performance (Y-Axis) and Tested Variable (X-Axis)*





**SUB-HYPOTHESIS NUMBER 102**  
**DATA ITEM: CM TEAM'S MOTIVATION**  
**FROM AN OPPORTUNITY FOR CAREER ADVANCEMENT**

**Spearman Rank Correlation results for factors affecting CTP:**

- ☐ no significant correlation.

**Spearman Rank Correlation results for factors NOT affecting CTP:**

- ☐ *project procurement method* ( $C_s = 0.6699$ ;  $\text{sig.} = 0.0002$ );
- ☐ CM's people-oriented management style ( $C_s = 0.4871$ ;  $\text{sig.} = 0.0076$ );
- ☐ *direct use of power in the CM's management style* ( $C_s = -0.6421$ ;  $\text{sig.} = 0.0004$ ).

**RESULTS FROM THE MOTIVATING TEAMS QUESTIONS**  
**CORRELATION BETWEEN CR MANAGEMENT STYLE & MOTIVATION/DEMOTIVATION**  
**DATA ITEM QUESTIONS 15.5.1 - 15.6.9**

**CR's mechanistic management style MOTIVATES due to:**

- ☐ CM's achievement from meeting complex challenges ( $C_s = 0.4874$ ; sig. = 0.0113);
- ☐ CR's job security ( $C_s = 0.5939$ ; sig. = 0.0053);

**CR's mechanistic management style DE-MOTIVATES due to:**

- ☐ CR being accountable for unclear/conflicting objectives ( $C_s = 0.4682$ ; sig. = 0.0470);
- ☐ CR's sense of isolation or marginalisation ( $C_s = -0.5281$ ; sig. = 0.0408).

**CR's flexible management style MOTIVATES due to:**

- ☐ CR's achievement from meeting complex challenges ( $C_s = 0.5022$ ; sig. = 0.0139);
- ☐ CM's recognition (money/kudos) of contribution made ( $C_s = 0.4665$ ; sig. = 0.0154).

**CR's flexible management style DE-MOTIVATES due to:**

- ☐ CM having to work to unreasonable time frames ( $C_s = -0.4466$ ; sig. = 0.0458);
- ☐ design team having insufficient authority to meet obligations ( $C_s = -0.6491$ ; sig. = 0.0193).

**CR's task-oriented management style MOTIVATES due to:**

- ☐ CR's achievement from meeting complex challenges ( $C_s = 0.5610$ ; sig. = 0.0060);
- ☐ CR's recognition (money/kudos) of contribution made ( $C_s = 0.5080$ ; sig. = 0.0128);
- ☐ CR's opportunity to extend skills and experience ( $C_s = 0.5607$ ; sig. = 0.0072);
- ☐ CM's achievement from meeting complex challenges ( $C_s = 0.4903$ ; sig. = 0.0124);
- ☐ CM's recognition (money/kudos) of contribution made ( $C_s = 0.4520$ ; sig. = 0.0212);

**CR's task-oriented management style DE-MOTIVATES due to:**

- ☐ CM's pay and conditions ( $C_s = -0.5187$ ; sig. = 0.0150);
- ☐ CR's pay and conditions ( $C_s = -0.6149$ ; sig. = 0.0172);
- ☐ CR's physical working conditions ( $C_s = -0.4966$ ; sig. = 0.0544);
- ☐ CR having to re-do work ( $C_s = -0.5657$ ; sig. = 0.0237);
- ☐ CR having to work to unreasonable time frames ( $C_s = -0.6373$ ; sig. = 0.0086);
- ☐ CM having to work to unreasonable time frames ( $C_s = -0.4771$ ; sig. = 0.0221);
- ☐ CR having insufficient authority to meet obligations ( $C_s = -0.6219$ ; sig. = 0.0083).

**CR's people-oriented management style MOTIVATES due to:**

- ☐ CR's achievement from meeting complex challenges ( $C_s = 0.6186$ ; sig. = 0.0024);
- ☐ CR's sense of belonging & identification with the team project team ( $C_s = 0.7670$ ; sig. = 0.0003);
- ☐ CR's opportunity to extend skills and experience ( $C_s = 0.5339$ ; sig. = 0.0104);
- ☐ CM's recognition (money/kudos) of contribution made ( $C_s = 0.7130$ ; sig. = 0.0003);

**RESULTS FROM THE MOTIVATING TEAMS QUESTIONS**  
**CORRELATION BETWEEN CR MANAGEMENT STYLE & MOTIVATION/DEMOTIVATION**  
**DATA ITEM QUESTIONS 15.5.1 - 15.6.9**

**CR's people-oriented management style DE-MOTIVATES due to:**

- ☐ *pay and conditions* ( $C_s = -0.5874$ ;  $sig. = 0.0229$ );
- ☐ **CM's pay and conditions** ( $C_s = -0.7080$ ;  $sig. = 0.0009$ );
- ☐ design team's being accountable for unclear/conflicting objectives ( $C_s = -0.4775$ ;  $sig. = 0.0740$ );
- ☐ *lack of recognition of CR's contribution made* ( $C_s = -0.5224$ ;  $sig. = 0.0267$ );
- ☐ *CM's having to work to unreasonable time frames* ( $C_s = -0.6705$ ;  $sig. = 0.0013$ );
- ☐ *CR having insufficient authority to meet obligations* ( $C_s = -0.6623$ ;  $sig. = 0.0050$ );
- ☐ design team's reaction to inter-team conflict ( $C_s = -0.4486$ ;  $sig. = 0.0644$ );

**CR's direct use of power management style MOTIVATES due to:**

- ☐ CM's a sense of belonging & identification with the project team ( $C_s = -0.4990$ ;  $sig. = 0.0145$ );
- ☐ **CR's a sense of belonging & identification with the project team** ( $C_s = -0.7141$ ;  $sig. = 0.0008$ );
- ☐ *design team's a sense of belonging & identification with the project team* ( $C_s = -0.6030$ ;  $sig. = 0.0086$ );
- ☐ CM's recognition (money/kudos) of contribution made ( $C_s = -0.4521$ ;  $sig. = 0.0211$ );
- ☐ *CR's opportunity to extend skills and experience* ( $C_s = -0.5009$ ;  $sig. = 0.0163$ );
- ☐ *design team's equitable rewards relative to other's input to the project* ( $C_s = -0.5795$ ;  $sig. = 0.0546$ );

**CR's direct use of power management style DE-MOTIVATES due to:**

- ☐ *CR's pay and conditions* ( $C_s = 0.5207$ ;  $sig. = 0.0437$ );
- ☐ *CM's pay and conditions* ( $C_s = 0.5989$ ;  $sig. = 0.0050$ );
- ☐ CR's sense of isolation or marginalisation ( $C_s = 0.4534$ ;  $sig. = 0.0426$ );
- ☐ *lack of recognition of design team's contribution made* ( $C_s = 0.6318$ ;  $sig. = 0.0227$ );
- ☐ *CM having to work to unreasonable time frames* ( $C_s = 0.5776$ ;  $sig. = 0.0056$ ).

**RESULTS FROM THE MOTIVATING TEAMS QUESTIONS**  
**CORRELATION BETWEEN CM MANAGEMENT STYLE & MOTIVATION/DEMOTIVATION**  
**DATA ITEM QUESTIONS 15.5.1 - 15.6.9**

**CM's mechanistic management style MOTIVATES due to:**

- ☐ no significant correlation.

**CM's mechanistic management style DE-MOTIVATES due to:**

- ☐ no significant correlation.

**CM's flexible management style MOTIVATES due to:**

- ☐ CR's achievement from meeting complex challenges ( $C_s = 0.6675$ ; sig. = 0.0011);
- ☐ CM's achievement from meeting complex challenges ( $C_s = 0.5283$ ; sig. = 0.0061);
- ☐ on-site workface's achievement from meeting complex challenges ( $C_s = 0.5791$ ; sig. = 0.0056);
- ☐ CR's a sense of belonging & identification with the project team ( $C_s = 0.4493$ ; sig. = 0.0351);
- ☐ CM's a sense of belonging & identification with the project team ( $C_s = 0.5586$ ; sig. = 0.0052);
- ☐ CM's opportunity to extend skills and experience ( $C_s = 0.5254$ ; sig. = 0.0074);
- ☐ on-site workforce's opportunity for career advancement ( $C_s = 0.5640$ ; sig. = 0.0057);

**CM's flexible management style DE-MOTIVATES due to:**

- ☐ CR's pay and conditions ( $C_s = -0.4935$ ; sig. = 0.0559);
- ☐ CR's physical working conditions ( $C_s = -0.4717$ ; sig. = 0.0677);
- ☐ lack of recognition of CR's contribution made ( $C_s = -0.4891$ ; sig. = 0.0380);
- ☐ CR's having to work to unreasonable time frames ( $C_s = -0.6262$ ; sig. = 0.0098);

**CM's task-oriented management style MOTIVATES due to:**

- ☐ on-site workforce's achievement from meeting complex challenges ( $C_s = 0.4958$ ; sig. = 0.0174);
- ☐ CR's a sense of belonging & identification with the project team ( $C_s = 0.4798$ ; sig. = 0.0244);
- ☐ CM's recognition (money/kudos) of contribution made ( $C_s = 0.4945$ ; sig. = 0.0102).

**CM's task-oriented management style DE-MOTIVATES due to:**

- ☐ CR's having insufficient authority to meet obligations ( $C_s = -0.7210$ ; sig. = 0.0022).

