**OPTIMISATION OF
EMBODIED ENERGY
IN DOMESTIC CONSTRUCTION**

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Master of Engineering

2006

RMIT

STATEMENT

This thesis contains no material previously accepted for a degree, diploma or other award in any other institution. I affirm to the best of my knowledge that this research work contains no material previously published or written by any other person except where due reference is made in the thesis text.

A handwritten signature in black ink, appearing to read 'Siu Keih Ting', is written over a horizontal dotted line.

Siu Keih Ting

1st December, 2006

ACKNOWLEDGEMENTS

It has been an exciting and challenging experience doing this study. Many have assisted me and made valuable contributions to this study. I am indebted to the following people and wish to express my deepest thanks to them.

The invaluable knowledge input, support, understanding and, most importantly, encouragement from Dr. Saman de Silva, form the bases of this project. His availability and willingness to help, combined with his proficiency in the field has provided a very supportive environment for this research.

I would also like to thank my second supervisor Dr. Graham J. Treloar for his expertise in this research. His willingness to share the knowledge in this field is highly valued.

Ian, Clement, Lawrence, Jimmy, Raymond, Jacqueline and Shamy for their tender, love and care during my master studies. Without them, this research life would be bleak and lonesome.

Finally, I am most grateful to my family, especially my brother Jean, who is always there for me. Their moral support and encouragement lifted me up throughout the difficult time. This thesis is dedicated to them.

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LIST OF PUBLICATION

Refereed conference paper (national)

Siu TING and Saman de SILVA (2004) Optimisation of Embodied Energy in Domestic Construction, IABSE Symposium ‘Metropolitan Habitats and Infrastructure’, Shanghai, China, 22 – 24 September

SUMMARY

Over the years many developed economies around the world have used the domestic building sector capital growth as an indicator and as a stimulant to economic growth. However, attention to environmental duty of this industry has come to light only recently. There is an apparent increase in government attention and community awareness regarding the sustainability aspect of this growing industry and a greater emphasis is now being given to its environmental duty. The present pattern of metropolitan development in major Australian cities is one of spreading low-density suburbs. According to the Australian Bureau of Statistics the current trend indicates that there is a 30% increase in average dwelling size and material consumption and also a decline in the number of people per dwelling. This means the energy consumption per capita, both embodied and operational energy is on the rise in the domestic sector. In relative terms the emphasis on the conservation of embodied energy component is far less than the operational energy component. This research dissertation discusses the importance and needs in addressing this existing gap.

Housing is an essential amenity. However the impact, due to current trend of increasing embodied energy consumption per capita should be minimised. This may even require major cultural shift to traditional construction processes, practices and home owner perceptions. This thesis presents the outcomes of a study investigating ways to produce a “bill

of embodied energy” for housing sector aligned to the standard practice of “bill of quantities”. The intension here is to contribute to improve the awareness of the community, through a web based tool, and to provide strong base for researchers and policy makers to ascertain embodied energy of current domestic construction practices.

Optimisation of Embodied Energy in Domestic Construction

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CHAPTER 1

INTRODUCTION

Embodied energy is the energy consumed by all of the processes associated with the production of a building product, from the acquisition of natural resources to product delivery and also over the full life cycle. In a true sense this should include the mining and manufacturing of materials and equipment, the transport of the materials and the administrative and financing. Embodied energy is a significant component of the environmental impact of a domestic building. This thesis focuses on this aspect of the construction of domestic buildings.

The design and construction of a new domestic building is one of the most resource-intensive and economically significant decisions made by developers and consumers. Every domestic building is a complex combination of many processed materials, each of which contributes to the building's total embodied energy. Renovation and maintenance also add to the embodied energy over the building's life. This chapter introduces the background, scope and objectives of the study. The structure of the thesis is also outlined.

1.1. **Problem Statement**

Today, there is greater public awareness and knowledge regarding environmental issues and a higher expectation of environmental responsibility. Significant ecological damage and global economic instability are the result of wasteful and extravagant use of energy resources in the building and transportation industries. Battle and McCarthy (2001) stated that within this framework, construction is the largest source of pollution. Due to environmental impact, there is a greater push to take into account the embodied energy used in construction.

The domestic building industry accounts for 8% to 10% of the Gross Domestic Product (GDP) in developed economies and is growing rapidly. Therefore, increased examination of the building industry has prompted a search for criteria, approaches and practices, which can guide more environment-friendly building design, construction and operation. Cole and Kernan (1996) discussed that it is important to focus on gathering more comprehensive and reliable information on the environmental attributes of building materials and tools for evaluating alternative design options.

The demand and supply gap for residential buildings widen every year. The housing shortage in many countries has reached critical levels as the population continues to rise. For this reason, material consumption in domestic environments has risen alarmingly. Domestic buildings' geometric design and topology demand different social, cultural, economic and environmental needs and often favour individuals' preferences and ever changing fashions. Furthermore, industrialized building processes use of high-energy intensive materials such as aluminium, cement, concrete and steel to achieve speed of construction and economy. A notable exception was that observed by Morel *et al.* (2001), where the choice of construction

materials will play an important part in the sustainability of an industrialized building and some encouraging similar trends are evident in current domestic building sector too.

Battle and McCarthy (2001) suggested that building demand could be limited by producing design guidelines and energy targets for given plots of land. Typically, this will influence decision making with respect to both the building systems and architectural response. Importantly, it will place greater emphasis on the architect to develop a building type that is environmentally responsive or selective rather than environment rejecting.

The process of calculating embodied energy is complex and involves numerous sources of data. There are various methods to derive embodied energy coefficients of materials and these include life-cycle analysis, input-output analysis, process analysis and hybrid analysis. Embodied energy is the cumulative energy embedded in the process of bringing a domestic unit into being. Embodied energy analysis comprises the assessment of the direct and indirect energy requirements associated with a process. The embodied energy includes the energy consumed during the mining and manufacturing of materials and equipment, as well as the energy required in transporting and handling, engineering, construction practices, associated administrative and financing processes (Treloar, 1998).

Embodied energy in building materials has been studied in the past several decades by researchers interested in the relationship between building materials and construction processes, and their environmental impacts. Cole and Kernan (1996) claimed that there are four forms of embodied energy in building construction. They are operating energy, recurring energy, demolition energy and initial embodied energy. Throughout the world, the domestic building industry is responsible for high levels of pollution as a result of the energy consumed during extraction, processing and transportation of raw materials.

1.2. Research Objectives

Embodied energy is defined here as the cumulative energy embedded in the process of bringing a domestic unit in to being. This includes the energy embedded in the processing and manufacturing of materials, transporting and handling, engineering and construction practices. The expected outcomes of the research are,

- Literature search on current methods of establishing basic embodied energy data and presenting an inventory of basic embodied energy data
- The development of a more rationalised embodied energy database to align with exhaustive list of billed items given in standard domestic cost guides
- The development of a method of estimating embodied energy of a domestic construction based on basic embodied energy data;
- The development of a web based tool to optimise embodied energy and cost for a given housing project
- Conduct three case studies representing single dwellings, medium density dwellings (15 to 35 units per block) and high density dwellings (40 to 80 units per block).

Optimisation of embodied energy during planing stage is essential, through the selection of low energy construction materials, smart engineering, building technologies and practices, which are distinctly different in the three housing sectors mentioned above. This thesis contributes towards improving the understanding of the complex problem of embodied energy in typical Australian housing developments. This research also investigates methodologies to engineer a favourable configuration with less embodied energy within a given set of constraints.

1.3. Research Scope

Domestic building construction puts significant pressure on the environment through energy consumption and green house emissions as a result. This research aims to investigate embodied energy in different categories of domestic buildings, namely single dwelling, medium density and higher density construction, as opposed to the cost of construction. The significant outcome of this research is to develop a decision support environment and a web based tool to evaluate optimum embodied energy configuration and to spread the ‘Bill of Embodied Energy (BEE)’ concept through optimisation of embodied energy and building costs to suit individual needs.

The scope of the study is limited to the collection of embodied energy data for commonly used materials, building products, construction practices and processes including administration and financing. It includes the collection of data for key element groups such as structures, finishes and services, which are typical to the domestic industry and especially common in volume builders market.

1.4. Structure of the Thesis

This thesis consists of six chapters. An extensive literature survey on the current practices on embodied energy is presented in Chapter Two. The literature review summarises the environmental impact from embodied energy, the methods of assessing embodied energy, embodied energy used in a domestic building and some currently available tools.

Chapter Three presents the condition in collecting data, grouping of embodied energy data and a preliminary analysis. The analysis is based on a model of the total initial embodied energy used in a typical domestic building in Victoria, Australia.

A Bill of Embodied Energy is proposed in Chapter Four. The proposed Bill of Embodied Energy approach and the related issues in developing the tool to incorporate and align to standard schedule of activities, building materials and products and industry practices. This chapter also present validation of the tool by comparing embodied energy obtained from the proposed Bill of Embodied Energy (BEE) software tool and the estimates by other researchers, presented in Chapter 3.

Chapter Five contains three case studies of different sectors of domestic building construction, namely a single dwelling, medium density housing and high density housing.

Chapter Six presents a concise overview of the investigation, conclusions and the recommendations for further research.

CHAPTER 2

LITERATURE REVIEW

As discussed in Chapter 1, methods for assessing environmental sustainability of domestic buildings include the assessment of cumulative energy consumption during whole of life performance. Energy consumption, which is a direct indicator of the carbon dioxide emissions of a domestic building comprise of both embodied energy and operational energy. The building continues to affect the environment directly and indirectly throughout its operation, maintenance, refurbishment and final demolition (Treloar *et al.*, 2000). Figure 2.1 schematically illustrates the scaffolded manner in which the accumulation of both forms of energy, namely embodied energy and operational energy, consumption takes place. As mentioned in the scope this study only focuses on the embodied energy component of the construction phase. This study also attempts to rationalise and enhance the embodied energy estimating capabilities and develop tools and procedures. It also investigates and discusses the possibility of preparing a “bill of embodied energy” for housing projects alongside more conventional pre-construction procedure of preparation of a priced bill of quantities.

Figure 2.1 Schematic Illustration of Accumulation of Energy Consumption in Domestic Buildings

This Chapter presents the outcomes of the literature review undertaken during this study, which also includes the current available tools and some case studies by others. Literature search only covers the embodied energy component of the building construction phase.

2.1. Environmental Impact from Domestic Building

Domestic building industry provides an essential amenity to community. As all other construction activities, domestic construction projects also have a significant impact on the environment. The impact on the environment includes the greenhouse emissions, depletion of natural resources, human well being, damage to flora and fauna, depletion of animal habitats and waste. The negative outcomes include global warming potential, ozone depletion, acidification potential, nitrification potential and solid waste generation. Weir and Muneer

(1996) noted that in the building and construction trade, carbon dioxide emissions and resource consumption are the largest environmental concerns.

Consideration of the extent to which construction impacts the environment is becoming a topical issue for construction researchers. Most people and organizations are now becoming aware of the importance of optimisation of embodied energy and conservation of operational energy. Green products including green energy are finding a limited but growing market. A number of designers, developers and building users, aware of the environmental impact, are motivated to pursue more environmentally sustainable design and construction strategies (Scheuer *et al.*, 2003). There is research into new material production, product design, manufacturing methods, recycling technology and waste disposal management (Weir and Muneer, 1996). However it appears that the conservation of operational energy, through initiatives such as mandatory five-star rating for new houses, is given, relatively, much more emphasis to that of embodied energy. This means that the construction products and materials with low embodied energy contents and longer lifespan must always be encouraged.

This is because the initial impact of a building on the environment results from the energy and other products consumed in its construction. In Australia, the construction and operation of buildings account for 30% to 40% of the nation's energy use and energy related greenhouse gas emissions (Lawson, 1996). Thus, it is clear that the environmental impact associated with buildings is as much an issue as its financial cost. The comparison of embodied energy and operational energy of typical Australian house hold given in Figure 2.2 (CSIRO, 2004) suggests that on average it would take around 30 years for operational energy to breakeven with embodied energy. Treloar (1997) mentioned that each year, the energy embodied in construction can represent up to one-fifth of national energy consumption in Australia. It may therefore deduct, considering domestic construction is representing over

50% of the building sector, which embodied energy of domestic construction sector amounts to around 10% of the total national construction energy consumption.

Source: CSIRO, 2004

Figure 2.2 Relations between Embodied Energy and Operational Energy

Many studies have been undertaken in the past to quantify the environmental cost of building products. However, as there are many complex ways in which industrial processes impact the environment, it is not yet possible to accurately quantify all potentially harmful effects involved. The local environmental impact issues, such as indoor air quality, dust emission and water consumption is also getting wide acceptance (Morel *et al.*, 2001). This thesis only focuses on a study of energy embodied in building components and use in current domestic construction practices.

2.2. Embodied Energy Analysis

Embodied energy is defined here as the energy consumed in all activities necessary to support a process. It comprises a direct and an indirect component. For building construction, the direct energy includes that used primarily on site such as the fuels used directly for the

assembly of the building. The indirect energy includes the energy required for the manufacture of building materials and the energy resides in the inputs to the construction process. Energy embodied in the construction of buildings can be a significant component of their life-cycle energy requirements (Treloar, 1998). The differences in embodied energy of construction materials and products depend not only on the mode of calculation, but also on the economic and ecological conditions. In this study consideration was given to evaluate embodied energy of standard components of domestic construction widely used in Australia construction industry. This required detailed analysis of the quantities of material and the published embodied energy data. Numerous techniques for assessing the environmental impacts are available, all of which have their advantages and disadvantages.

Energy analysis is a technique, as discussed below, employed to determine the amount of energy used to perform activities and produce specific goods or provide services. Such analysis may use a variety of methods to reveal the embodied energy of an activity or a service. The four main methods of energy analysis are outlined as follows.

2.2.1. Life-Cycle Analysis

Since the late 1960s, life-cycle analysis (LCA) has become an increasingly important tool. Life-cycle analysis compares the environmental impacts of alternative building materials, components and services. Cole (1999) and ISO 14040 (1999) stated that life-cycle analysis involves the evaluation of the relevant environmental, economic and technological implications of an object or process throughout its lifetime from creation to waste. A full life-cycle analysis involves identification of environmental impacts, assessment of environmental hazard and improvement. Due to the diverse and complex nature of construction projects, however, life-cycle analysis is only used for considering the impact of design decisions on the

environment. Life-cycle analysis data is derived using embodied energy data of basic materials used in specific construction sectors (Treloar *et al.*, 2000).

Life-cycle analysis is the analysis from the direct and indirect of environmental ‘loadings’ and ‘impacts’ of construction processes. The term ‘loadings’ refers to activities that have environmental effects. Environmental loadings are calculated for emissions to air, water and land. Environmental loadings are calculated for each life-cycle phase of a product. A life-cycle perspective requires that both the upstream and downstream implications of construction activities be assessed. Upstream activities refer to the manufacture of goods and services used in the construction process, while downstream activities include operation, maintenance and demolition of the building (Treloar, 1997). Figure 2.3 shows the upstream and downstream components of a building’s life-cycle, for the construction phase.

Source: Treloar *et al.*, 2000

Figure 2.3 Upstream and Downstream Phases of a Building’s Life-Cycle

The term ‘impacts’ refers to actual effects resulting from activities which directly affect the environment. For example, the habitat damage caused by the extraction of raw materials and the use of a material which is known to contribute to the emission of gases

harmful to the ozone layer. Waste and recycling activities are also considered. In life-cycle analysis, the whole of life-cycle of the product may be considered, including manufacture, use, alteration and disposal (Treloar, 1998).

2.2.2. Input-Output Analysis

Embodied energy figures based on input-output analysis were used to evaluate completeness of the life-cycle analysis inventories. This is done using a specific mathematical technique called the Leontie inverse matrix (Treloar, 1998) because input-output analysis is based on national economic data and offers the possibility of calculating the total energy, both direct and indirect, consumed in the production of components or materials.

The advantage of input-output analysis is that every energy transaction across the entire national economy is captured. Direct energy intensities are typically calculated by summing the products of the direct input-output coefficients, which are the energy supply sectors and the appropriate national average energy tariffs. Indirect energy requirements for the manufacture of goods and services can be traced manually through the direct input-output matrix (Treloar, 1997). For example, the energy required directly to make concrete can be multiplied by the direct consumption of concrete by a construction sector, in this case the residential building industry.

The principal disadvantages associated with input-output analysis are the errors inherent to input-output analysis resulting from the proportionality and homogeneity assumptions and the assumption that price is an indicator of actual flows of goods and services. In the proportionality assumption, inputs to a sector are assumed to be linearly proportional to its output. In the homogeneity assumption, sector outputs are assumed to be

proportional to price, regardless of the variation in each different product of the sector (Treloar, 1997).

Source: Treloar, 1997

Figure 2.4 Input-Output Frameworks by Upstream Stage

Figure 2.4 indicates the extent and framework of the input-output model. Treloar (1998) identified that the input-output model is effectively a ‘black box’ and consequently the systematic identification of the most important inputs to an economic sector is hampered.

2.2.3. Process Analysis

Process and input-output analyses have provided many of the currently available embodied energy data. Process analysis is here defined broadly as embodied energy analysis using any sources of data other than input-output tables. Although the process analysis is incomplete some particular embodied energy paths are specified, often very accurately, as a matter of course (Treloar, 1997). However, the key of this process analysis failing due to its focus on detailing which has limit the completeness of the system boundary. The sufficiently

complete system boundary may be impossible to cover using process analysis, because of the complexity of upstream processes.

Process analysis begins with the measurement of all direct energy requirements of the main process and the output of the process, over a reasonable period of time (Treloar, 1997). In spite of the considerable time required, process analysis is the most common method of energy analysis. The second step is the identification of inputs of other products required by the process over the same period. The third step is the determination of the energy embodied in each product required by the main process. Products are commonly disaggregated only in to quantities of basic materials, meaning that the services and the processes that assemble and transform basic materials are excluded.

Process analyses rarely extend further than a few stages upstream and tend to ignore many inputs at each stage. This is because very few companies have data available on the capital values of their plants, as discussed by Alcorn and Baird (1996). Only some companies were able to estimate the residual value of their plant, but it was impossible for them to estimate with any meaningful accuracy as to how long their current plant would be in production. However, even with this inherent limitation, with the data available from the companies, process analysis is perhaps producing results that are sufficiently accurate for the purpose and considered specific.

2.2.4. Hybrid Analysis

A hybrid analysis method combines the useful features of the three analysis method outlined above, especially input-output analysis and process analysis. Hybrid techniques attempt to combine the benefits of input-output analysis and process analysis while minimising their respective limitations. The process analysis framework cannot be used as a

basis for hybrid analysis because of its incompleteness. However, the comprehensive input-output framework also cannot currently be used as a basis for hybrid analysis because the substitution of process analysis data in to the input-output model causes unwanted indirect effects.

Treloar (1997) recommended that a new input-output-based hybrid analysis method is required, so that specific process analysis data can be substituted for the most important components of the national average input-output model. A hybrid input-output method that enables any amount of industry data to be incorporated within a consistent input-output model while retaining overall system boundary completeness is indicated in Figure 2.5. Input-output-based hybrid methods can be classified in to three steps:

- (1) substitution of process analysis data in to the input-output model;
- (2) adding a column to the input-output model for the process analysis data; and
- (3) modification of direct energy paths with process analysis data.

Source: Treloar, 1998

Figure 2.5 Schematic of the Hybrid Input-Output-Based LCA Inventory Method

This new method is dependent on the decomposition of the input-output model in to mutually exclusive components. With this new method, the modification of a component using process analysis data can be done accurately. Only then can the remainder of the unmodified components be added to the value of the modified components to make the framework more comprehensive while maximising the reliability.

2.3. Embodied Energy Use

The energy use in buildings can be divided in to three main components: operating energy, recurring energy and initial embodied energy. Cole and Kernan (1996) demonstrated that demolition energy is insignificant. Figure 2.6 illustrates how materials are established from raw materials and put through the pre-building phase, building phase and post-building phase. Ideally, the best materials should enter in to the pre-building phase as raw materials and exit with the least amount of embodied energy, in order to be re-used or recycled with little or no waste material.

Figure 2.6 Processes of the Production of a Building from Raw Material to the Waste

If the quantity of any material is multiplied by its coefficient of embodied energy (embodied energy per unit measure), then the corresponding embodied energy due to that material in the house can be obtained. The total embodied energy for all the materials can then be found by summing the individual values (Pullen, 1995). Using the technique described above, it is possible to determine the effect of different materials such as timber or steel framing on the embodied energy of a house design. By carrying out more complex energy assessment with other energy inputs, generally, operational energy, recurring energy and initial energy can be determined. As discussed in the scope of work, this study only focuses on embodied energy component at the stage of occupancy.

2.3.1. Significance of Initial Embodied Energy

The initial embodied energy of a building is the energy used to acquire raw materials and manufacture, transport and install building products in the initial construction of a building ready to occupying. Initial embodied energy typically describes only the energy to initially produce a building and does not include the energy associated with maintaining, repairing and replacing materials and components over the lifetime of the building.

It may be considered counter productive to save energy embodied initially in the construction of a building at the expense of recurrent direct or indirect energy requirements. For example, it may take several years to recover the energy embodied in thicker levels of insulation in temperate climates, which may be an acceptable period (Treloar, 1997). In contrast, it may take several decades to pay back high levels of embodied energy in providing thermal mass, which may be an unacceptable length of time. Other factors, such as maintenance requirements, need to be considered, but problems with incomplete energy analysis methods may lead to invalid results.

Most recently, increasing operational energy efficiency makes embodied energy considerations ever more significant. The energy initially embodied in a building could be as much as 67% of its operating energy over a 25-year period. If additional embodied energy gained over the building life is also included, the total life-cycle energy could be larger than the operating energy over the same period (Cole and Kernan, 1996).

2.3.2. Significance of Operating Energy

Operating energy varies considerably with building use patterns, climate and season and the efficiency of the building and its systems. In this regard, it is useful to distinguish between these aspects of operating energy. The operating energy is energy directly influenced the insulation standards, efficiency of lighting and other systems and those, which are dependent upon the way in which the building is used and manage.

The energy used for operation can be considerably decreased by improving insulation of the building envelope, technical solutions, and etc. However, a notable exception is the claim by Treloar (1998) that increased operational energy efficiency alone may not result in minimum energy consumption in an overall life-cycle sense due to the effect of embodied energy requirements, such as those for additional thermal insulation.

Conservation efforts in the building industry over the past 20 years have focused almost exclusively on reducing building operating energy and building designers now have a reasonable understanding of operating energy performance (Cole and Kernan, 1996). This focus is also including number of valuable techniques for both accessing and improving on building operating energy. Studies of low energy houses have shown that the energy for production can account for 40% to 60% of the total energy use (Winther and Hestnes, 1999). However, it has been demonstrated that even if the energy for operation was very low in one

building due to insulation and high quality appliances, the total energy use in embodied energy of production, maintenance of such appliances and insulation in that building over 50 years was higher than that in a building with a higher energy requirement need for operation (Thormark, 2002). In other words this emphasises the importance of looking at energy consumption in a holistic and integrated manner.