**RESULTS FROM THE MOTIVATING TEAMS QUESTIONS**  
**CORRELATION BETWEEN CM MANAGEMENT STYLE & MOTIVATION/DEMOTIVATION**  
**DATA ITEM QUESTIONS 15.5.1 - 15.6.9**

**CM's people-oriented management style MOTIVATES due to:**

- ☐ CR's achievement from meeting complex challenges ( $C_s = 0.6365$ ; sig. = 0.0018);
- ☐ CM's achievement from meeting complex challenges ( $C_s = 0.5950$ ; sig. = 0.0020);
- ☐ on-site workforce's achievement from meeting complex challenges ( $C_s = 0.4849$ ; sig. = 0.0200);
- ☐ CM's a sense of belonging & identification with the project team ( $C_s = 0.5605$ ; sig. = 0.0051);
- ☐ CM's recognition (money/kudos) of contribution made ( $C_s = 0.4778$ ; sig. = 0.0130);
- ☐ CM's opportunity to extend skills and experience ( $C_s = 0.5012$ ; sig. = 0.0106);
- ☐ CM's opportunity for career advancement ( $C_s = 0.4871$ ; sig. = 0.0076);
- ☐ CR's opportunity for career advancement ( $C_s = 0.4634$ ; sig. = 0.0263).

**CM's people-oriented management style DE-MOTIVATES due to:**

- ☐ no significant correlation.

**RESULTS FROM THE MOTIVATING TEAMS QUESTIONS**  
**CORRELATION BETWEEN CM MANAGEMENT STYLE & MOTIVATION/DEMOTIVATION**  
**DATA ITEM QUESTIONS 15.5.1 - 15.6.9**

**CM's direct use of power management style MOTIVATES due to:**

- ☐ CM's achievement from meeting complex challenges ( $C_s = -0.4567$ ; sig. = 0.0176);
- ☐ on-site workforce's achievement from meeting complex challenges ( $C_s = -0.5764$ ; sig. = 0.0057);
- ☐ CR's a sense of belonging & identification with the project team ( $C_s = -0.5433$ ; sig. = 0.0108);
- ☐ CM's a sense of belonging & identification with the project team ( $C_s = -0.5068$ ; sig. = 0.0113);
- ☐ on-site workforce's a sense of belonging & identification with the project team ( $C_s = -0.7654$ ; sig. = 0.0002);
- ☐ CR's recognition (money/kudos) of contribution made ( $C_s = -0.4557$ ; sig. = 0.0256);
- ☐ CM's recognition (money/kudos) of contribution made ( $C_s = -0.5621$ ; sig. = 0.0035);
- ☐ on-site workforce's recognition (money/kudos) of contribution made ( $C_s = -0.4920$ ; sig. = 0.0139);
- ☐ CR's opportunity to extend skills and experience ( $C_s = -0.7556$ ; sig. = 0.0003);
- ☐ CM's opportunity to extend skills and experience ( $C_s = -0.6740$ ; sig. = 0.0006);
- ☐ CM's opportunity for career advancement ( $C_s = -0.6421$ ; sig. = 0.0004).

**CM's direct use of power management style DE-MOTIVATES due to:**

- ☐ CM's having to work to unreasonable time frames ( $C_s = 0.4656$ ; sig. = 0.0226);
- ☐ on-site workforce's having insufficient authority to meet contractual/ethical obligations ( $C_s = 0.4495$ ; sig. = 0.0445).

**RESULTS FROM THE MOTIVATING TEAMS QUESTIONS  
CORRELATION BETWEEN DESIGN TEAM'S MANAGEMENT STYLE  
& MOTIVATION/DEMOTIVATION  
DATA ITEM QUESTIONS 15.5.1 - 15.6.9**

**Design team's mechanistic management style MOTIVATES due to:**

- ☐ *design team's equitable rewards relative to other's input to the project ( $C_s = 0.5673$ ; sig. = 0.0599).*

**Design team's mechanistic management style DE-MOTIVATES due to:**

- ☐ *design team's physical working conditions ( $C_s = 0.4999$ ; sig. = 0.0715);*
- ☐ *design team's having to re-do work ( $C_s = -0.4745$ ; sig. = 0.0661).*

**Design team's flexible management style MOTIVATES due to:**

- ☐ *design team's pay and allowances ( $C_s = 0.4504$ ; sig. = 0.0716);*

**Design team's flexible management style DE-MOTIVATES due to:**

- ☐ *no significant correlation.*

**Design team's task-oriented management style MOTIVATES due to:**

- ☐ *design team's pay and conditions ( $C_s = 0.5571$ ; sig. = 0.0536);*
- ☐ *design team's having insufficient authority to meet contractual/ethical obligations ( $C_s = -0.7221$ ; sig. = 0.0092).*

**Design team's task-oriented management style DE-MOTIVATES due to:**

- ☐ *no significant correlation.*

**Design team's people-oriented management style MOTIVATES due to:**

- ☐ *design team's a sense of belonging & identification with the project team ( $C_s = 0.6072$ ; sig. = 0.0100);*
- ☐ *design team's exercise of power ( $C_s = 0.6444$ ; sig. = 0.0079).*

**Design team's people-oriented management style DE-MOTIVATES due to:**

- ☐ *design team's sense of isolation or marginalisation ( $C_s = -0.4983$ ; sig. = 0.0623).*

**Design team's direct use of power management style MOTIVATES due to:**

- ☐ *design team's a sense of belonging & identification with the project team ( $C_s = -0.6799$ ; sig. = 0.0051).*

**RESULTS FROM THE MOTIVATING TEAMS QUESTIONS  
CORRELATION BETWEEN DESIGN TEAM'S MANAGEMENT STYLE  
& MOTIVATION/DEMOTIVATION  
DATA ITEM QUESTIONS 15.5.1 - 15.6.9**

**Design team's direct use of power management style MOTIVATES due to:**

- ☐ no significant correlation.

**Design team's direct use of power management style DE-MOTIVATES due to:**

- ☐ *design team's pay and conditions ( $C_s = 0.6460$ ; sig. = 0.0314);*
- ☐ *design team's physical working conditions ( $C_s = 0.5152$ ; sig. = 0.1033);*
- ☐ **lack of recognition of design team's contribution made ( $C_s = 0.7645$ ; sig. = 0.0112);**
- ☐ **design team's having insufficient authority to meet contractual/ethical obligations ( $C_s = 0.7379$ ; sig. = 0.0144);**
- ☐ *design team's reaction to inter-team conflict ( $C_s = 0.6688$ ; sig. = 0.0096).*



**RESULTS FROM THE MOTIVATING TEAMS QUESTIONS  
CORRELATION BETWEEN KEY SUB-CONTRACTOR'S MANAGEMENT STYLE  
& MOTIVATION/DEMOTIVATION  
DATA ITEM QUESTIONS 15.5.1 - 15.6.9**

**On-site workforce's mechanistic management style MOTIVATES due to:**

- ☐ key sub-contractor's opportunity for career advancement ( $C_s = -0.4842$ ; sig. = 0.0177);

**On-site workforce's mechanistic management style DE-MOTIVATES due to:**

- ☐ no significant correlation.

**On-site workforce's flexible management style MOTIVATES due to:**

- ☐ no significant correlation.

**On-site workforce's flexible management style DE-MOTIVATES due to:**

- ☐ no significant correlation.

**On-site workforce's task-oriented management style MOTIVATES due to:**

- ☐ key sub-contractor's achievement from meeting complex challenges ( $C_s = 0.6536$ ; sig. = 0.0017).

**On-site workforce's task-oriented management style DE-MOTIVATES due to:**

- ☐ no significant correlation.

**On-site workforce's people-oriented management style MOTIVATES due to:**

- ☐ no significant correlation.

**On-site workforce's people-oriented management style DE-MOTIVATES due to:**

- ☐ no significant correlation.

**On-site workforce's direct use of power management style MOTIVATES due to:**

- ☐ key sub-contractor's achievement from meeting complex challenges ( $C_s = -0.4851$ ; sig. = 0.0200).

**On-site workforce's direct use of power management style DE-MOTIVATES due to:**

- ☐ no significant correlation.

## APPENDIX 3

### DATA FOR HYPOTHESIS TESTING

**Data from the following files are presented:**

- PHDCHAR* - contains mainly general data about project characteristics;
- PHDCLCR* - contains mainly data about the client and client representative;
- PHDCMGT* - contains mainly data about the construction management team;
- PHDESIGN* - contains mainly data about the design team;
- PHDKEYSC* - contains mainly data about key sub-contractors;
- MOTIV* - contains data about motivation factors;
- DEMOTIV* - contains data about de-motivation factors;

*Appendix 3 Data For Hypothesis Testing*

COLUMN ->	1	2	3	4	5	6	7
	MODEL						
Hypothesis							
Question	q1.1	q1.3	q1.11	q1.12a	q1.12b	q1.12c	q1.12d
casechar	endval	wdact	wdest	eotscope	eotweather	eotir	eotother
1	6818.337	273	180	83	10	-32768	-32768
2	9241.870	184	208	-32768	-32768	-32768	-32768
3	22563.08	353	234	42	98	-32768	-32768
4	17348.89	327	254	-32768	59	2	-32768
5	6891.564	325	325	-32768	-32768	-32768	-32768
6	7349.144	153	124	-32768	-32768	-32768	25
7	9632.640	134	107	24	-32768	-32768	3
8	14163.20	430	325	65	17	15	8
9	8647.310	261	261	-32768	-32768	-32768	-32768
10	21501.03	369	342	-32768	45	-32768	-32768
11	6341.075	360	298	28	32	2	-32768
12	15743.58	381	381	-32768	-32768	6.5	2.5
13	5951.711	267	218	13	40	3	4
14	4260.138	145	142	1	-32768	-32768	-32768
15	5827.762	253	230	-32768	27	-32768	10
16	11148.80	425	251	71	56	21	23
17	6184.474	246	238	30	100	-32768	-32768
18	12531.47	393	275	68	-32768	4	13
19	8407.334	548	307	96	25	119	-32768
20	11064.16	369	266	77	22	2	-32768
21	7226.415	331	352	-32768	3	3	-32768
22	13232.31	322	188	115	-32768	-32768	15
23	6691.931	382	300	19	49	-32768	15
24	18594.13	364	389	-32768	47	2	-32768
25	4084.889	90	81	10	-32768	-32768	-32768
26	7144.911	415	270	123	19	22	14
27	39901.51	414	435	-32768	13	20	-32768
28	15486.33	247	256	-32768	-32768	-32768	-32768
29	42053.78	337	337	-32768	-32768	-32768	-32768
30	37336.43	552	345	212	-32768	1	-32768
31	27501.34	326	278	24	24	-32768	-32768
32	24890.95	284	284	-32768	-32768	1	-32768
33	12934.16	279	276	-32768	-32768	2	-32768