2.3.3. Significance of Recurring Energy

Recurring embodied energy is difficult to estimate over the long term since energy is non-renewable. Any energy requirement by construction personnel is assumed to be part of the initial embodied energy. The recurring embodied energy is also the energy consumed in the maintenance, repairing, restoring, refurbishing and replacing materials, components or systems during the life of the building. Cole and Kernan (1996) stated that the embodied energy associated with replacement and repair of building elements over the life of a building is greater than that associated with any single element of the initial embodied energy.

Currently, for many building types, particularly in the commercial and retail sectors, major refurbishment often involves substantial reconstruction in to domestic building and is being undertaken at increasingly shorter intervals. Fit-out consists of internal partitions and doors, floor, wall and ceiling finishes and mechanical and electrical services. These elements are replaced more frequently than structural and envelope elements and use a greater proportion of energy intensive materials, for example, plastics and copper.

Since the basic structure of the building is assumed permanent, there is no recurring embodied energy associated with this component. Building services and interior finishes and components are the most significant categories of recurring embodied energy. However, the interior finishes and components, which represent only a relatively small portion of the initial

embodied energy, dominate the recurring embodied energy. Cole and Kernan (1996) demonstrated that recurring energy on the interior finishes and components show the result of approximately 1.3, 3.2 and 7.3 times their initial values for 25, 50 and 100 years building life-spans, respectively. Although there are clearly many uncertainties regarding future developments in materials and construction technologies, recurring embodied energy will remain a significant component of life-cycle energy which cannot be fully quantified.

2.4. Current Available Tools

Given the data intensity of life-cycle analyses, it is understandable that only recently has software emerged which attempts to incorporate life-cycle analysis methods in to the design and analysis of buildings. However, because of continuing data limitations and due to the every changing construction techniques and material choices, none of these tools are currently capable of modelling an entire building or computing the environmental impacts from all life-cycle phases and processes (Reijnder and Roekel, 1999). The processes that do exist at present are at best time consuming but at worst inaccurate. Two available tools are introduced in this section.

2.4.1. OPTIMIZE

OPTIMIZE is a Canadian database and computer program for estimating the life-cycle energy and environmental impact of residential buildings as measured in terms of both outdoor and indoor pollutant generation. The energy consumption itself during the use of a house is not evaluated with OPTIMIZE (CCIH, 1991). It is assumed that users will have access to existing programs for estimating the annual consumption of different fuels for

purposes of space heating and cooling, domestic hot water supply and operation of lights and appliances. It also describes how the life-cycle cost of a building, including external costs, may be determined.

To use the program it is only necessary to input the quantities of building materials in a particular house or assembly, in typical builder's units. A series of linked spreadsheets and databases then automatically calculate and summarize the weight and cost of every commodity, the embodied energy by fuel type, the maintenance and replacement energy over the life-time of the house, and the associated quantities of air pollutants and external costs. Estimates are made of the life-time quantity of outdoor and indoor air pollutants associated with the use of each type of energy embodied in the products and with the processes.

Program a OPTIMIZE facilitates the estimation of following main components of the life-cycle costing:

- (1) of the materials and maintenance;
- (2) the replacing factor: depend on the house's life-time, element's life-time, percentage of element's repair;
- (3) the waste factor: for each building element, about 5% is waste;
- (4) the demolition energy and energy of transportation of the waste;
- (5) the recycling of a building's demolition waste;
- (6) of reutilization for the building; and
- (7) the other external cost.

2.4.2. LICHEE

LICHEE is a life-cycle house energy estimator developed by CSIRO Building, Construction & Engineering (CSIRO BCE) in conjunction with the Cement and Concrete Association of Australia. The LICHEE system utilises 3D object-oriented CAD data, together with data about a building's total environmental impact, to create a lifetime profile for a particular design (Drogemuller *et al.*, 2002).

LICHEE analyses a standard house and produces a detailed report of building elements, materials, operational energy, embodied energy and life-cycle energy, to create an overall life-time energy picture of the design. The object-oriented nature of LICHEE enables the creation of a design with 3D objects such as a room or a roof and each time an object is altered or modified, objects which were not altered remain unchanged. This makes the entire design easy to modify or to be compared with alternative designs.

LICHEE is not a standalone system but a series of six sophisticated intercommunicating programs such as the Nationwide House Energy Rating Software (NatHERS) or ArchiCad (an object-oriented CAD architectural system compatible with IFC software) working in an integrated manner. LICHEE uses databases that are relevant to life-cycle assessments which are widely occupied over the world. The NatHERS component of the software, for example, allows LICHEE to produce a rating for a particular design, which indicates the building envelope's ability to minimise heating and cooling energy. ArchiCad enables a user to assess alternative designs in terms of environmental impact, without having to re-enter and update data about each new design.

Part of quantifying the life-cycle impact of a building involves determining each individual material's 'impact intensities' or properties, such as heat transfer rates, durability, life expectancy and embodied energy. To make embodied energy calculations, LICHEE

draws from a database of values for standard materials. It applies that data to the individual materials that have been chosen for a particular design, and then multiplies each separate item by the number of items to be used to construct the building. The end result is then fed back in to the analysis of the whole building's life-cycle impact.

2.5. Case Studies

Chen *et al.* (2001) studied two typical residential buildings in Hong Kong — 40-storey residential buildings, Harmony Block (HB) and New Cruciform Block (NCB). Harmony Block has a floor area of 39,040m² and 16 apartment units per floor with a central service core. New Cruciform Block consists of 10 apartment units per floor and a usable floor area of 26,600m². Standard factory-manufactured building components are used in both buildings. However, large panel steel formwork common to the block configuration was used in these buildings, which led to high quality construction and great efficiency in embodied energy and cost. The results indicate that the use of recycled steel and aluminium may produce savings of more than 50% in embodied energy. The embodied energy intensity for manufacturing and transporting building materials is reported as 7.15GJ/m² for HB and 6.96GJ/m² for NCB when using virgin steel and aluminium, while it is only 2.93GJ/m² for HB and 2.87GJ/m² for NCB when using recycled steel and aluminium, which are significant reductions.

Cole and Kernan (1996) examined the total life-cycle energy used in a 4620m² three-storey building for alternative wood, steel and concrete structural systems with underground parking. There are significant differences between the embodied energies of the three structural options. The initial embodied energy of the wood structure is 0.92GJ/m², significantly less than that of the equivalent steel option, which has the value of 1.48GJ/m² and the concrete option is 1.17GJ/m². Proportionally, the embodied energy of the steel

structure is 1.61 times greater and that of the concrete structure is 1.27 times greater than that of the wood structure.

Another case study was done by Morel *et al.* (2001) on the process of materials selection, design and construction for a series of small residential buildings in southern France. The embodied energy analysis shows energy consumption for one concrete house is 239GJ. It appears that the typical concrete house consumes 246% more energy than a house made with stone masonry where the energy consumption is 97GJ and 340% more energy required for the rammed soil house where energy consumption is 70GJ. The transport energy use to bring the materials to the building site was also calculated and the embodied energy of materials was calculated at the factory exit. The transport impact on the environment was significantly less for the stone masonry building with 480% lower and the rammed soil building with 640% lower than concrete building. By adopting local materials, the amount of energy used in building decreased by up to 215% and the impact of transportation by 433%. However, Morel *et al.* (2001) noted that adoption of local materials in developed countries could be hindered by the loss of traditional building crafts and lack of an appropriate building standard.

Reddy and Jagadish (2003) presented that aluminium and steel are the two high-energy metals commonly used in building construction. Even though aluminium is much lighter than steel, it consumes six times more energy than steel per unit weight. The modern tendency to use aluminium doors and windows can contribute significantly to the energy input in to a building. Consumption of these metals should be kept to a minimum in order to keep the embodied energy in a building low.

Cole (1999) investigated energy and greenhouse gas emissions associated with the construction relative to total initial embodied energy associated with materials production and fabrication. He found that construction accounted for 6% to 16% of the total embodied energy for wood assemblies, 2% to 5% for steel assemblies, and 11% to 25% for concrete assemblies.

Buchanan and Levine (1999) added that wood is a much better building material than more energy intensive materials such as bricks, aluminium, steel and concrete in considering global carbon emissions. However, an increase in wood use can only be justified if there is a corresponding increase in the area of forest available for long term sustainable management. Increase use of wood as a construction material, leads to a 17% increase in the average wood content of building stock in New Zealand. As a result, a 20% decrease in fossil fuel energy and a 20% decrease in atmospheric carbon emissions from manufacturing of all building materials have resulted, this helped the reduction of the embodied energy of the building industry.

Clearly, other considerations may influence the sequence of this process. For example, the pre-selection of building form will clearly influence the choice of building materials. However, the embodied energy of buildings can vary over a wide range depending upon the choice of building materials and building techniques. Reinforced concrete frames, reinforced concrete slabs, clay brick masonry, concrete block masonry and tiled roofs represent common conventional systems forming the main structure of buildings. Similar building systems can be found in many other developed and developing countries. Alternative building technologies such as stabilised mud blocks, prefabricated roofing systems, masonry vaults, filler slab roofs and lime-pozzolana cements can be used to minimise the embodied energy of buildings.

2.6. Expert Opinion

Expert consensus is used as an alternative when historical records are not adequate to develop embodied energy assessment tool (Treloar, 1997). Previous studies suggested that the development of embodied energy methodologies would be incomplete without some reference to data quality and error assessment.

To address the issues of data quality in embodied energy analysis, an attempt has been made to quantify the main sources of potential error in the estimation of the embodied energy of the materials and components of a house. Pullen (1995) stated that in the case of comparing alternative building materials or components, a lack of consideration of potential error could lead to misleading conclusions. New sources of process analysis data are required in order to make sure the future applications to produce reliable embodied energy data results in to complete products. Treloar (1998) suggested that this should include processes such as services involving banking, and processes involving the transformation of basic materials.

Previously, the environmental aspects of construction materials and design options were evaluated only qualitatively, emphasising issues such as recycled content, reduced solid wastes or lower energy associated with manufacturing. Qualitative assessments, however, cannot test the assertion that overall environmental performance has actually been improved (Myer and Chaffee, 1997).

CHAPTER 3

BILL OF EMBODIED ENERGY – CONCEPT AND METHODOLOGY

The first step towards optimisation of embodied energy in domestic construction is the improvement of our awareness and the capabilities in evaluating energy embedded in a domestic building. Although significant attempts have been made in the conservation of operational energy, through initiatives such as mandatory five star energy ratings and public awareness campaigns for new constructions, relatively lesser emphasis has been put on the optimisation of embodied energy aspect of domestic construction (HomeStar Energy Rating Services, 2003). After a detailed assessment of currently available best practices of embodied energy evaluation methods it was made apparent that availability of a standardised practice is lacking.

One major deterrent to improve the awareness within the industry and community to set targets for optimisation is that the available embodied energy data are in their most basic form. In most of the cases available embodied energy data are expressed in Mega Joules per unit measure of the construction material rather than the cumulative embodied energy of the numerous elements, both materials and activities, which contributes to complete a standard construction activity. For example if the end user wants to ascertain the embodied energy of a standard reinforced concrete stiffened slab as the foundation that requires the user to work from the first principles using basic data. This is quite understandable as the agencies

involved in establishing such basic data do not necessarily have an engineering background in the domestic industry.

Compared to other established practices in the industry such as cost estimate guides, labour norms, design capacity tables for various structural elements, product installation manuals and etc., the embodied energy evaluation methodologies need significant improvement to ensure robust and readily available standardised approach. It must be noted that the major proportion of the research time has been therefore invested on the aspect of standardising available basic data leading to the development of the web based tool which is considered as the major contributions from this research. Such standardised embodied energy data and robust tools, in the authors opinion, would influence the industry firstly towards the awareness and secondly towards optimisation.

Evaluation of embodied energy of standard construction elements such as different standard foundation types and sizes, floor slabs, finishes etc, using the available basic embodied energy data aligned to standard bill items given in the widely accepted cost guides considered as the most effective way to move forward. An important goal for the domestic building sector and the community is to produce buildings with minimal environmental impact, from an embodied energy point of view, by selecting low embodied energy element for their buildings.

This Chapter presents the work involved in and the progress made in the embodied energy evaluation methodology leading to standardising the practice, which is aligned to the widely accepted industry cost guide. Section 3.1 introduces the methodology and the current format of the basic embodied energy data used in this study. The grouping of the collected data and the specimen calculations of embodied energy evaluation of elements are discussed in Section 3.2. The preliminary study of a typical domestic building using the said method is presented in Section 3.3.

3.1. **Basic Data**

This study required reliable embodied energy data of various processed construction materials involved in the domestic construction. Such data obtained from published literature forms the base of this study and as such referred in this study as the “*Basic Data*”. The verification of the accuracy of reported basic embodied energy data or the procedure adopted in establishing such basic data is not within the scope of this research. However it is considered appropriate to discuss some of the limitations reported in literature which may be influencing the quality and accuracy of basic data in general and in effect obviously inherent in this research outcome.

Embodied energy coefficients are used to establish direct embodied energy. It is acknowledged that they may vary due to a variety of reasons including different derivation methods or dissimilar production processes. Pullen (1995) stated that more information is required on the quality of embodied energy data both in quantitative and qualitative terms. It must be noted that the current methods of establishing the basic data is a progressive evolving field of study. There are significant amount of work currently being undertaken in this active field. As such quality and quantity of data are progressively improving. It is also clear that there is a significant scatter in the established data indicating the sensitivities and variabilities surrounding the processes and procedures.

It is observed through literature that obtaining data from companies producing building materials yielded generally good results. According to Alcorn and Baird (1996) and Adalberth (1997), very few companies had data available in a form from which energy coefficients could be deduced immediately. Even fewer had done calculations to establish the amount of energy they were using to produce their total output or individual products. None had applied other factors, such as the energy cost of producing electricity, to the calculation of the energy intensities of their products.

Nonetheless, it appears that there was considerable interest, support and practical help in the acquisition of energy figures, especially during last decade. Understandably reluctance to release what could potentially be commercially sensitive information is also reported. In such instances companies were not prepared to disclose energy use or production data. Others were prepared to release information on the basis that the original form of the figures would remain confidential and only an energy coefficient would be produced for the material in question. It is also published that some firms were prepared to release data, but only on the basis that they were not identified.

Cole (1999) added that the transportation for various materials from distribution centres to specific building sites, as well as worker travel distances. For the building construction is a labour intensive practice and as such account is taken of worker transportation to and from the construction site. The transportation of construction personnel to and from the construction site is a significant component of the construction process ranging from 5% to 85%. The distance which each material needs to be transported will vary for each method of construction, which is the reason transporting energy, is not included in the most of available embodied energy values. Morel *et al.* (2001) suggested that transportation of materials is a major factor in the cost and energy of a building. Most of the building materials in urban and semi-urban centres are transported using trucks in most countries. Research by Reddy and Jagadish (2003) indicates that materials such as sand are transported from a distance of 70 to 100 km in cities like Bangalore, India. Similarly, bricks, crushed aggregate, etc. travel about 40 to 60 km before reaching a construction site, in urban and semi-urban centres. The study gives the embodied energy of natural sand and crushed stone aggregate as about 1.75 MJ/m^3 for every one km of transportation distance and that of bricks, about 2.0 MJ/m^3 per km travel.

Embodied energy intensities denote the amount of direct and indirect energy that is required to produce one unit of such materials. These embodied energy intensities should include imports. Transportation covers shipping of materials from place of extraction to manufacturing site and from manufacturing site to construction site. The energy intensities of imports are in most cases unknown and are therefore often neglected or assumed to be equal to the domestic energy intensities of similar products. The assumption has errors in the indigenously calculated embodied energy intensities vary from country to country. Differences in a country's economic structure and in the level of technology can give rise to varying energy intensities (Battle and McCarthy, 2001).

However, building construction also includes burden from electricity used for power tools and lighting, as well as diesel fuel used by heavy equipment at the construction site. Activities include site preparation, structural and envelope installation, mechanical, electrical equipment installation, and interior finishing. Energy and environmental flows associated with the construction process could not be developed directly, since there was no record of equipment use or operational hours (Scheuer *et al.*, 2003).

Energy embodied in inputs of services, such as banking and government administration, is rarely mentioned. Treloar (1998) discussed that administration in the embodied energy analysis of a house should appear in the energy cost for the construction contractor's administration, rather than local government administrative services. Inputs of other services, such as finance and insurance, either for the contractor, the building owner, or upstream manufacturers, were not mentioned. This may be because they were assumed to be negligible. Where 'services' are mentioned in the embodied energy analysis of a building, what is usually meant is 'building services' such as plumbing and air conditioning.

Table 3.1 Basic Data – Embodied Energy of Products and Materials

Product	Unit	Embodied Energy (GJ/unit)
15 MPa conc.	m ³	0.16600
20 MPa conc.	m ³	0.17600
30 MPa conc.	m ³	0.19800
banking	\$	0.00107
bitumen	m ³	7.93000
carpet	m ²	0.36400
cement in 15 MPa conc.	t	12.20000
cement in 20 MPa conc.	t	12.20000
cement in 30 MPa conc.	t	12.20000
clay brick	m ²	0.75400
clear float glass 4mm	m ²	1.87000
colorbond decking	m ²	0.59200
copper	t	660.00000
copper (elect)	t	757.00000
fibreglass batts R2.5	m ²	0.16100
furniture	\$	0.00120
household appliance	\$	0.00193
laminare	t	85.70000
MDF architrave 67mm	m	0.05110
MDF architrave 92mm	m	0.05850
membrane	m ²	0.00288
paint	m ²	0.00498
particleboard	m ³	4.44000
plasterboard 10mm	m ²	0.08700
plasterboard 13mm	m ²	0.10900
plastic	t	85.70000
reflective foil	m ²	0.22900
sand	m ³	0.26000
screenings	m ³	0.33500
stainless steel	t	48.70000
steel	t	48.70000
structural steel	t	48.70000
tiles, ceramic	m ²	1.30000
timber	m ³	5.06000
timber (plywood)	m ³	27.60000
timber (structural)	m ³	5.06000
toughened glass 6mm	m ²	4.54000
UPVC pipe (90 slotted)	m	0.02690
UPVC pipe 100	m	0.03420
UPVC pipe 20	m	0.00684
UPVC pipe 25	m	0.00855
UPVC pipe 40	m	0.01370
vinyl flooring	m ²	0.08970
vitreous china	kg	0.20400

Source: Treloar, 1998

The bulk of data used in this study is obtained from Treloar (1998). He has introduced a hybrid technique to evaluate the more refined form of estimates addressing many of the above discussed concerns. Table 3.1 summarises the basic data proposed by Treloar (1998) which are used in this study.

3.2. Concept of Bill of Embodied Energy – BEE

As mentioned before one of the main focuses here is to encourage the existing domestic construction practices to accommodate the estimation of embodied energy as an essential component of their planning. The argument here is that if the industry recognises and influences the optimisation of the embodied energy at the early stage of planning, the resulting life-cycle energy becomes lower. This would also encourage the informed decision making in establishing even lower targets over a period and encourage policy changes for better products and processes. This is a major cultural shift which is considered essential and at this stage, to best of author's knowledge, policy innovation in this area is lacking compared to potable water conservation and operational energy conservation.

In current practice economies of scale justify many decisions. It is becoming more and more apparent that, when projects are evaluated using a triple bottom line approach - environmental, economical and social, economies of scale may require a deferent perception and approach. Establishing the priced "bill of quantities" (BOQ) for a given construction project is one of the mandatory requirements. This is arguably the most influential driver in most of the decisions. The proposed concept endeavours to draw a parallel between a "BOQ", which the industry is more accustomed to, and the bill of embodied energy, referred to here as a "BEE".

To achieve this outcome, as mentioned before, the methodology adopted in the study is to estimate and standardise the embodied energy of billed items given in standard cost guides used in Australia. This alignment, in my view, is expected to create a positive impact. Also it is important to realise that the domestic construction industry adopts a large volume of standard engineered products. If and when the embodied energy estimates of such standard engineered products are made available alongside the unit costs of such repetitive large volume items, the full appreciation of the situation is feasible. This research has established a cost and embodied energy data base for the listed items of widely accepted Emma and Cordell (2004) building cost guide. Using this database a software tool facilitating the optimisation of embodied energy against cost is also developed. This web based software tool called “BEE” is capable of producing a bill of embodied energy along side a priced bill of quantities. Time constraints warranted in developing only user interactive optimisation capabilities but the tool can be further developed to automate the process. This task is recommended for further work.

3.3. Estimation and Organisation of Cost and Embodied Energy Data

As mentioned before this research is required to collate and rationalise embodied energy data. Many aspects of the domestic industry practice over many years have advanced towards an engineered and rationalised system. These include prescriptive design approach, proprietors’ product range, pre-fabricated installation processes etc. On the positive side this enables efficient and speedy construction practice which saves time and money. On the negative side this has cemented a trade culture and patrons’ perception of a “standard home”. It must also be noted that many investment decisions on housing are driven by the re-sale value. Such conditions are not conducive to sudden changes. On the one hand the changes within domestic industry, especially if commercially sensitive, may need substantial effort and time before being accepted to become a standard practice. On the other hand, any sudden

changes requiring alterations to owner perception takes even longer time. The evaluation of embodied energy by establishing the Bill of Embodied Energy, as a standard pre-condition is therefore a contentious topic, and therefore requires significant effort and time to consolidate.

Figure 3.1 Embodied Energy and Cost Databases Structure

The listing and rationalising of various construction activities in domestic construction is a complex issue. This depends on the specialist trades, construction interfaces and practices. It can become unproductive to establish embodied energy assessments of various components of a domestic building independent of the standard practices. Emma and Cordell (2004) building cost guide provides an exhaustive list of such standard construction items which is effectively used in this research. Figure 3.1 illustrates the organisation of the listing used to evaluate embodied energy of various components. It is also used as the framework in developing and organising both embodied energy and cost databases.

The objective of the exercise is to structure embodied energy data to align with standard and established domestic construction practices. In this manner it is feasible to estimate and quantify embodied energy of standard building components which can be robust in application. All construction activities in domestic construction are divided in to three main groups. Namely structure, services and finishes. Structure group involves structural elements both load bearing and non load bearing. Services group includes all building services such as plumbing, electricity, heating and cooling, appliances etc. Finishes include all internal and external decorations, door and window furnishes, painting etc. Each group is then subdivided in to a number of elements similar to the examples given above. Each element is then subdivided in to a number of items which comprise a number of components. Table 3.2 provides a summary listing of elements under each group as examples. A full list of the elements is provided in Appendix A, Table A.1.