FILE PHDCHAR      casechar = case number from 1 to 33

General notes:    Row 1 indicates if the variable is calculated. Row 2 contains a column reference. Row 3 indicates if the variable is used in the CTP index model and if so the whole column is shaded. Row 4 contains the reference to the hypothesis tested for the variable in the form HY-X. Row 5 indicates the source of the data i.e. the question in Appendix 1. Row 6 indicates the variable name. Where columns have been calculated the word 'column' appears in row 4 and the calculation is indicated e.g. (3)+(8) for columns 3 plus 8. *Blank values have been filled with the vale -32768 when transferred from STATGRAPHICS to the spreadsheet presented above.*

*Appendix 3 Data For Hypothesis Testing*

	CALC				CALC					
8	9	10	11	12	13	14	15			
				MODEL						
	columns		HY-9	columns	HY-38	HY-39	HY-40			
q1.12	(3)+(8)	q1.2	q1.11	(8)/(2)	q3.1	q4.1	q5.1			
eotttotal	adjust	gfa	adjust_act	eot_act	q3_1	q4_1	q5_1			
93	273	7208	1	0.340659	3	2	2			
0	208	6850	1.13043478	0	3	6	3			
140	374	16000	1.05949008	0.396600	3	2	3			
61	315	10000	0.96330275	0.186544	4	4	5			
0	325	400	1	0	4	2	2			
25	149	20000	0.97385620	0.163398	4	3	3			
27	134	6500	1	0.201492	3	2	2			
105	430	-32768	1	0.244186	4	4	3			
0	261	7800	1	0	7	3	5			
45	387	15600	1.04878048	0.121951	3	5	5			
62	360	3000	1	0.172222	5	1	1			
9	390	56000	1.02362204	0.023622	2	5	2			
60	278	5024	1.04119850	0.224719	2	6	3			
1	143	3367	0.98620689	0.006896	4	6	2			
37	267	5776	1.05533596	0.146245	2	3	4			
171	422	-32768	0.99294117	0.402352	2	3	4			
130	368	3650	1.49593495	0.528455	1	2	2			
85	360	5300	0.91603053	0.216284	2	2	5			
240	547	6240	0.99817518	0.437956	4	3	3			
101	367	8300	0.99457994	0.273712	6	3	4			
6	358	6000	1.08157099	0.018126	3	2	3			
130	318	-32768	0.98757764	0.403726	1	4	2			
83	383	5000	1.00261780	0.217277	4	6	5.5			
49	438	9000	1.20329670	0.134615	2	6.5	5			
10	91	-32768	1.01111111	0.111111	6	6	5			
178	448	4062	1.07951807	0.428915	2	2	2			
33	468	36701	1.13043478	0.079710	3	6	6			
0	256	23600	1.03643724	0	2	6	6			
0	337	14500	1	0	5	4	3			
213	558	-32768	1.01086956	0.385869	1	1	3			
48	326	-32768	1	0.147239	2	6	3			
1	285	16200	1.00352112	0.003521	3	3	3			
2	278	9500	0.99641577	0.007168	6	2	2			

FILE PHDCHAR

Notes:

Appendix 3 Data For Hypothesis Testing

16	17	18	19	20	21	22	23
HY-41	HY-42	HY-43	HY-44	HY45	HY-46	HY-47	HY48
q6.1	q7.1	q7.3	q8.1	q9.1	q10.1	q11.1	q11.3
q6_1	q7_1	q7_3	q8_1	q9_1	q10_1	q11_1	q11_3
4	3	2	4	3	4	3	3
4	6	3	4	4	4	4	3
6	3	2.5	3.5	3	3.5	4	3
4	5	5	4	5	4	4	4.5
5	2	1	4	2	3	4	3
6	1	2	3	3	4	2	2
-32768	5	2	4	3	3	3	3
4	6	5	3	3	3	5	4
6	7	6	4	7	6	7	7
6	6	5	4	2	5	1	2
1	7	1	2	6	7	7	7
5	2	2	4	6	4	6	6
6	2	3	4	3	4	6	6
4	6	3	4	5	4	5	5
5	6	6	6	6	4	6	6
2	2	3	4	3.5	3	3	3
3	3	2	2	3	4	3	3
3	2	2	4	5	5	5	5
3	4	3	4	3	4	1	2
3	4	3	4	6	6	2	2
4	2	3	4	4	4	6	4
7	2	1	4	4	4	6	5
6	5.5	6	4	4.5	4	5	4
6	3	5	4	4	7	4	4.5
6	6	6	6	6	6	6	6
4	3	2	4	3	5	3	4
6	1.5	3	5	6	4	6	5
6	2	2	5	3	4	4	4
5	5	5	4	6	5	3	4
6	1	1	4	5	4	7	5
4	4	4	2	4	3	4	4
4	4	3	5	6	3	3	4
4	6	3	4	6	5	5	6

FILE PHDCHAR

Notes:

*Appendix 3 Data For Hypothesis Testing*

CALC.	CALC.					
24	25	26	27	28	29	30
		Note 1	Note 2	Note 2	Note 2	
columns	columns					HY-2
(40)-(2)	(40)/(2)					q1.3
wdactvarnc	wdpred_act	phdchaflag	verntime	bromtime	valjun87	floor_bsmt
-10.8173	0.96037619	4	339.4423	328.0452	2.540622	0
54.487609	1.29612830	6	391.6014	359.3835	3.443670	0
67.039697	1.18991415	6	595.7092	469.7315	8.407367	2
10.581697	1.03235993	4	526.4971	434.1226	6.464515	0
-87.986738	0.72927157	2	341.1508	329.0982	2.567908	0
6.091061	1.03981085	4	351.6157	335.5067	2.738409	0
16.56466	1.12361686	6	399.2982	363.8763	3.589277	0
-50.109056	0.88346731	3	478.6113	408.4873	5.277437	1
-39.49323	0.84868494	2	379.5519	352.2852	3.222127	1
-39.698035	0.89241724	3	582.3620	462.9861	8.011634	2
69.527929	1.19313313	6	328.0603	320.9808	2.362787	1
-119.980099	0.68509160	2	503.0090	421.6588	5.866312	5
-56.671376	0.78774765	2	318.4335	314.9363	2.217703	3
-19.460398	0.86579036	3	272.1236	284.8769	1.587396	0
17.71702	1.07002774	5	315.2992	312.9541	2.171518	0
-260.794168	0.38636666	1	427.6952	380.1882	4.154225	0
54.39245	1.22110752	6	324.2271	318.5818	2.304434	0
-58.36298	0.85149369	3	451.8540	393.7593	4.669431	1
-148.361789	0.72926680	2	374.5644	349.3234	3.132708	0
60.655323	1.16437756	6	426.1660	379.3200	4.122686	1
23.973078	1.07242621	5	348.8436	333.8159	2.692678	0
4.085636	1.01268831	4	463.5600	400.2404	4.930575	0
-97.018689	0.74602437	2	336.4699	326.2087	2.493521	1
93.563321	1.25704209	6	543.9309	443.2440	6.928473	1
-12.968145	0.85590950	3	266.8037	281.3094	1.522095	0
-51.46505	0.87598783	3	346.9889	332.6819	2.662309	0
80.18601	1.19368601	6	778.7572	557.3487	14.86794	2
2.881097	1.01166435	4	499.1291	419.5799	5.770458	0
135.745379	1.40280527	7	798.2253	566.2024	15.66992	1
136.445645	1.24718414	6	754.8132	546.3488	13.91215	0
6.698527	1.02054762	4	653.7827	498.4669	10.24744	2
25.994972	1.09153159	5	623.8448	483.7741	9.274770	0
5.146975	1.01844794	4	458.6212	397.5133	4.819479	0

**FILE PHDCHAR**

NOTE 1: *phdchaflag* (CTP index value range) values - [1] < 0.6; [2] 0.6 to 0.849; [3] 0.85 to 0.949; [4] 0.95 to 1.049; [5] 1.05 to 1.149; [6] 1.15 to 1.39; [7] 1.40 and greater.

NOTE 2: *Verntime* is the number of workdays predicted using the data and Ireland's model (see chapter 2 section 2.8.2). *Bromtime* is the number of workdays predicted using the data and Bromilow's model (see chapter 2 section 2.8.3). *Valjun87* is the indexed conversion of endval (column 1 to June 1987 dollars using the AIQS construction cost index).

Appendix 3 Data For Hypothesis Testing

	31	32	33	34	35	36	37
	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3
HY-3							
q1.4							
floor_max	pred_tm_c1	pred_tm_c2	pred_tm_c3	pred_tm_c4	pred_tm_c5	pred_tm_c6	
3	70.00458	0.40469512	0	0.630582	-0.4760222	0.239511	
3	81.0394404	0	0	0.525485	-0.5511836	0.479022	
6	124.527287	0.47115195	0	0.420388	-0.6764526	0.479022	
4	109.733011	0.22161020	0	0.630582	-0.7015064	0.399185	
1	70.3654304	0	0	0.735679	-0.626345	0.479022	
11	72.5765903	0.19411372	-0.488867	0.630582	-0.5762374	0.399185	
2	82.6709137	0.23936829	-0.488867	0.630582	-0.4384415	0.239511	
2	99.5242956	0.29008716	0	0.630582	-0.4509684	0.45240966	
2	78.4869097	0	0	0.735679	-0.7265602	0.558859	
14	121.670905	0.14487512	0	0.525485	-0.7265602	0.42579733	
1	67.6017925	0.20459586	0	0.735679	-0.3006456	0.479022	
39	104.722681	0.02806242	0	0.630582	-0.626345	0.3592665	
1	65.5711023	0.26696089	0	0.420388	-0.6513988	0.399185	
1	55.8238572	0.00819293	0	0.420388	-0.250538	0.319348	
2	64.9102762	0.17373562	0	0.735679	-0.626345	0.5189405	
6	88.6965575	0.47798563	0	0.315291	-0.601068	0.319348	
2	66.7930516	0.62779219	0	0.735679	-0.7766678	0.18628633	
6	93.8304799	0.25694137	0	0.630582	-0.6012912	0.3592665	
3	77.4309373	0.52028145	0	0.630582	-0.3507532	0.319348	
4	88.3718209	0.32516416	0	0.735679	-0.375807	0.479022	
3	71.990707	0.02153430	0	0.735679	-0.4509684	0.558859	
33	96.3204827	0.47961764	0	0.630582	-0.6764526	0.159674	
3	69.3769141	0.25812044	0	0.630582	-0.501076	0.399185	
4	113.455357	0.15991984	0	0.630582	-0.501076	0.479022	
17	54.7065644	0.13199733	-0.488867	0.630582	-0.876883	0.319348	
4	71.5987723	0.50954151	0	0.420388	-0.250538	0.319348	
11	163.843261	0.09469373	0	0.735679	-0.751614	0.399185	
20	103.895597	0	0	0.630582	-0.751614	0.37257266	
1	168.038838	0	0	0.735679	-0.7265602	0.399185	
3	158.686536	0.45840378	0	0.630582	-0.7265602	0.479022	
2	136.972824	0.17491671	0	0.525485	-0.626345	0.239511	
2	130.553468	0.00418301	0	0.420388	-0.4008608	0.319348	
3	95.2697619	0.00851595	0	0.630582	-0.6513988	0.479022	

FILE PHDCHAR

NOTE 3: *pred\_tm\_c1* is the predicted time for coefficient 1 based on the CTP prediction model (see chapter 2 page 33). The next six variables *pred\_tm\_c2* to *pred\_tm\_c7* are calculated from the prediction model coefficients from that model multiplied by the relevant data variables. The value *pred\_c2\_7* is the sum of columns 32 to 38. The variable *pred\_time* is derived from the model described (chapter 2 page 33)

NOTE 4: This variable is coded for building end-use as follows - [1] education, [2] office, [3] retail, [4] hospital, [5] industrial, [6] hotel, [7] transport, [8] entertainment.

38	39	40	41	42	43	44
Note 3	Note 3	Note 3	Note 4	Note 5	Note 6	Note 7
sum columns			HY-4	HY-5	HY-6	HY-7
(32)to(38)			q1.6	q1.6	q1.7.1	q1.7.2
pred_tm_c7	pred_c2_7	pred_time	bldgtypnum	worktypnum	contypenum	desndegnum
0.521715	1.32048092	262.18270	5	4	1	3
0.626058	1.0793814	238.48760	2	2	1	5
0.521715	1.21582435	420.03969	6	2	2	1
0.5738865	1.12375730	337.58169	1	2	1	4
0.626058	1.214414	237.01326	5	3	2	2
0.626058	0.78483432	159.09106	2	1	1	4
0.417372	0.59952479	150.56466	2	1	1	4
0.417372	1.33948243	379.89094	1	2	1	2
0.4695435	1.0375213	221.50677	2	2	3	4
0.626058	0.99565525	329.30196	2	2	1	4
0.730401	1.84905226	429.52792	5	2	2	4
0.521715	0.91328092	261.01990	2	3	1	4
0.730401	1.16553609	210.32862	4	4	3	3
0.313029	0.81041993	125.53960	3	4	1	4
0.626058	1.42806812	270.71702	2	2	1	4
0.104343	0.61589963	164.20583	2	2	1	4
0.730401	1.50349072	300.39244	5	2	2	4
0.626058	1.27155667	334.63702	1	2	1	4
0.521715	1.64117325	399.63821	1	2	1	4
0.417372	1.58143016	429.65532	1	2	1	4
0.730401	1.59550490	354.97307	1	2	1	4
0.626058	1.21947904	326.08563	6	3	1	4
0.626058	1.41286944	284.98131	1	2	1	4
0.626058	1.39450584	457.56332	8	2	1	5
0.626058	0.34223533	77.031855	2	1	1	4
0.626058	1.62479751	363.53495	1	2	1	4
0.626058	1.10400173	494.18601	2	3	4	4
0.626058	0.87759866	249.88109	2	3	4	4
0.626058	1.0343618	472.74537	3	2	2	3
0.626058	1.46750558	688.44564	7	4	2	4
0.5738865	0.88745421	332.69852	2	4	4	2
0.521715	0.86477321	309.99497	5	2	2	2
0.626058	1.09277915	284.14697	1	2	1	3

## FILE PHDCHAR

NOTE 5: This variable is codes for type of work undertaken as follows - [1] fit-out work, [2] new work, [3] refurbishment, [4] mixture of 1-3.

NOTE 6: This variable is coded for contract procurement method as follows - [1] traditional contract, [2] construction management, [3] project and construction management, [4] design and construct.

NOTE 7: This variable is coded for stage of design development at construction start as follows - [1] some (under 25%), little (25% to 50%), [2] much (50% to 75%), [3] most (more than 75%), [4] re-designed.



45	46	47	48	49	50	51
Note 8	Note 9	Note 10	Note 11			Note 12
HY-11	HY-12			HY-8	HY-1	
q2.2	q2.2			q1.9-10	q1.1	
clientnum	cltsizeum	pred_area	surv87pred	wdcat	costcat	adjustRK
1	2	174.76026	186.278424	2	1	2
3	3	169.66118	223.036666	1	2	3
1	1	147.07976	378.374147	3	4	3
2	3	171.38560	323.848136	3	3	2
1	3	43.491410	187.460516	3	1	2
1	3	65.427250	194.73426	1	1	2
1	3	202.64706	228.573881	1	2	2
2	3	-32768	287.186641	4	3	2
1	2	226.27859	214.424939	2	2	2
1	3	37.165400	367.724177	3	4	2
1	2	154.66474	178.443287	3	1	2
1	3	4.5129496	305.752086	3	3	2
1	3	213.98792	171.871257	2	1	2
1	1	166.32245	140.997176	1	1	2
2	3	188.67447	169.742613	2	1	3
1	3	-32768	249.240684	4	2	2
1	3	142.92877	175.820388	2	1	4
2	3	83.206207	267.107055	3	2	1
2	3	160.70798	210.881005	5	2	2
2	3	154.44717	248.11843	3	2	2
2	3	157.08562	192.801923	3	1	3
1	-32768	-32768	275.854648	3	2	2
2	3	141.28971	184.225628	3	1	2
1	1	161.59170	337.416602	3	3	4
3	3	-32768	137.533152	1	1	2
2	3	103.62346	191.511279	4	1	3
3	3	84.540043	530.317154	4	5	3
3	3	19.420051	302.783749	2	3	2
1	2	417.09177	547.074311	3	5	2
2	3	-32768	509.856395	5	5	2
1	1	-32768	425.423172	3	4	2
1	3	352.10874	401.026566	2	4	2
2	3	205.18349	272.156943	2	2	2

## FILE PHDCHAR

- NOTE 8: This variable is coded for client type as follows - [1] private, [2] government, [3] private consultant (acting on behalf of a government department).
- NOTE 9: This variable is coded for client company size as follows - [1] small, [2] medium, [3] large.
- NOTE 10: The variable *pred\_area*, predicted construction duration, is calculated in workdays from the GFA model (described in chapter 2 page 28).
- NOTE 11: The variable *surv87pred* is the predicted construction time based on regression model based on pilot study data (described in chapter 2 page 30).
- NOTE 12: The variable *adjustRK* is derived from the variable *adjust\_act* (column 11) where values are -[1] 0.9 to 0.95; [2] 0.95 to 1.05; [3] 1.05 to 1.15; and [4] over 1.15.

Appendix 3 Data For Hypothesis Testing

COLUMN	1	2	3	4	5	6	7
	MODEL						MODEL
Hypothesis	see NOTE 5	HY-12	HY-14	HY-15	HY-16	HY-17	HY-18
Question	q1.6	q2.3.1	q2.3.2	q2.3.3	q2.4.1	q2.4.2	q2.4.3
case/cr	work_type	org_exp	cr_exp	cr_confid	obj_cost	obj_time	obj_qual
1	mixed	5	3	1	5	6	6
2	new	4	6	7	6	5	5
3	new	6	5	5.5	4	6	4
4	new	3	6	4	7	2	6
5	refrb	4	4	5	3	6	7
6	lit	3	6	6	7	7	6
7	lit	7	4	-32768	6	6	6
8	new	7	6	4	7	5	6
9	new	1	7	7	7	4	7
10	new	7	7	7	5	7	5
11	new	7	7	6	2	4	7
12	refrb	6	7	6	6	2	6
13	mixed	6	6.5	7	6	7	4
14	mixed	6	7	6	6	7	4
15	new	7	7	7	6	6	7
16	new	7	6	6	6	5	3
17	new	6	6	6	5	7	7
18	new	7	6	6	6	5	6
19	new	7	6	6	6	5	6
20	new	6	7	7	7	7	7
21	new	7	6	5	6	6	7
22	refrb	6	6	6	7	7	6
23	new	7	6	6	3.5	5	6
24	new	6	6	6	6	7	6
25	lit	7	7	6	5	7	6
26	new	6	2	4	6	4	4
27	refrb	7	7	7	6	7	7
28	refrb	7	7	7	6	7	6
29	new	7	7	7	5.5	6.5	7
30	mixed	6	6	6	6	6	6
31	mixed	7	3	6	6	6	5
32	new	1	1	6	5	7	4
33	new	7	7	4	7	6	6