Table 3.2 Summary of Elements within Each Grouping

Groups	Elements
Structures	<ul style="list-style-type: none"> - Piering & piling - Concrete in-situ - Concrete composite - Mansory – Brickwork - Structural steel - Carpentry - Roofing
Finishes	<ul style="list-style-type: none"> - Metalwork - Insulation - Glazing - Plastering - Floorcovering - Plumbing - Doors - Sundry appliances
	<ul style="list-style-type: none"> - Carpentry - Joinery - Roofing - Tiling - Painting - Windows - Blinds & curtains
Services	<ul style="list-style-type: none"> - Plumbing - Drainage - Roofing plumbing - Electrical services - Mechanical – air conditioning - Fire protection

Building cost guide (Emma and Cordell, 2004) provides a detail description of most widely used items and components in Victoria, Australia (Refer Appendix A, Table A.2). They are defined either by standard sizes, strength grades, material type etc. The evaluation of embodied energy of a unit measure of the component involves a full breakdown of all materials involved and the quantity take-off of such materials involved in the process. Using

the basic data provided in Table 3.1 (Treloar, 1998), with the estimated quantities of each material contributing to a unit measure of the component it is possible to evaluate the cumulative embodied energy of the component under consideration. It is assumed that the embodied energy resulting from the use of power tools, site preparation and transportation etc., of the component is closely represented by the cumulative sum of the allowances made when establishing basic data.

A number of specimen calculations are presented here in Table 3.3 through to Table 3.10 to demonstrate the above approach. The full account of estimated embodied energy values for each standard component listed in the building cost guide is given in Appendix A, Table A.3. The embodied energy estimates presented in this study represent embodied energy of unit measure of each component in GJ. Significant research effort and time had to be invested in to the establishment of these embodied energy estimates although process is fairly straight forward. These established data are then incorporated in to the database of the software tool – *BEE*, discussed in Chapter 4. It is also considered as a major contribution from this research as such data is not available to the community over the web.

The primary data used in Embodied Energy and Cost Databases (Appendix A) are obtained, respectively, from Emma and Cordell (2004) and Treloar (1998). The descriptors of the construction items or activities are also in accordance with the Emma and Cordell (2004). In estimating and expressing the embodied energy component of a given construction item or activity, same units used in Emma and Cordell (2004) building cost guides for meaningful comparisons. Specimen calculations are presented in Table 3.3 to Table 3.10 to illustrate the method. It is obvious that the computations are only a small sample of the exhaustive list of items given in Appendix A.

Table 3.3 Specimen Calculation of Strip Footing

Specimen Calculation – Strip FootingSpecification

Reinforced concrete strip footing of 300mm deep x 300mm wide; 20 MPa concrete placed by pump in to trenches; 2 layers of F8TM3 trench mesh

Embodied Energy Estimates (1m Length)

Direct Energy:

$$20 \text{ MPa conc.} = 0.176 \text{ GJ/m}^3,$$

$$\text{Steel} = 48.7 \text{ GJ/t},$$

$$\begin{aligned} \text{Concrete} &= (0.3\text{m} \times 0.3\text{m} \times 1.0\text{m} \times 0.176 \text{ GJ/m}^3) \\ &= 0.0158 \text{ GJ} \end{aligned}$$

$$\text{F8TM3} = 150 \text{ mm}^2/\text{m},$$

$$\rho_{\text{steel}} = 7.85 \text{ t/m}^3,$$

$$\begin{aligned} \text{Reinforcement} &= (150 \times 10^{-6} \text{ m}^2/\text{m} \times 1.0\text{m} \times 7.85 \text{ t/m}^3 \times 48.7 \text{ GJ/t} \times 2 \text{ layers}) \\ &= 0.0158 \text{ GJ} \end{aligned}$$

$$\begin{aligned} \therefore \text{Total Embodied Energy} &= (0.0158 + 0.0158) \text{ GJ} / 1.0\text{m} \\ &= \mathbf{0.1305 \text{ GJ/m}} \text{ (refer to Page 174, Table A.3, Section 3.1)} \end{aligned}$$

Table 3.4 Specimen Calculation of Raft Slab

Specimen Calculation – Raft SlabSpecification

Reinforced concrete raft slab comprising 100mm thick slab with edge beams; including excavation for edge beams; 100mm sand base; 200 μ m polythene underlay; termite soil barrier treatment; 20MPa concrete placed by pump; steel trowel finish; 1 layer of F8TM3 trench mesh and 1 layer of F72 square mesh; with 300mm deep x 300mm wide edge beams

Embodied Energy Estimates (10m $\times$ 10m Area)

Direct Energy:

$$20 \text{ MPa conc.} = 0.176 \text{ GJ/m}^3,$$

$$\text{Reinforcement} = 48.7 \text{ GJ/t},$$

$$\text{Sand} = 0.26 \text{ GJ/m}^3,$$

$$\begin{aligned} \text{Concrete (beams)} &= 0.3\text{m} \times 0.3\text{m} \times 10\text{m} \times 0.176 \text{ GJ/m}^3 \times 2 \text{ beams} \\ &= 0.3168 \text{ GJ} \end{aligned}$$

$$\begin{aligned} \text{Concrete (slabs)} &= 0.1\text{m} \times 10\text{m} \times 10\text{m} \times 0.176 \text{ GJ/m}^3 \\ &= 1.7600 \text{ GJ} \end{aligned}$$

$$\text{F8TM3} = 150 \text{ mm}^2/\text{m},$$

$$\rho_{\text{steel}} = 7.85 \text{ t/m}^3,$$

$$\begin{aligned} \text{Steel (F8TM3)} &= 150 \times 10^{-6} \text{ m}^2/\text{m} \times 10\text{m} \times 7.85 \text{ t/m}^3 \times 48.7 \text{ GJ/t} \times 1 \text{ layer} \\ &= 0.5734 \text{ GJ} \end{aligned}$$

F72 mesh	$= 3.1\text{kg/m}^2$,
Steel (F72 mesh)	$= 3.1 \times 10^{-3}\text{t/m}^2 \times 10\text{m} \times 10\text{m} \times 48.7\text{GJ/t} \times 1 \text{ layer}$ $= 15.0970\text{GJ}$
Sand	$= 0.1\text{m} \times 10\text{m} \times 10\text{m} \times 0.26\text{GJ/m}^3$ $= 2.6\text{GJ}$
$\therefore$ Total Embodied Energy	$= (0.3168 + 1.7600 + 0.5734 + 15.0970 + 2.6)\text{GJ} / (10 \times 10)\text{m}^2$ $= \mathbf{0.2035\text{GJ/m}^2}$ (refer to Page 175, Table A.3, Section 3.6)
** The polythene underlay and the termite soil barrier treatment have been excluded from embodied energy estimates, considering their impact is negligible.	

Table 3.5 Specimen Calculation of Stiffened Raft Slab

Specimen Calculation – Stiffened Raft SlabSpecification

Reinforced concrete stiffened raft slab comprising 100mm thick slab with edge and internal beams; including excavation for beams; 100mm sand base; 20 MPa concrete placed by pump; steel trowel finish; 1 layer of F11TM3 trench mesh and 1 layer of F72 square mesh; with 300mm deep x 300mm wide beam @ 7.0 meter spacing

Embodied Energy Estimates (21m × 21m Area)

Direct Energy:

$$20 \text{ MPa conc.} = 0.176 \text{ GJ/m}^3,$$

$$\text{Steel} = 48.7 \text{ GJ/t},$$

$$\text{Sand} = 0.26 \text{ GJ/m}^3,$$

$$\begin{aligned} \text{Concrete (100mm section of slab)} &= 21\text{m} \times 21\text{m} \times 0.1\text{m} \times 0.176 \text{ GJ/m}^3 \\ &= 7.7616 \text{ GJ} \end{aligned}$$

$$\begin{aligned} \text{Concrete (6nos.} \times 200\text{mm} \times 300\text{mm beams)} &= 6\text{nos.} \times 0.2\text{m} \times 0.3\text{m} \times 21\text{m} \times 0.176 \text{ GJ/m}^3 \\ &= 1.3306 \text{ GJ} \end{aligned}$$

$$\text{F11TM3} = 300 \text{ mm}^2/\text{m},$$

$$\rho_{\text{steel}} = 7.85 \text{ t/m}^3,$$

$$\begin{aligned} \text{Steel (F11TM3)} &= 300 \times 10^{-6} \text{ m}^2/\text{m} \times 6\text{nos.} \times 21\text{m} \times 7.85 \text{ t/m}^3 \times 48.7 \text{ GJ/t} \\ &= 14.4508 \text{ GJ} \end{aligned}$$

$$\text{F72 mesh} = 3.1 \text{ kg/m}^2,$$

$$\rho_{\text{steel}} = 7.85 \text{ t/m}^3,$$

$$\begin{aligned} \text{Steel (F72 mesh)} &= 3.1 \times 10^{-3} \text{ t/m}^2 \times 21\text{m} \times 21\text{m} \times 48.7 \text{ GJ/t} \\ &= 66.5778 \text{ GJ} \end{aligned}$$

$$\begin{aligned} \text{Sand} &= 21\text{m} \times 21\text{m} \times 0.1\text{m} \times 0.26 \text{ GJ/m}^3 \\ &= 11.4660 \text{ GJ} \end{aligned}$$

∴ Total Embodied Energy

$$\begin{aligned} &= (7.7616 + 1.3306 + 14.4508 + 66.5778 + 11.4660) \text{ GJ} / (21 \times 21) \text{ m}^2 \\ &= \mathbf{0.2304 \text{ GJ/m}^2} \text{ (refer to Page 175, Table A.3, Section 3.7)} \end{aligned}$$

Table 3.6 Specimen Calculation of Clay Brickwork

Specimen Calculation – Clay BrickworkSpecification

Clay metric standard 110mm thick bricks; 230 x 110 x 76mm laid in 1:1:6 cement mortar

Embodied Energy Estimates (1m × 1m Area)

Direct Energy:

Clay Brick = 0.754GJ/m²,

15 MPa concrete = 0.166GJ/m²,

Clay Brick = 0.7540GJ/m²

Mortar = [(1.0m × 1.0m – 0.23m × 0.076m × 50nos.) + 2sides × 1.0m × 1.0m] × 0.166GJ/m²
= 0.3529GJ/m²

∴ Total Embodied Energy = (0.7540 + 0.3529)GJ/m²
= **1.1069GJ/m²** (refer to Page 176, Table A.3, Section 4.1)

Table 3.7 Specimen Calculation of Wall Framing

Specimen Calculation – Wall FramingSpecification

Wall frame 2400mm high comprising untrenched plates; 75 x 38mm @ 450mm centres studs; one row nogging and bracing

Embodied Energy Estimates (4.5m Length)

Direct Energy:

$$\text{Timber} = 5.06 \text{ GJ/m}^3,$$

$$\text{Steel} = 48.7 \text{ GJ/t},$$

$$\begin{aligned} \text{Studs} &= 10 \text{ nos.} \times 0.075 \text{ m} \times 0.038 \text{ m} \times 2.4 \text{ m} \times 5.06 \text{ GJ/m}^3 \\ &= 0.3461 \text{ GJ} \end{aligned}$$

$$\begin{aligned} \text{Noggings} &= 4.5 \text{ m} \times 3 \text{ nos.} \times 0.075 \text{ m} \times 0.038 \text{ m} \times 5.06 \text{ GJ/m}^3 \\ &= 0.1947 \text{ GJ} \end{aligned}$$

$$\rho_{\text{steel}} = 7.85 \text{ t/m}^3,$$

$$\begin{aligned} \text{Bracings} &= \sqrt{(2.4^2 + 0.45^2)} \text{ m} \times 10 \text{ nos.} \times 0.02 \text{ m} \times 0.001 \text{ m} \times 7.85 \text{ t/m}^3 \times 48.7 \text{ GJ/t} \\ &= 0.1867 \text{ GJ} \end{aligned}$$

$$\begin{aligned} \therefore \text{Total Embodied Energy} &= (0.3461 + 0.1947 + 0.1867) \text{ GJ} / 4.5 \text{ m} \\ &= \mathbf{0.1617 \text{ GJ/m}} \text{ (refer to Page 179, Table A.3, Section 7.6)} \end{aligned}$$