FILE PHDCLCR

Appendix 3 Data For Hypothesis Testing

8	9	10	11	12	13	14	15
HY-19	HY-20	HY-21	HY-22	HY-23	HY-24	HY-25	HY-26
q2.4.4	q2.4.5	q2.4.6	q2.5.1	q2.5.2	q2.6.1	q2.6.2	q2.6.3
obj_stab	obj_clar	obj_cred	cr_influ	cr_complex	q2_61	q2_62	q2_63
3	4	1	6	2	4	5	4
6	6	5	4	5	6	6	6
3	6	6	2	2	6	3	5
6	6	6	4	4	7	3	5
6	6	6	3	2	3	3	2
6	7	3	6	5	6	3	3
7	6	5	5	3	2	5	2
2	1	4	6	2	4	1	2
7	7	7	7	6	7	7	7
7	7	5	6	5	5	7	6
7	4	1	4	1	6	6	4
6	4	7	6	2	6	2	4
6	6	6	1	6	6	7	4
7	7	3	6	6	7	6	7
7	6	7	7	5	7	6	7
2	2	6	4	4	6	3	5
6	7	4	7	6	7	7	6
5	6	6	5	5	6	6	6
6	6	6	4	4	6	4	5
6	3	6	1	2	4	4	4
7	7	6	1	7	2	6	1
7	7	6	6	6	6	6	6
5	5	5	2	4	6	6	-32768
6	6	7	6	6	6	7	6
6	7	6	7	6	6.5	7	7
4	3	2	6	2	2	1	2
7	6	6	7	7	7	6	6
7	7	6	7	7	7	6	6
7	7	7	7	6	7	7	6
6	2	5	4	3	7	2	4
6	5	6	6	2	3.5	4	-32768
4	5	5	4	3	3	4	4
6	5	6	5	4	4	5	4

FILE PHDCLCR

16	17	18	19	20	21	22	23
HY-27	HY-28	HY-29	HY-30	HY-31	HY-32	HY-33	HY-34
q2.6.4	q2.6.5	q2.6.6	q2.7.1	q2.7.2	q2.7.3	q2.7.4	q2.7.5
q2_64	q2_65	q2_66	q2_71	q2_72	q2_73	q2_74	q2_75
2	4	3	2	6	2	4	2
6	5	4	6	5	6	6	5
6	6	5.5	5.5	5	6	6	6
3	5	5	6	6	5	6	5
4	6	4	5	6	5	6	6
4	-32768	2	5	3	6	6	6
1	6	5	2	4	5	5	2
2	2	2	2	2	2	2	2
7	7	7	7	7	7	7	7
6	3	4	5	4	7	7	4
4	3	6	6	4	6	4	4
2	4	2	2	2	4	6	5
5	4	6	6	4	6	5	7
7	7	6	6	2	6	6	6
7	6	6	6	6	6	6	6
5	3	4	-32768	-32768	5	-32768	2
6	6	6	6	4	7	6	6.5
6	6	5	5	6	6	5	5
6	4	4	5	6	4	6	-32768
5	3	5	2	2	4	5	4
6	1	1	6	6	6	6	6
6	6	6	4	2.5	7	5	7
6	2	2	5	4	5	6	6
6	7	4	6	6	6	7	6
7	7	6	6	6	7	6	7
4	1	1	3	4	1	4	2
6	6	6.5	6	7	6	7	6
6	6	6	6	7	6	7	6
7	7	5	7	6	7	7	7
3	6	5	6	4	6	7	6
4	2	1	-32768	6	3	5	6
6	6	3	6	5	3	7	4
5	4	2	2	5	4	6	5

FILE PHDCLCR

Appendix 3 Data For Hypothesis Testing

24	25	26	27	28	29	30	31
HY-35	HY-36	HY-37	HY-49	HY-50	HY-64	HY-67	HY-68
q2.7.6	q2.7.7	q2.7.8	q12.1	q12.2	q14.3	q15.2	q15.2
q2_76	q2_77	q2_78	q12_1	q12_2	q14_3	cr_mech	cr_flex
5	3	4	5	2	3	4	4.666666
6	5	6	6	5	4	2	6
7	7	6	6	6	5	4.166666	5
6	5	5	4	4	3	2.666666	6.333333
6	6	6	5	6	3	5.333333	6
6	6	4	5	5	5	5.666666	5.333333
5	6	4	5	3	5	1.333333	4.833333
4	2	2	2	4	2	5	4.666666
7	7	7	6	6	7	6.333333	7
7	7	6	7	7	6	3	6.333333
3	4	3	6	1	6	4.666666	4
6	6	2	5	6	3	5	5.333333
6	6	7	6	6	6	3.333333	5.666666
5	5	6	6	6	5	1.666666	6
6	6	5	6	7	4	4	6
5	2	5	4	4	4	4	4
6	7	6.5	7	7	6	4.666666	6.666666
4	5	5	5	5	4	3	4.666666
6	5	4	4	4	4	6	2.666666
5	5	5	4	5	4	6	2
7	1	5	6	4	4	6	4.666666
7	7	6	6	7	7	1.333333	6
5	2	4	4	4	4	3.666666	4.5
7	6	6	7	6	5.5	4.333333	5.333333
6.5	7	6	7	6.5	7	1.333333	6.333333
3	1	2	3.5	4	2	6	2
6	6	6	6	6	6	4	5.666666
6	6	6	6	6	5	4	5.666666
6	7	6	7	7	7	4	5.666666
6	6	7	6	6	3	7	3.666666
5	5	4	4	3	4	4.666666	5
4	4	3	6	6	4	5.333333	4.666666
6	6	4	4	4	4	6	4.666666

FILE PHDCLCR

32	33	34	35	36	37	38	39
	MODEL						
HY-69	HY-70	HY-71	HY-88	HY-89	HY-91	HY-94	HY-97
q15.3	q15.3	q15.4	q16.2.1	q16.2.2	q16.3.1	q16.4.1	q16.6
cr_task	cr_people	cr_power	cr_cm_com	cr_des_com	cr_com	cr_decisn	cr_IT_use
3.8	3.8	5	3	3	3	2.6666666	1
5.2	4.4	3.571428	6	6	5	4	-32768
4.4	5.4	2.285714	7	6	3	5	3
4.2	5.6	3.571428	5	-32768	3	2	-32768
4	5	3.857142	5	4.66666667	-32768	5	6
5.4	4.6	4.142857	4.6666666	3.33333333	-32768	5	3
4.2	3.5	4.857142	5.6666666	3	5	3.3333333	1
3.2	3.6	4.142857	4.3333333	3.66666667	3	2	-32768
6.6	5.8	2.428571	7	7	6	5.3333333	4.5
4.2	5.8	3.428571	6.5	5	6.3	5.3333333	6
5.4	2.4	5	2	5	4	6.3333333	7
5.8	5	5.714285	4	4	6	4.6666666	-32768
5.2	5.2	2.142857	6	4	5.33333	4	7
4.2	2	3.285714	5	4	5	6	-32768
5.6	5	3.571428	6.5	6.5	5.33333	5.6666666	-32768
-32768	-32768	-32768	4	4	4	4	-32768
5.4	6.2	3.285714	6	-32768	5	6	6
3	4.8	7.333333	4.5	5	5	5	-32768
3.4	2.8	4.714285	4	4	-32768	4	-32768
3	3	5.142857	6	4	6	4	-32768
3.8	3.6	4	6	4	5	5	6
4.6	5.4	3.857142	6	2	6	7	-32768
4.4	4	4.142857	3	3	-32768	3	-32768
4	4	2.571428	6	6	5	5	4
4.6	7	4.285714	7	6	6.5	6.3333333	-32768
2	2	5.428571	3	2	3	3	4
5.8	6	3	5.6666666	5.66666667	5.33333	6	6
5.8	6	3	5.6666666	5.7	4.66666	6	6
5.4	5.8	3	5	5	6	4.6666666	6
6	5.8	2.714285	7	4.66666667	5.66666	2.3333333	-32768
4.4	5	4	5	4.66666667	4.33333	5	-32768
3.8	3.2	5.428571	4.6666666	3.33333333	6	4	5
5.2	5.2	4.285714	4.5	5	4	5	-32768

FILE PHDCLCR

Appendix 3 Data For Hypothesis Testing

COLUMN	1	2	3	4	5	6	7
	Note 12					Note 13	
Hypothesis		HY-51	HY-52	HY-53	HY-54	HY-55	HY-56
Question		q13.1	q13.3.1	q13.3.2	q13.3.3	q13.3.4	q13.3.1-4
case	company	q13_1	q13_31	q13_32	q13_33	q13_34	cm_plan
1	1	4	4	4	4	4	4
2	2	6	6	6	5	5	6
3	3	4.5	5	5	5	4	5
4	2	5	5	4	5	5	5
5	3	6	7	6	6	6	6
6	3	7	7	6	6	6	6
7	3	6	6	5	4	4	5
8	2	3	2	6	6	6	5
9	4	7	6	6	6	6	6
10	5	7	6	7	6	6	6
11	4	6	-32768	6	-32768	6	6
12	6	6	5	6	5	6	6
13	4	3	3	5	6	5	5
14	7	6	6	6	6	6	6
15	8	7	7	7	6	6.5	7
16	7	3	2	2	2	3.5	2
17	4	6	7	7	6	6	7
18	8	5	6	6	4	5	5
19	9	5	6	6	5	5	6
20	9	6	6	6	6	7	6
21	7	7	6	6	7	6	6
22	11	7	6	7	7	7	7
23	8	6	6	6	6	6	6
24	8	7	7	6	6	6	6
25	11	7	7	7	7	7	7
26	9	4	5	6	6	4	5
27	10	7	7	7	7	7	7
28	10	7	6	6	6	6	6
29	12	6	7	7	6	7	7
30	15	3	6	6	6	6	6
31	11	6	3	5	6	5.5	5
32	13	7	6	6	7	7	7
33	14	6	6	6	5	6	6

FILE PHDCMGT

- NOTE 12: The variable *company* is used as a reference to the construction company participating in the survey. This data was not used as variable for analysis because representative projects were not sought, therefore, comparison of performance by construction company is meaningless.
- NOTE 13: The variable *cm\_plan* is a straight forward mean of values recorded for questions 13.3.1 to 13.3.4 which is used as an overall construction planning indicator score.
- NOTE 14: The variable *cm\_control* is a straight forward mean of values recorded for questions 13.3.5 to 13.3.8 which is used as an overall construction time control indicator score.