Table 3.8 Specimen Calculation of Upper Floor Framing

Specimen Calculation – Upper Floor FramingSpecification

Standard framing to upper floor including 150 x 50mm @ 450mm centres joists and solid blocking at 1800mm centres (floor boards not included)

Embodied Energy Estimates (5.4m × 5.4m Area)

Direct Energy:

$$\text{Timber} = 5.06 \text{ GJ/m}^3,$$

$$\begin{aligned} \text{Timber (12} \times \text{5.4)} &= 12\text{nos.} \times 5.4\text{m} \times 0.15\text{m} \times 0.05\text{m} \times 5.06\text{GJ/m}^3 \\ &= 2.4592 \text{ GJ} \end{aligned}$$

$$\begin{aligned} \therefore \text{Total Embodied Energy} &= 2.4592\text{GJ} / (5.4 \times 5.4)\text{m}^2 \\ &= \mathbf{0.0843 \text{ GJ/m}^2} \text{ (refer to Page 179, Table A.3, Section 7.3)} \end{aligned}$$

Table 3.9 Specimen Calculation of Tilt-up Concrete Wall Panel

Specimen Calculation – Tilt Up Concrete Wall PanelSpecification

30MPa precast concrete with 100mm thick tilt up wall panels (30m^2) with smooth off form finish cast on site and fixed in position including craneage

Embodied Energy Estimates ($1.0\text{m} \times 1.0\text{m}$ Area)

Direct Energy:

$$30 \text{ MPa conc.} = 0.198\text{GJ/m}^3,$$

$$\text{Steel} = 48.7\text{GJ/t},$$

$$\begin{aligned} \text{Concrete} &= 0.1\text{m} \times 1.0\text{m} \times 1.0\text{m} \times 0.198\text{GJ/m}^3 \\ &= 0.0198\text{GJ} \end{aligned}$$

Steel (Assume 150 kg/m^3 reinforcement)

$$\begin{aligned} &= 150 \times 10^{-3}\text{t/m}^3 \times 0.10\text{m} \times 1.0\text{m} \times 1.0\text{m} \times 48.7\text{GJ/t} \\ &= 0.7305\text{GJ} \end{aligned}$$

$$\begin{aligned} \therefore \text{Total Embodied Energy} &= (0.0198 + 0.7305)\text{GJ} / (1.0 \times 1.0)\text{m}^2 \\ &= \mathbf{0.7503\text{GJ/m}^2} \text{ (refer to Page 206, Table A.3, Section 26.2)} \end{aligned}$$

Table 3.10 Specimen Calculation of Pitched Roof Framing

Specimen Calculation – Pitched Roof FramingSpecification

Standard framing 20° pitched roof; 600mm overhang; including 100 x 38mm rafters @ 450mm centres; ridge; underpurlins; struts and collar ties; (Calculated on flat plan area; measured to outer line of overhang)

Embodied Energy Estimates (9.0m × 9.0m Area)

Direct Energy:

$$\text{Timber} = 5.06 \text{ GJ/m}^3,$$

$$\begin{aligned} \text{Rafters} &= 20\text{nos.} \times 0.1\text{m} \times 0.038\text{m} \times 9.0\text{m} \times 5.06\text{GJ/m}^3 \\ &= 3.4610\text{GJ} \end{aligned}$$

$$\begin{aligned} \text{Ridges} &= 15\text{nos.} \times 0.015\text{m} \times 0.025\text{m} \times 9.0\text{m} \times 5.06\text{GJ/m}^3 \\ &= 0.2562\text{GJ} \end{aligned}$$

$$\begin{aligned} \text{Underpurlins} &= 4.2286\text{m} \times 20\text{nos.} \times 0.1\text{m} \times 0.038\text{m} \times 5.06\text{GJ/m}^3 \\ &= 1.6262\text{GJ} \end{aligned}$$

$$\begin{aligned} \therefore \text{Total Embodied Energy} &= (3.4610 + 0.3416 + 1.6262)\text{GJ} / [(9 \times 9) \times \cos 20^\circ]\text{m}^2 \\ &= \mathbf{0.0702 \text{ GJ/m}^2} \text{ (refer to Page 181, Table A.3, Section 7.15)} \end{aligned}$$

3.4. The Assumptions

Some simplifications and assumptions needed to be made due to the lack of availability of basic data when establishing some embodied energy estimates.

For example, there are numerous types of steel and plastic products adopt in the domestic construction. Different grades of steel, stainless steels and normal steel, structural and none structural steel, reinforcing bars (ribbed or plain), hot rolled and cold formed steel structural members, etc. This is the same with plastics and polyurethane or cement products. It is arguable that embodied energies of these products are markedly different or close enough for the intended purpose. However, as discussed in Chapter 2, LCA analysis hardly capture variations of the type discussed above as they only quantify major industry sector. This suggest that in the absence of more refined data the only alternative available to the researchers would be to use the embodied energy coefficients of a more representative material to supplant missing data. For instant embodied energy coefficients of “steel” to represent all deviations of steel products assuming that the impact of such an approach is better than not accounting at all.

The other assumption is that the basic embodied energy data adopted by this study given in Table 3.1 include processing, transportation and placement on site.

Where no embodied energy data is available, such as in the case of domestic appliances, building services components etc., the cost is modified using recommended factors given in Table 3.1.

CHAPTER 4

PROPOSED SOFTWARE TOOL -

Methods of establishing basic embodied energy data is discussed in Chapter 2. The need to transform such basic data in to a more robust form of embodied energy information to align with the standard industry practices and the work carried out achieving that are presented in Chapter 3. The concept of the “Bill of Embodied Energy – BEE” is also introduced in Chapter 3.

This Chapter presents the work completed in developing a web based software tool, incorporating the more robust form of embodied energy information proposed in Chapter 3. This chapter is also attempting to demonstrate the capabilities and the versatility of such a web based tool in disseminating the importance of optimising the embodied energy in domestic construction to community. Upon implementation, the proposed tool can be quite effective in minimising the embodied energy in the current domestic construction practice with a particular emphasis on establishing even lower targets for future developments. This chapter also presents a brief user guide for the BEE software and the demonstration case comparison outcomes in validating and calibrating the web based software tool.

The BEE software tool is developed in part to demonstrate the methodology and to introduce the concept of “Bill of Embodied Energy”. Chapters 2 and 4 have discussed in detail the challenges and limitations of the existing embodied energy data and regional and

process dependency of the data. Cost data given in building cost guides are also regional and time dependent. Emma and Cordell (2004), “Building Cost Guide, Housing, Victoria”, which provided the cost data used in the BEE tool obviously only applicable to Victoria, Australia. However, the methodology, the data base and the program structure can be easily adapted to serve other regions and localities.

4.1. Configuring the BEE Tool

The concept of bill of embodied energy is introduced and discussed in Chapter three which forms the basis of the development of the tool. A brief description of two other commercially available software tools OPTIMIZES and LICHEE was provided in Section 2.4. Consideration is also given to the time constraints of a masters study program in selecting the final configuration of the software development. Extensive time and effort had put in to building the rationalised cost and embodied energy data base. As demonstrated in Section 3.2, aligning list of standard elements to have both cost and estimated embodied energy was a challenge. It is also obvious that the key variables, the cost and the embodied energy estimates, bound to change over the years and need periodic updates. It is also important to acknowledge that estimating embodied energy, at best, is not necessarily a perfected science. As the users of costing information services are aware that there is no such thing as a right or wrong price for any particular item of work, only high and low prices, estimated embodied energy information should also be treated in the same light.

After careful consideration on a number of different possible configurations for the BEE tool development the final framework and a flow chart was agreed upon as shown in Figure 4.1. It is also felt that rather than developing a stand alone desktop based tool, to investigate possibility of developing a web based tool. Author’s capabilities in web

development were somewhat limited at the start of the research and as such help was obtained where necessary from RMIT community.

One major driver to attempt a web based tool is the desire to disseminate the concept of BEE to a wider community involving researchers, home owners, builders and designers. It is author's belief that the current commercially available tools are restricted to specialist and professional groups. It is also envisaged that, as this is the first part of a long drawn research project at RMIT, availability of a large volume of embodied energy information for a number of different house plans, different material choices etc., would be useful in future work. In deciding the final configuration and the web based format for BEE tool the spin-off benefit discussed above also influenced the decision. This is considered feasible if the tool is made available free of charge on the web and in return seek the consent of the user to obtain their analysis results. This confidentiality agreement can be reach when providing the user name and password.

4.1.1. BEE Tool Framework and Flowchart

Figure 4.1 illustrates the framework and the flowchart of the BEE software development. As evident from the flow chart, it treats three domestic sectors as three independent streams. From the software development point of view, the reason for this is to provide more flexibility for future developments. From embodied energy evaluation point of view, it is important to recognise that these sectors of domestic construction industry differ significantly as they adopt different form of structure, finishes and building services. Obviously, the high density construction is more compact in living space and demand heavy structural needs including frame and foundations etc. Also the material selection, vertical transportation of men and material during construction, building services and building façade are significantly different to that of the single dwelling or medium density housing.

As mentioned before, domestic industry is highly rationalised in both, engineered products and prescriptive design guides, to achieve quick construction cycles. This is quite apparent when inquire in to the listed items and building components given in the cost guides as well. The conditions discussed above have a direct influence on how industry responses and operates and therefore has a direct influence on the embodied energy.

In light of the above, under each domestic sector, all activities were further divided in to three sub groups, namely structure, finishes and services as discussed in Chapter 3. It is interesting to note that basic embodied energy data for building services, building façades and some high quality finishes and domestic appliances are extremely hard to find or not available at all. Many researchers who involve in establishing basic embodied energy data recognise this condition and recommend, including Treloar (1998), to use cost as an indicator of the embodied energy where data is not available. Although this may be debatable, under the prevailing circumstances, this is the only alternative path available in such instances. Most of the case studies conducted to date suggest (Alcorn and Haslam, 1996) the proportion of embodied energy resides within the finishes and services in comparison to major structural and non structural elements are relatively small mainly due to their low volume.

Each of these groups supports an exhaustive list of elements and components in their respective areas. Therefore the estimated embodied energy of these elements, as discussed in Section 3.3 aligned to descriptors provided in the cost guide, are organised in the database under each respective group.

Computer program BEE performs a simple calculation to find out the embodied energy and the cost for a given component when the quantities are entered. To complete the process quantities are entered for all such relevant components under each element type within the group. Process must then be repeated for two other groups in a progressive and sequential manner to cover all three groups. BEE also writes and retains progressive

computations of cost and embodied energy to a bill of embodied energy alongside bill of quantities and also provides the cumulative total of embodied energy and the cost. Figure 4.1 illustrates how the optimisation takes place, which is an interactive process, within the above said procedure by indicating that as a sub loop. This means that the user can trial out different options until a satisfactory outcome is found without leaving the main procedure. The optimum or preferred option is recorded only when the user is satisfied and save the outcome.

As shown in Figure 4.1 a comprehensive but simple report is then generated giving list of billed items, embodied energy of each billed item and the cost of each billed item. Obviously it also provides the cumulative total of embodied energy and the cumulative total cost of the project. This process discussed here is further explained using the screen outputs for more clarity in Section 4.1.3.

Figure 4.1 Flowchart and the Framework of BEE Development

4.1.2. Program Coding

The software tool, *BEE* – “*Bill of Embodied Energy*” is coded and developed mainly using PHP language, which is also known as Hypertext Pre-processor. PHP is a widely used scripting language that is popular in web development applications. This coding language is popular among web developers as it is very versatile in writing dynamically generated pages. Bill of Embodied Energy is programmed to record user’s input, interactively, in to a plain text file. PHP eliminates the need for numerous small cgi programs by allowing you to place simple scripts directly in to HTML language to be displayed online. PHP also makes it easier to manage large web sites by placing all components of a web page in a single html file.

For example, if you are creating an online catalogue, you will most likely have a design template for all related catalogue pages. Traditionally, this design is generated manually in HTML and different data is presented within the template design. With PHP, one application can be used to generate all the pages required to display information from a database. In such instances data will appear in the proper page, in the right locations, and with the appropriate related content. This eliminates redundant page generation, simplifying maintenance. PHP also reduces the site down to a handful of template pages, with scripts that generate the rest of the site.

Apart from PHP, software program *BEE* also makes use of Javascript, a client-side scripting language particularly for menu creation. JavaScript is the most popular scripting language on the internet, and works in all major browsers, such as Internet Explorer, Mozilla, Firefox, Netscape and Opera. JavaScript was designed to add interactivity to HTML pages. This is feasible because a JavaScript consists of lines of executable computer code which can be embedded directly in to HTML pages.

BEE is temporarily hosted with a free web hosting provider – Ins Studio which supports the functionality. After coded, the program is uploaded to the web server via AceFTP program. AceFTP program is an all-around FTP client with a user-friendly interface. It delivers speed, reliability and powerful features, including a built in Explorer-style site manager, server-to-server file transfer, simultaneous site browsing, concurrent file transfers, integrated file preview viewer and more. The program also allows you to resume broken transfers and monitor them graphically with the Transfer Rate Viewer which enhances the capabilities, efficiency and trouble shooting. For webmasters, it supports setting of file permission on the remote server, using an easy-to-use properties dialog. Additional features include firewall support, auto-dialup, logging, and support for external viewers and more.

BEE software has a significant potential for further growth and expansion. This has been recognised in the design by selecting state-of the art coding languages and in the selection of code generation and debugging tools to provide maximum possible flexibility in further work.

4.1.3. User Guide

The following section presents a brief user guide and discusses the relationship between the *BEE* framework given in Figure 4.1 and the user interactive screens.

Accessing BEE through the Web

As mentioned the proposed BEE tool is a web based tool which can be accessed through the following web address. It must be noted that as mentioned in Section 4.1.2, current web hosting provider is a temporary arrangement (valid until December 2007) and will subject to change in future. To access the program, user is required to enter the username and the password given below.

Web Address: www.bee.ins-studio.com

User Name: s9912265

Password: 9912265

BEE Introduction Screen

Upon entering correct username and the password, *BEE* will greet the user with the screen shown in Figure 4.2 giving a brief introduction about the program and its capabilities. To continue the process, the user is required to enter a filename, which is also regarded as the project identification. This is a text file in to which all interactive input and output data are written. Click on the “*Start Using BEE Now*” button at the bottom of the screen to proceed to the next screen.

Figure 4.2 Welcome Screen

Selecting the Type of Domestic Sector

As mentioned before, in this study the domestic buildings are broadly categorised in to three domestic sectors. They are the single dwelling, medium density and high density. The definitions of medium and high density, within the context of this study, are medium density construction (15 to 35 units per block) and high density construction (40 to 80 units per block). The first screen appears when prompt to start BEE is given in Figure 4.3. As can be seen the user is required select the type of domestic sector from this screen by clicking on the appropriate type of domestic sector.

Figure 4.3 Domestic Construction Sector Selecting Screen

Estimation and Optimisation of Embodied Energy

Figure 4.4 Group Selecting Screen

Upon the selection of the type of domestic sector, the user will be offered to select specific groupings as shown in Figure 4.4. In producing a complete bill of embodied energy, elements and components within each group need to be taken in to account, by estimating one group at a time in a sequential manner until all three groups are fully accounted for.

Pointing the cursor on to each group, the corresponding list of the elements under each group can be viewed as shown in figure 4.5(a), figure 4.5(b) and figure 4.5(c).

Figure 4.5(a) Element Selection Screen – Structures Group

Figure 4.5(b) Element Selection Screen – Finishes Group

Figure 4.5(c) Element Selection Screen – Services Group

The embodied energy and cost calculations occur when the user reaches the screen shown in Figure 4.6. This screen is design to display the calculated embodied energy and cost as the user trial out various options to optimise embodied energy against cost of the components. As can be seen, from Figures 4.5(a) to 4.5(c) and Figure 4.6 when the user reaches this stage he has already selected the domestic construction sector, the group and the element type.

BEE
Current File: example.txt

Current Element: **Footings**

Component:

Material/Dimension/Methods of Construction:

Cost:	\$ 0.00
Embodied Energy:	0.0000 GJ

Selection Summary

Types of Elements: 0
Total Cost: \$ 0
Total Embodied Energy: 0 GJ
[View Full Report](#)

Figure 4.6 Interactive Optimisation Screen

Each item type has a number of components (Refer Appendix A, Table A.1) to select from. These are standard items similar to what is provided in the cost guide. The optimisation can be attempted by the way of making decisions, interactively, selecting options available while comparing cost and the embodied energy as mentioned above. Before reaching this stage a quantity take-off should have been already completed similar to what would have been done when preparing a priced bill of quantities. As each component is selected the quantities

must be entered in the same units appearing to the left of the “QTY” input box (Refer Figure 4.8). The interactive process can continue any number of trials until a firm decision can be made prior to saving. Figure 4.7(a) and 4.7(b) illustrates, through pull down menus, the process for a strip footing. All interim assessment attempts will not be recorded until the “SAVE” button is activated.

BEE
Current File: example.txt

Current Element: **Footings**

Component: -Select Type-
-Select Type-
Strip Footings
Pad Footings - Square pad
Pad Footings - Circular pad

Cost:	\$ 0.00
Embodied Energy:	0.0000 GJ

SAVE BACK

Figure 4.7(a) Interactive Optimisation Screen – Component Selection

BEE
Current File: example.txt

Current Element: **Footings**

Component: Strip Footings

Material/Dimension/Methods of Construction: -Select Type-
-Select Type-
300mm deep x 300mm wide with F8TM3
300mm deep x 400mm wide with F8TM4
400mm deep x 300mm wide with F8TM3
400mm deep x 300mm wide with F11TM3
400mm deep x 400mm wide with F11TM4
500mm deep x 300mm wide with F11TM3
500mm deep x 300mm wide with F12TM3
600mm deep x 400mm wide with F12TM4
600mm deep x 300mm wide with F12TM3(encased in double layer of 200 um polythene)

Embodied Energy:	0.0000 GJ
------------------	-----------

SAVE BACK

Figure 4.7(b) Interactive Optimisation Screen – Type of Construction Selection

Figure 4.8 illustrates how the interim trial results are displayed in real times as the process is completed. This would enable the user to have an appreciation of the embodied energy and the cost of each component. This would also enable, interactively, the optimisation of the embodied energy against the cost.

BEE
Current File: example.txt

Current Element: **Footings**

Component:

Material/Dimension/Methods of Construction:

QTY: m

Reinforced concrete strip footing; including excavation; 20 MPa concrete placed by pump into trenches; 2 layers of trench mesh

Cost:	\$ 1930.5
Embodied Energy:	6.525 GJ

Figure 4.8 Interactive Optimisation Screen – Input Quantity

When the final outcome of the trial process is saved the analysis results will be appearing on the “Embodied Energy” as shown in Figure 4.9. This process needs to be continued until all components under each element are completed. This process should repeat independently for all three groups, namely structure, services and finishes (Refer Figure 4.4).

A complete report comprising all construction elements and components within each of these three groups is generated as the finalisation process takes place for each step along the way. User can undo any mistakes they make by deleting any completed task. Appendix C (Table C.1) and Appendix D (Table D.1, Table D.2 and Table D.3) give a number of final reports generated by BEE for different case studies to demonstrate its capabilities. It is worth noting that how the embodied energy and cost for the overall project as well as for each item

is displayed alongside each other. To the author's knowledge this is the first of its' kind, web base tool which provides such analysis for Australian domestic construction market.

BEE

Current File: example.txt

No	Component	Material/Dimension/Methods of Construction	Unit	Qty	Cost (\$)	Embodied Energy (GJ)	Remove
1	Strip Footings	300mm deep x 300mm wide w/with F8TM3	m	50	1930.5	6.525	Remove
TOTAL COST						\$ 1930.5	
TOTAL EMBODIED ENERGY						6.525 GJ	

Figure 4.9 BEE Report Screen

4.2. Calibration of the Proposed Tool

Published results of a typical Australian domestic building studied by Treloar (1998) are used to evaluate the functionality and to compare results of the BEE software tool. Outcome of the evaluation is presented here.

4.2.1. Brief on Previous Study by Treloar (1998)

The typical domestic building reported by Treloar is situated in Essendon, Victoria, Australia. The dwelling is one of six in a block – a semi-detached, two-storey, two-bedroom brick-veneer unit. The total floor area of the control building is 123m², including the single-car garage.

The substructure of the building is reinforced concrete. The external load bearing walls are veneered double-brick 230mm thick. The interior structural framing (e.g. internal

walls, upper floor, roof, etc.) is timber and the roof cladding is colour-bond profiled steel decking. The walls and ceiling are insulated with reflective foil and fibreglass batts and the single glazed windows are timber framed. The floor finish is carpet cover in the living areas and bedrooms, vinyl tile cover in the kitchen and family areas and ceramic tile cover in the bathroom and toilet. Electrical appliances installed included a stove, refrigerator, washing machine, clothes drier, microwave oven, dishwasher and a space heater.

Treloar (1998) demonstrated that the total cost for the demonstration dwelling was around \$98,092.50, according to 1998 estimates, and the total embodied energy of the dwelling is about 835GJ. The costs and the embodied energy figure normalised per unit area (per square meter) are, respectively, \$797.50/m² and 6.79GJ/m². Figure 4.10 provides a breakdown based on three groups, namely structure, finishes and services. The figure shows a major part of initial embodied energy is used in the finishes elements (50.8%), followed by structural (43.4%) and only 5.8% of initial embodied energy is used in services. Figure 4.11 gives a detailed breakdown of all major activities involved in a typical single dwelling in Australia. It is evident that high volume items such as external walls, internal walls and roof have greater impact on the end outcome and therefore the optimisation should be focused on such high intensity, high volume sectors.

Figure 4.10 Embodied Energy of Demonstration Dwelling

Source: Treloar, 1998

Figure 4.11 Components Embodied Energy of Demonstration Dwelling

Treloar (1998) acknowledged that the total embodied energy for the demonstration dwelling derived above is subject to many assumptions, including the use of a national average price for the building construction. However, the assumption that the product quantities and direct energy intensities inferred by the input-output model apply to this

building is likely to be more significant because of the relative importance of the indirect energy indicated by the previous studies.

4.2.2. **BEE Analysis Results**

The same dwelling is analysed using the BEE software tool presented here. It has reported a total embodied energy estimate of 810GJ and an estimated total cost of \$125,186. Figure 4.12 gives a breakdown of the three main groups based on BEE results. When embodied energy and the costs were normalised per unit area of the dwelling, they amounts to 6.59GJ/m² and the total cost to \$1017.78/m². The BEE generated detail report on the analysis providing descriptions of billed items and quantities, their embodied energy estimates and their costs are given in Appendix C, Table C.1.

Figure 4.12 BEE Tool Estimates

Figure 4.12 provides a breakdown based on three groups, namely structure, finishes and services. The figure shows major parts of initial embodied energy reside in the finishes (51.8%) followed by structural elements (45.6%) and only 2.6% of initial embodied energy is used in services a trend similar to Treloars (1998) analysis.

4.2.3. Comparison and Discussion

All aspects of evaluation based on BEE software tool are in good agreement with published results by Treloar (1998) except the cost estimates. This is expected as Treloar's estimates were based on 1998 cost figures and he has used a national average cost/unit area where as BEE database uses the latest cost guide values provided for each item.