Appendix 3 Data For Hypothesis Testing

8	9	10	11	12	13	14	15
Note 14							
HY-57	HY-58	HY-59	HY-60	HY-61	HY-62	HY-66	HY-77
q13.3.5	q13.3.6	q13.3.7	q13.3.8	q13.3.5-8	q14.1	q15.1	q15.2
q13_35	q13_36	q13_37	q13_38	cm_control	q14_1	q15_1	cm_mech
4	4	4	4	4	5	5	3.667
4	6	6	6	6	6	6	2.667
5	6	6	5	6	6.5	4	3
4	3	4	5	4	3.5	4	2.667
6	6	6	5	6	5	6	3
5	6	6	7	6	6	5	3.666
3	6	5	6	6	6	2	4.666
4	6	6	3	5	3	2	5
5	6	7	7	7	7	7	5
6	7	7	6	7	6	7	3.33
7	6	6	6	6	6	6	3.33
5	6	6	5	6	5	6	4
3	2	2	2	2	2	4	3.333
5	6	7	7	7	7	6	4.6667
7	6	6	7	6	6	6.5	4.333
3	3	4	3	3	2	3	4
6	7	6	5	6	6	6	4.666
5	5	5	5	5	5	5	3.6667
5	5	3	4	4	5	4	5
7	7	6	6	6	6	4	5
6	6	6	7	6	6	6	4.333
7	7	7	7	7	7	6	1.333
6	4	4.5	6	5	6	3	4.5
6	6	6	6	6	6	6	5.6667
7	7	7	7	7	7	6	3.6667
4	2	3	3	3	4	4	3.66667
7	7	7	7	7	7	6	4
6	6	6	6	6	6	6	4
7	7	7	7	7	7	7	4.5
6	6	5	6	6	6	6	6.3
5.5	6	6	4.5	6	5	6	2
7	7	7	7	7	4	7	4
5	6	5	5	5	5	6	4.333

FILE PHDCMGT



16	17	18	19	20	21	22
					MODEL	
HY-78	HY-79	HY-80	HY-81	HY-87	HY-90	HY-93
q15.2	q15.3	q15.3	q15.4	q16.1	q16.2.3	q16.3.3
cm_flex	cm_task	cm_people	cm_power	cm_com_mgt	cm_des com	cm_com
4.66667	5	4.2	4	5	3	3.666666
6	5.6	5.8	3.571428	6	6	6
5.333333	4.5	4.5	2.857142	6	6	4
6.333333	6.2	4.4	3.714285	5	5	4
6	5.8	5.8	3.142857	6	6	5
5.333333	6	6	3.428571	6	5	5.666666
5	5	4.4	4.285714	3	3	4
4.666666	3.8	4.6	4	5	5.6666667	4
6.166666	6.4	6.6	3.428571	7	7	6.5
6.666666	6.4	6.6	3.571428	6	5.33333333	6
6.5	4.4	5.8	4.4	6	6	7
5.666666	6	5.8	3.428571	2	4.5	7
5.666666	5.2	5.2	2.142857	5	5	6
6	4.4	6	3	6	4	5
6.666666	7	6.2	3.571428	6	6.5	7
4	4.6	3.8	3.714285	5	4	4
6.666666	5.4	5.8	2.666666	7	2.33333333	6
5.333333	5	4.4	3.571428	3	4.5	5
5.666666	4.5	4.6	3.714285	4	4	4
5.333333	4	4	4.428571	6	6	6
5.666666	5	5.6	4.571428	6	7	6
6	5.6	5.6	5.142857	7	2	6
5.166666	5.4	4.6	4.714285	4	5	4.5
5.666666	6	5.4	3.571428	7	6	6
7	6.6	5.2	4.571428	7	4	7
4.333333	4	4	3.285714	4	4	4
5.666666	5.8	6	3	6	5	5.666666
5.666666	5.8	6	3	6	4.66666667	5.333333
6.333333	6.8	4.2	3.428571	6	5	6
6.666666	6.4	5.8	3.142857	6	6	7
6.3	6	5.8	2.428571	6	3	4.666666
4.666666	5.6	5.4	5.571428	6	4	5.333333
6	5.6	5.8	3.428571	5	6	5.5

FILE PHDCMGT

23	24	25
MODEL		
HY-96	HY-99	HY-100
q16.4.3	q16.6	q17.1
cm_decisn	cm_IT_use	cm_perfor
4	5	5
5	6	6
5	5	5.5
5	5.5	5
6	6	7
5.3333333	6	7
4	4	6
4.3333333	4	4
6.6666666	4.5	7
6	6	6
4	7	7
5	5	6
4	7	5
6	3	6
7	6	7
4	1	3
6	7	6
4.3333333	6	5
4	5	5
5.3333333	4	6
6	7	6
7	6	6
4	6	4
6	6	6
6.3333333	6	7
4	6	3
6	6	7
6	6	6
6	6	7
6.6666666	6	6
5	5.5	5.5
6	5	6
5.6666666	6	6

FILE PHDCMGT

COLUMN	1	2	3	4	5	6	7
Hypothesis	HY-63	HY-72	HY-73	HY-74	HY-75	HY-76	HY-92
Question	q14.2	q15.2	q15.2	q15.3	q15.3	q15.4	q13.3.2
casesdesign	q14_2	des_mech	des_flex	des_task	des_people	des_power	des_com
1	3	4	4.666666	5	3.8	3.7142857	3
2	4	4	5	5	4.8	3.2857142	5
3	5	4.583333	3.75	4.2	4	2.8	4
4	4	3.2	6.333333	4.2	5.6	3.5714285	4
5	3	4.833333	6	4	5.6	3.1428571	4
6	5	5.833333	5.166666	5.2	3.6	5	3
7	1	5.333333	1.8	3.6	1	4.9285714	3
8	4	5	4.6	3.4	4.4	3.5714285	5
9	6	5	6	6.2	5.5	2.7142857	6.3
10	5	5.166666	4.833333	3.2	4	3.7142857	4
11	6	4.166666	3.5	6	-32768	-32768	6.7
12	4	4.166666	4.333333	4.6	3.6	4	3
13	6	3	5	3.6	4.2	3	3.7
14	3	3.833333	4	2	2	4.8571428	-32768
15	4	4	6	5.6	5	3.5714285	5.333333
16	4	4	4	-32768	-32768	-32768	-32768
17	2	6	4.666666	3	3	4.25	3.666666
18	5	4.833333	4.5	-32768	-32768	-32768	3
19	3	6	5.333333	4	4	-32768	-32768
20	4	5.5	2.833333	3	3	5.1428571	3
21	3	4.333333	5.333333	3.8	4.8	4	5
22	1	-32768	-32768	1	-32768	-32768	2
23	4	4	3.333333	4.6	4	5.3	5
24	7	5.833333	6	4.4	6.6	2.7142857	5
25	6	2.333333	5	-32768	-32768	-32768	6
26	2	4.666666	3.5	3	4	4.2857142	4
27	6	4.666666	6	5.833333	6	3.7142857	5.7
28	5	4.666666	6	5.8	6	3.7142857	4.7
29	6	4	5.333333	6	4.5	3	5
30	3	6	3.333333	3.8	4	-32768	4.666666
31	6	4.333333	5.666666	3.6	2.6	4.2857142	4.333333
32	4	3.666666	4.333333	4.2	2.8	3.5714285	3.3
33	3	5.333333	5	3.75	4	-32768	5

FILE PHDESIGN

8	9
HY-95	HY-98
q16.4.2	q16.6
des_decisn	des_IT_us
2.66666667	1
4.66666667	-32768
6.5	3
5	5
1.33333333	6
5	5
2.66666667	5.5
4	6
6	2
2.33333333	5
5.33333333	7
4	-32768
4.66666667	4
3.66666667	5
5.33333333	-32768
4	-32768
4	4
3	-32768
4	-32768
4	-32768
5.33333333	2
1	-32768
4.3	-32768
5	7
6	6
3	-32768
5.3	6
4	6
3.7	6
4	-32768
4	7
5	4
5.3	5

FILE PHDESIGN

Appendix 3 Data For Hypothesis Testing

COLUMN	1	2	3	4	5	6
Hypothesis	HY-65	HY-82	HY-83	HY-84	HY-85	HY-86
Question	q14.4	q15.2	q15.2	q15.3	q15.3	q15.4
casekeysc	q14_4	key_mech	key_flex	key_task	key_people	key_power
1	3	3.666666	4.666666	4.6	4	4.1428571
2	6	4	6	5	4.4	3.8571428
3	4	3.5	4.333333	5.8	2.75	4.1428571
4	6	2.666666	6	5.4	5.2	3.7142857
5	5	3.333333	5.666666	6	6	3.5714285
6	6	3.333333	5	5.6	5.8	3.6
7	3	3.666666	3.833333	5	4	3.4285714
8	2	4.333333	6	3.6	3.2	4.7142857
9	5	5	5.833333	4.8	4.6	3.1666666
10	5	5.3	4.333333	6	6.8	3.4285714
11	6	3.333333	6.5	6	6	2.8
12	6	4	5.666666	6	5.8	3.2857142
13	6	4.333333	5	5	4.4	3.1428571
14	6	3.333333	4.666666	6	6	3.7142857
15	5	4.333333	5.666666	6.6	5.2	3.5714285
16	4	4	3.666666	4.4	3.8	4.4285714
17	6	3	5.333333	5	3.8	4.3333333
18	-32768	3.666666	4.666666	4.4	4.2	3.7142857
19	2	5	5.666666	4	4	3.7142857
20	4	5	4	4	4	4.4285714
21	7	3.666666	2.666666	5	4	3.71
22	7	1.333333	6	5.6	5.6	4.1428571
23	5	3.833333	5	5	4	4.2142857
24	5	4.666666	5.333333	5.8	5.6	3.4285714
25	6.5	6	6	6.6	5.6	4.7142857
26	3	5	3.333333	4	4	3.2857142
27	6	4.666666	5.666666	5.8	6	3
28	6	4.666666	5.666666	5.8	6	3.4285714
29	7	2.333333	5.666666	6.8	4.2	3.4285714
30	6	6.333333	6.666666	5.6	5.4	3.1428571
31	6	5	6.333333	5.2	6	2.7142857
32	7	5	4.666666	5	4.8	4
33	5	4.333333	6	5.6	5	4.1428571

FILE PHDKEYSC

COLUMN	1	2	3	4	5	6	7
Hypothesis							
Question	q15.5.1	q15.5.2	q15.5.3	q15.5.4	q15.5.5	q15.5.6	q15.5.7
case	cr_1551	cr_1552	cr_1553	cr_1554	cr_1555	cr_1556	cr_1557
1	2	4	2	3	5	4	3
2	5	5	5	5	4	4	5
3		6		5.5	5	5	
4		6		4	3	4	2
5	5	6	5	6	6	6	6
6	4	6	6	3	6	6	4
7	1	4	4	5	5	5	
8	4	4		2		4	4
9	4	6	6	7	6	5	1
10		6		6	5	5	4
11	4	6	6	1	6	1	
12	2	6	6	2	6	6	
13	2	6	5	6	6	7	2
14				1			
15	4	6	5	5	5	5	1
16							
17	1	7	2	6	6	6	
18							
19			6		6		
20							
21		6					2
22		6		3	6		
23	6	4	2.5	4	3	4	
24	4	4	4	5	4	4	
25	4	6	4		6	2	
26		1	4			1	
27			2		6	6	
28			2		6	6	
29	4	4	5	6	6	5	4
30	1	6	6	6	6	6	6
31			6	5	6		
32	4	4	7	1	4	3	1
33		6	6				

## FILE MOTIV

General Note: Only two variables, cm\_1553 and cm\_1559, have been selected due to sample size being small (less than 30). Also the reliability of CR, Design and Site Workforce data is open to question.

8	9	10	11	12	13	14	15
q15.5.8	q15.5.9	q15.5.1	q15.5.2	q15.5.3	q15.5.4	q15.5.5	q15.5.6
cr_1558	cr_1559	des_1551	des_1552	des_1553	des_1554	des_1555	des_1556
4	4	2	4	2	3	5	4
4	4	5	5	5	5	4	4
4.5			6		5.5	5	5
4	4		6		4	3	4
6	6	5	6	5	6	6	6
4	6	5	6	6	4	5	4
5	5	1	4	5	4	5	5
5	4		5	4	5	4	4
6	5		6		6	5	4
3			4	5	5	6	4
	6	1	4	1	6	5	6
5	6	2	6	6	2	4	4
2	6	2	6				6
	6	6		6			
4	5	4	6	5	5	5	5
4	6	4	4	3	4	4	4
2			5				6
	6						
			6	6			
	6						
4	2	3	5	5	4	6	5
		4	4	4	5	4	4
	6						
	1						
	6						
	6						
4	4	2	4	5	5	6	5.5
4	6	1	6	6	6	6	6
		6	5		4.5	5.5	
6	6	7	4	3	1	2	3
			6			6	

FILE MOTIV

Appendix 3 Data For Hypothesis Testing

16	17	18	19	20	21	22	23
HY-101							
q15.5.7	q15.5.8	q15.5.9	q15.5.1	q15.5.2	q15.5.3	q15.5.4	q15.5.5
des_1557	des_1558	des_1559	cm_1551	cm_1552	cm_1553	cm_1554	cm_1555
3	4	4	4	5	4	5	3
5	5	4	4	5	5	5	4
			4	6	1	5.5	5.5
2	4	4	6	4	2	4	3
5	5	5	5	6	5	6	6
4	4	4	5	6	6	6	6
	1	5	1	4	4	3	5
4	4	4	4	5	4	6	4
	6		4	7	6	7	5
5	3	4	4	6	6	7	6
5		6		6	1	6	2
	1	5	2	6	6	4	5
	2	6	2	6	5	6	6
	3		2		6		
1	4	5	4	6	5	5	5
			5	4	4	3	4
	4	4	1	7	2	6	6
			2	5	4	5	4
		6	4	6	6	6	
			6	6	7	2	2
		2			6		
				6		6	6
	6	5	5	5	5	3	4
			4	5	5	5	4
			4	6	6		6
			4		4		
					2		6
					2		6
5.5	4	6	5	6	5	6	6
6	4	6	1	6	6	6	6
			5.5	6.5	4.5	6	6
1	1	1	5	6	4	1	5
				6			

FILE MOTIV



Appendix 3 Data For Hypothesis Testing

24	25	26	27	28	29	30	31
HY-102							
q15.5.6	q15.5.7	q15.5.8	q15.5.9	q15.5.1	q15.5.2	q15.5.3	q15.5.4
cm_1556	cm_1557	cm_1558	cm_1559	site_1551	site_1552	site_1553	site_1554
4	4	4	5	5	5	4	5
5	5	5	4	4	4	5	5
5.5		5	6	4	5	4	5
4	2	5	2	6	5	3	4
6	5	5	5	6	5	5	6
5	4	4	5	6	6	6	6
5	3	4	4	1	4	5	5
4	4	4	5	4	5	4	4
5	1	6	6	5	5		4
6	6	6	5	5	5	7	6
7	1	1	6		6		2
6		1	5	2	6	6	4
7	2	2	6	5		6	6
6		2	6	5		6	
5	1	4	5	4	6	5	5
2	4	5	4	5	4	4	3
7		5	6	2	6	3	6
6	3	4	5	5		5	5
	4		2	6	2	6	
2	2	4	4	7	3	7	2
	2		6	7		7	
			2		5		
2	4	6	2	7	4	6	4
4			2	4	5	6	5
		2				6	2
6			6	6		6	
6			6	6		6	
5	4	6	5	5	6	5	6
6	6	4	6	1	6	6	6
6.5		2	6.5	6	5.5	2	5.5
5	1	4	5	7	3	2	1
			6	6		6	

FILE MOTIV

32	33	34	35	36
q15.5.5	q15.5.6	q15.5.7	q15.5.8	q15.5.9
site_1555	site_1556	site_1557	site_1558	site_1559
3	3	4	4	4
4	4	4	4	4
5	5			5.5
3	6	2	4	6
6	5	4	5	5
7	5	4	4	5
5	5	4	4	4
4	4	4	4	4
4			1	
4	6	5	4	5
2				6
5	6		1	5
5	2	2	2	5
			2	
5	5	2	4	5
4	2	4	5	4
6	6	3	2	6
			2	
	2	6		
5	2	6		4
		2		6
			2	
4	5	5	3	5
4	5			4
	2			
3	3			3
3	3			3
6	5	4	6	5
6	6	6	4	6
5.5	2			
2	4	1	1	1
6				5

FILE MOTIV

COLUMN	1	2	3	4	5	6	7
Hypothesis							
Question	q15.6.1	q15.6.2	q15.6.3	q15.6.4	q15.6.5	q15.6.6	q15.6.7
case	cr_1561	cr_1562	cr_1563	cr_1564	cr_1565	cr_1566	cr_1567
1	5	4	4	5	5	6	5
2	4	4	4	4	4	2	2
3		4	5	1	3	1	5
4	4	2	4	4	4	6	4
5	5	5	5	3	4	4	6
6	4	4	6	3	5	4	5
7							5
8	4	4	5	4	5	3	4
9	1	1	6	1	1	1	2
10							
11		1		6	6	1	1
12	4			6			2
13	2	2	6	6	6		
14			2				
15							
16							
17	1	2	1	1	4	2	1
18							
19							
20			6	6		7	4
21				2		6	
22	2						
23	2		5	2	2	4	2
24	4	4					
25			4		1		
26							
27				5	5		2
28				5	5		2
29	4	2	2	2	2	2	2
30	1	4	4	4	2	5	
31			6	4.5	4.5	2	
32	4	4	4	6	7	3	5
33		6	6				

FILE DEMOTIV

8	9	10	11	12	13	14	15
q15.6.8	q15.6.9	q15.6.1	q15.6.2	q15.6.3	q15.6.4	q15.6.5	q15.6.6
cr_1568	cr_1569	des_1561	des_1562	des_1563	des_1564	des_1565	des_1566
5	5	5	4	4	5	5	6
2	2	4	4	4	4	4	2
5	1			4		1	4
4	4	4	2	4	4	4	6
5	2	4	3	5	3	5	5
4	5	6	4	6	3	6	4
4	4			6	5	6	
5	3	4	4	6	4	5	4
1	1		1	5	1		1
6	1		1		2		6
		4			4		
	7		2				6
	6		2				
	3	4	5	4	4	5	4
4	6						
6				6	2		
	6						
2	1	5		3	3	5	
		4					
1	4						
							4
2	2						
2	2						
2	2	4		4	4	4	4
1	4	1	4	4	4	2	5
							6
3	4	4	4	5	4	4	5
			6			6	

FILE DEMOTIV

Appendix 3 Data For Hypothesis Testing

16	17	18	19	20	21	22	23
q15.6.7	q15.6.8	q15.6.9	q15.6.1	q15.6.2	q15.6.3	q15.6.4	q15.6.5
des_1567	des_1568	des_1569	cm_1561	cm_1562	cm_1563	cm_1564	cm_1565
5	5	5	4	4	5	4	4
2	2	2	4	4	4	4	4
3	2	2	2	2	3	1	1
4	4	4	4	2	5	4	4
6	4	2	4	3	5	3	5
6	4	5	4	2	6	3	5
7	6	7	4	5	5	4	5
4	5	4	4	4	6	4	5
1	1	1	2	1	6	2	3
					6		
		5		2		4	
2		6	4	6		4	2
6		7	2	2	6	6	6
6				6		2	
			4	5	5	5	4
			4	5	4	5	5
4		5	2	2	2	2	5
			4	5	3	3	4
	5			4	6	6	6
			4	2	5		
6		6	6	6	6	6	7
			1			6	
5	4	6	5	2	7	5	7
			4	4			5
					5		5
						5	5
5	2	2	2	2	2	2	3
	6	4	1	4	6	4	2
6			6				6
5	3	5	5	5	5	4	5
				6			

FILE DEMOTIV

Appendix 3 Data For Hypothesis Testing

24	25	26	27	28	29	30	31
q15.6.6	q15.6.7	q15.6.8	q15.6.9	q15.6.1	q15.6.2	q15.6.3	q15.6.4
cm_1566	cm_1567	cm_1568	cm_1569	site_1561	site_1562	site_1563	site_1564
5	5	4	4	4	5	6	4
2	2	2	2	4	4	4	4
2.5	3	3	1	4	3	4	
6	5	4	5	4	2	5	4
5	6	4	2	4	3	5	3
6	5	2	4	3	3	7	3
4	9	4	6	4	5	4	4
6	4	5	4	4	3	4	4
1	3	1	1	1	2	4	2
6	4		5	4		5	5
	7	6	2		4		6
6				4	6		4
			7		5		
	6		6				
3.5	4	5	6	4	5	5	5
5	5	4	4	4	5	4	5
3	2		3	5	6	2	4
2	5	3	3	3	4	3	4
	5		5			6	
7	4	2	6		6		
7	6	4	5	7	7	6	6
				6	6		
6	5	6	6	4	2	5	4
				4	4		
	4						
	2	2	2				5
	2	2	2				5
3	4	2	2	2	2	2	2
5		6	4	4	4	6	4
			5				
3	5	3	4	6	6	2	4
			6	6		6	

FILE DEMOTIV

32	33	34	35	36
q15.6.5	q15.6.6	q15.6.7	q15.6.8	q15.6.9
site_1565	site_1566	site_1567	site_1568	site_1569
4	6	5	5	4
4	2	2	2	2
4	3	4		4
4	6	6	6	4
4	6	7	4	2
5	6	5	2	4
4	4	7	4	4
5	6	4	4	4
4	1	4	4	1
	7	5		5
	6	6		
2	6			
	6	6	1	
	6		2	
4	3.5	4	5	6
5	5	5	4	4
5	6	4		
4	4	3	5	5
	5	6		6
4	6	6	5	4
7	7	6	4	4
3	5	3	4	2
5				
		6		
5		2	2	2
5		2	2	2
3	3	4	2	2
2	5		6	4
	6	6		
4	3	5	3	4
6				5

FILE DEMOTIV

## APPENDIX 4

### THE PILOT STUDY QUESTIONNAIRE



Site Management Survey

-----  
Case History Number:

Survey by:

Date:

Q1 Contact Person's Details

-----  
1.1 Company name

1.2 Contact name

1.3 Title/position

1.4 Phone number

Q2 Project Location Details

-----  
2.1 Address

2.2 Location Type:

2.2.1 CBD

2.2.2 Sub-urban

2.2.3 Country town

2.2.4 Remote

Q3 General Project Characteristics

-----  
3.1 End use

3.1.1 Single

3.1.2 Mainly single

3.1.3 Mixed

3.2 Impact of Existing Buildings

3.2.1 All new work

3.2.2 Renovation/recycling

3.2.3 Extensions to existing facilities

3.4 Building height in storeys (state number)

3.4.1 Less than 10

11 to 20

21 to 40

over 40

Q4 Project Description

-----

4.1 General description of the project

Q5 Project Classification

-----

5.1 Residential

5.1.1 Single/cluster under 5 storeys

5.1.2 Flats/apartments/units over 5 storeys

5.1.3 Other (state)

5.2 Commercial

5.2.1 Office/administration

5.2.2 Convention centre

5.2.3 Hotel/motel

5.2.4 Shopping centre

5.3 Industrial/manufacturing

5.3.1 Factory

5.3.2 Warehousing

5.3.3 Laboratories

5.4 Educational

5.4.1 Primary

5.4.2 Secondary

5.4.3 Tertiary

5.4.4 Research facility

5.4.5 Other (state)

5.5 Health Facility

5.5.1 Clinic

5.5.2 Hospital

5.5.3 Other (state)

5.6 Entertainment

5.6.1 Cinema complex

5.6.2 Theatre/arts centre

5.6.3 Auditorium

5.6.4 Sports stadium

5.6.5 Marina

5.6.6 Swimming pool

5.6.7 Golf course

5.6.8 Other (state)

Q6 Project Scope and Complexity

-----

6.1 Project Cashflow size

6.1.1 Approx. construction value in \$millions

6.1.2 Approx. construction period in months

6.2 Project Design Complexity

6.2.1 Simple shape

(Rectangular with minimal set out complexity)

6.2.2 Complex shape

(High levels of set out complexity)

6.2.3 Highly complex shape

(Very high levels of set out complexity)

6.3 Project Services Complexity

6.3.1 Standard services with simple layout

(This category refers to a level of services for the building that is considered standard for that market i.e. for an office development; heating, air conditioning, sprinklers, lifts etc. which have no distinguishing features from that normally provided.

and

The layout of these services will also **not** require close attention by site management to solve problems of clashes of services due to a high level of space constraints.)

6.3.2 Complex services or complex layout

(This category comprises more complex systems such as that found in 'up market' developments. These services may incorporate energy efficient measures such as zoned heating and cooling or electrical lighting similarly zoned.

or

Standard services such as that in 6.3.1 except that there is a higher level of supervision required to oversee the installations of services and answer questions regarding design clashes or difficulty in positioning services due to space constraints.)

6.3.3 Highly complex

(This category is restricted to so called 'intelligent' buildings with complex central supervisory systems such as card access linked into zoned heating/ventilation and power or lighting systems. Such systems also record movement of personnel through card access and lifts will be tuned to automatically adjust their response to demand patterns programmed by a computer system.

Other similarly complex services include that required in custodial institutions or hospitals with operating theatres.

This category may also include other specialised features that require close site management attention to supervise installation and communications between the design team and the installation team.)

6.4 Site Access

6.4.1 Free unrestricted access to or within site

(This category includes large open sites with sufficient room for materials to be delivered to site without the need to supervise queues of trucks etc.

or

where the site has sufficient space for trucks etc. to directly offload materials in accessible locations.)

6.4.2 Limited access to or within site

(This category includes conditions where trucks etc have to queue to gain access to the site, perhaps having to drive around the block several times due to clearway constructions or other constraints that make offloading materials difficult.

or

where the site is constrained so that materials have to be double or treble handled due to temporary storage space constraints. Generally this will result in site management being required to direct traffic within site as a substantial part of their duties.)

6.4.3 Highly constrained access to or within site

(This category includes those sites which are located in a position that make constant supervision of incoming and outgoing traffic necessary

or

where the site itself is so constrained that materials are required to be stored off-site and when stored on site are required to be moved several times due to a lack of temporary storage space.)

6.5 Facade Treatment

- 6.5.1 Infill construction (concrete, masonry etc.)
- 6.5.2 Pre-cast panels (concrete masonry etc)
- 6.5.3 Window wall systems
- 6.5.4 Other (state)

Q7 Control Mechanisms

- | 7.1   | Use of computers for:       | 1<br>Manual | 2<br>Micro | 3<br>Mini |
|-------|-----------------------------|-------------|------------|-----------|
| 7.1.1 | Accounting/cost control     |             |            |           |
| 7.1.2 | purchasing                  |             |            |           |
| 7.1.3 | Stock/materials control     |             |            |           |
| 7.1.4 | Site Admin. variations etc. |             |            |           |
| 7.1.5 | Planning & Scheduling       |             |            |           |
| 7.1.6 | Drawing issue/receipt       |             |            |           |
| 7.1.7 | Other (state)               |             |            |           |

Q8 Industrial Relations

8.1 Site Agreement Operating

- 8.1.1 Yes
- 8.1.2 No

- | 8.2   | Prevailing industrial climate: | 1<br>Within<br>Industry | 2<br>On<br>Site |
|-------|--------------------------------|-------------------------|-----------------|
| 8.2.1 | Better than expected           |                         |                 |
| 8.2.2 | As expected                    |                         |                 |
| 8.2.3 | Worse than expected            |                         |                 |

Q9 Project Delivery System

- 9.1 Own development
- 9.2 Design and construct
- 9.3 Cost plus
- 9.4 Tendered
- 9.5 Construction management
- 9.6 Other (state)

Q10 Client Classification

- 10.1 State federal government
- 10.2 Statutory authority
- 10.3 Commercial - experience with many projects
- 10.4 Commercial - experience with few projects

Q11 Supervision By Client Representatives

- 11.1 Low (only clerk of works or none)
- 11.2 High (on site consultants or frequent visits by client's representative)
- 11.3 Very High (comprehensive tests of components)

Q12 Effectiveness of Organisational Structure

1	2	3	4	5	6	7
Low			Med		High	

Q13 Factors Affecting the Site Management Structure

- 13.1 Building complexity
- 13.2 Spread of the workforce within building and site
- 13.3 Construction cost
- 13.4 Fast track design or traditional documentation
- 13.5 Client or company information demands
- 13.6 Other (state)

Q14 Workforce and Materials Movement

- 14.1 Fixed cranes - number and type
- 14.2 Mobile cranes - number and type
- 14.3 Concrete pumps
  - 14.3.1 - yes
  - 14.3.2 - no
- 14.4 Man/materials hoists - number and type
- 14.5 Use of building's lifts - proportion of time
- 14.6 Other major plant items

NOTE: Organisation chart requested including labour for materials movement and preliminaries works