Figure 4.13 presents a comparison of exact embodied energy figures from two studies. The disparity between two studies is around 2.2% for structure group and 1.0% for finishes group. Cost comparisons are ignored because the cost estimates are seven years apart and there is no relevance in comparing them. BEE estimates, as expected, are greater than the estimates by Treloar. This is due to two main reasons:

- (1) as discussed in Section 3.1, for some items where basic embodied energy data is not available, cost of the item has been used as an indicator of embodied energy, and
- (2) in BEE, embodied energy data of an item takes many more details in to account in evaluation, because of the descriptions provided by the cost guides are more specific, compared to Treloar's work. For example, in a typical ground slab it takes in to account the compacted sand underlay, water proofing membrane etc.

However, it is interesting to note that BEE embodied energy estimates in services group are almost half of Treloar's estimates. There are not sufficient details or breakdown of what involved in services estimates by Treloar except that he has made allowances for landscaping, special provisions, fences, gates and etc. BEE database does not include embodied energy estimates for administrative processes involved in a house construction. This is because of unavailability of reliable data in this area.

Figure 4.13 Comparison BEE Estimates with Treloar (1998) Estimates

CHAPTER 5

DOMESTIC BUILDING MODELLING

Embodied energy estimates of typical Australian domestic construction were investigated to identify general trends and presented here based on three case studies. The embodied energy and cost estimates of the three cases were analysed using the proposed software tool BEE, discussed in Chapter Four. The three cases presented here represent single dwelling, medium density (15 to 35 units per block) and high density (40 to 80 units per block). It is envisaged that these case study outcomes would not only reveal the general trends but also would identify the areas which are needed to be targeted for future research. It is also expected that because the three case studies presented cover all three domestic construction sectors, the outcomes represent a wide spectrum of structural and non-structural materials, building configurations and floor layouts.

Treloar (1998) had demonstrated through his case study, given in Figure 4.11 in Chapter Four, that 44.4% of the total embodied energy of the house he studied reside within the brick veneered building envelope of the single dwelling. Treloar's work is further extended later in this chapter, in Section 5.3, by investigating and comparing eight different alternative material configurations for structural components of the same building. Again the BEE software tool was used to assess both costs and the embodied energy.

5.1. Domestic Building Case Studies

As mentioned before, the present pattern of metropolitan development in major Australian cities is one of spreading low-density outer suburbs, medium density housing in the city fringe and high density housing in the city center. Particularly in the single dwelling sector, the volume builders' market trends determine the building size, configuration and material usage. Therefore the environmental objectives, associated with the planning, selection of materials, construction and operation of domestic buildings, can be effectively managed through policy innovation in this sector. Minimisation of embodied energy has never been addressed at a policy level. This is an area where significant contributions can be made. Three domestic sectors, each representing single dwelling, medium density and high density living, are existing real buildings in Victoria and the specific detail information is regarded as commercially sensitive and confidential.

5.1.1. Case Study I – Single Dwelling Housing

The selected single dwelling is a typical volume builder's range two storey house with 320m² (including garage) located in Wantirna, Victoria. The building has typical 2.7m (including 300mm structural depth) ground floor height and 2.4m upper floor height. House is a standard brick veneered construction with load bearing timber framing and trussed roof. Figures 5.1(a) to 5.1(f) give floor plans, internal layout, elevations and main features. Building specification summary is given in Table 5.1. BEE analysis output results providing bill of quantities, embodied energy estimates and cost estimates are given in Appendix D, Table D.1.

Figure 5.1 (a) Ground Floor Plan

Figure 5.1 (b) Upper Floor Plan

Figure 5.1 (c) Front Elevation

Figure 5.1 (d) Rear Elevation

Figure 5.1 (e) Side Elevation 1

Figure 5.1 (f) Side Elevation 2

Figures 5.1(a) – (f) Single Dwelling Case Study Drawings

Table 5.1 Building Specifications – Single Dwelling Case Study

Groups	Components
Structure	Footing/slab on ground
	- Stiffened concrete slab on ground
	Upper floors
	- Timber floor – Particle boards on timber joists
	External walls
	- Brick veneered façade, load bearing timber frames with internal plasterboard finish
	Internal walls
	- Timber framed with plasterboard finish
	Roof
	- Concrete tiles on timber trusses
Finishes	- Aluminium windows and timber doors
	- Carpet (living room, family area and bedrooms)
	- Ceramic wall and floor tiling (kitchen, bathrooms, toilet and laundry)
	- Plaster board ceiling
	- Paint on wall and ceiling

The foundation of the building is a reinforced concrete stiffened slab on ground and the external walls are brick veneered load bearing timber frames with plasterboards to inside face. The internal walls are load bearing timber frames with plasterboard finishes. Roof is concrete tiles on timber trusses with a 23° pitch. Rainwater gutters and downpipes are colour-bond type. All plumbing is PVC except hot water supply lines which are copper pipes. The walls and ceiling are insulated with reflective foil and fibreglass batts, and the single glazed windows are aluminium framed. The floor finished with carpet in the living areas, family areas and bedrooms, and ceramic tiles in all the wet areas such as the kitchen, bathrooms, toilet and laundry. The building is fitted with built-in wardrobes in all bedrooms. Electrical appliances installed included a stove, refrigerator, washing machine, clothes drier, microwave oven, dishwasher and a space heater.

5.1.2. Case Study I – BEE Analysis Results

BEE software is used for the analysis of the house and a detailed account of embodied energy and cost is given in Appendix D, Table D.1. The estimated total cost of the single dwelling is about \$205,518 and the total embodied energy is around 1312GJ. As mentioned the single dwelling has a total area of 320m². This means that when the cost and the embodied energy are normalised per unit area of the single dwelling, respectively, the average cost is \$642/m² and the average embodied energy is 4.1GJ/m². Assuming an average family of four people (two parents and two children) or five people (two parents and three children) live in this house, the per capita initial embodied energy ranges between 262 to 328GJ/person respectively.

Figure 5.2 summarises the embodied energy and the costs associated with each grouping of the building activities, namely structure, finishes and services, averaged per unit

area. The figure shows that 62.1% of the initial embodied energy is associated with the structural components, followed by 33.7% associated with the finishes and only 4.2% of initial embodied energy is associated with the services. A similar trend is evident when costs are compared as well where 54.2% invested on the structural components, followed by 40.3% invested on the finishes and 5.5% invested on the services. There is a common consensus that cost is a reasonable qualitative indicator of the embodied energy, which is also apparent in this analysis. In other words, as can be seen from Figure 5.3, values of the embodied energy and the cost correlate. It is also indicative that high volume/mass materials, mainly resulting from structural components, are directly associated with higher embodied energy component. High embodied energy intensive materials such as aluminium used in windows are fortunately used in relatively small volumes.

Figure 5.2 Comparisons of Embodied Energy and Cost – Single Dwelling

Figure 5.3 shows the embodied energy within various elements of a typical builders' range single dwelling. Such a breakdown is vital to identify areas which need to be targeted in product and process improvements. It is interesting to note that typical brick veneered timber framed external walls contributes around 34.7%, roof contributes around 13.8% and floor finishes contribute around 11.1%, which are the major initial embodied energy intensive

elements. The results also show that the brick veneered timber framed external walls have the highest embodied energy used in the single dwelling, as a single item, account to around one third of the total embodied energy. Optimisation of such high intensity, high volume sectors should be given priority and can be achieved by using innovative building technologies with low embodied energy.

Figure 5.3 Embodied Energy Distributions – Single Dwelling

5.1.3. Case Study II – Medium Density Housing

The medium density domestic building investigated consists of four levels of two bedroom apartments. The ground floor has only six units with a central carpark area and all other floors have eight units per floor. The floor area of the two bedroom unit is about 120m² with a 3 m floor height. This medium density housing block, located in North Melbourne, Victoria, comprising 30 units in total, represents the upper end of the medium density sector as per the definition used in this study.

As built details of the foundation and some structural framing elements of the building were not available at the time of the study and some reasonable estimates, based on assumptions, were made in this regard. Foundation system is considered to be a raft slab on ground combined with pad footings supporting columns and load bearing walls. The first floor slab above the carpark act as a transfer slab, where loads from the load bearing walls above are transferred to the columns underneath. Foundation, structural frame, some load bearing walls and suspended floor slabs are reinforced concrete. All external walls and separation walls between units are double-brick load bearing walls. Internal partitions are dry wall construction. The roof is colorbond sheets on timber framing and the single glazed windows are aluminium framed. The finishes and the appliances are similar to what is used in the single dwelling. The plans and elevations of the thirty unit medium density housing block investigated are shown in Figures 5.4(a) to 5.4(e). The building specification summary is given in Table 5.2. BEE analysis output results providing bill of quantities, embodied energy estimates and cost estimates are given in Appendix D, Table D.2.

Figure 5.4 (a) Ground Floor Plan

Figure 5.4 (b) 1st Level to 3rd Level Floor Plan

Figure 5.4 (c) Typical Two Bedroom Floor Plan

Figure 5.4 (d) Front Elevation

Figure 5.4 (e) Side Elevation

Figure 5.4(a) – (e) Medium Density Case Study Drawings

Table 5.2 Building Specifications – Medium Density Case Study

Groups	Components
Structure	Foundation
	- Pad footings
	- Raft slab on ground
	Upper Floors
	- Suspended R/C floor
	External Walls/Façade
	- Load bearing double clay brick
	Internal walls
	- Clay brick (living room, bedrooms and kitchen)
	- Timber framed plasterboards (bathroom, toilet and laundry)
	Roof
	- Colorbond steel profiled sheeting on timber frame
Finishes	- Aluminium sliding windows and timber doors
	- Carpets (living room, and bedrooms)
	- Ceramic wall and floor tiling (kitchen, bathroom, toilet and laundry)
	- Plasterboard ceilings
	- Paint on walls and ceiling

5.1.4. Case Study II – BEE Analysis Results

Analysis is carried out using the BEE software tool developed in this study. The total cost for the thirty unit medium density housing block is about \$2,781,372 and the estimated total embodied energy is about 35,976GJ. The complete bill of embodied energy with analysis results can be found in Appendix D, Table D.2. As mentioned before the typical housing unit has an area of 120m² and therefore the total living area of this thirty units medium density housing block is considered as 3600m². It must be noted that in the above living area calculation, areas for common amenities such as stair wells, access corridors, parking spaces,

storage, cleaner's room etc are excluded. This means that when the cost and the embodied energy are normalised per unit area of the effective living area of 3600m^2 , respectively, the average cost is $\$773/\text{m}^2$ and the average embodied energy is $10\text{GJ}/\text{m}^2$. Assuming an average family of three people (two parents and one child) or a young couple live in these houses. The per capita embodied energy consumption is around 400 to 600GJ/person.

Figure 5.5 Comparisons of Embodied Energy and Cost – Medium Density

Figure 5.5 summarises the embodied energy and the costs associated with each group of the building, namely structure, finishes and services, averaged per unit area. The results suggest that about 80.2% of the initial embodied energy is associated with the structural components, followed by 18.8% associated with the finishes and only 1.0% of initial embodied energy is associated with the services. A similar trend is evident when costs are compared as well where 60.0% invested on the structural components, followed by 36.6% invested on the finishes and 3.4% invested on the services.

From Figure 5.5, it may appear that there is no definite relationship between the cost and the embodied energy especially from the structures group outcome. This must be interpreted with caution because inherently high-rise buildings have larger proportion of dead space, also called un-tenable areas, occupied by the structural elements compared to a single

dwelling. These structural elements are, in relative terms, high in embedded energy, voluminous and less costly. When cost and embodied energy are normalised per square meter of the tenable area that can give rise to seemingly distorted impression of the comparisons compared to a single dwelling.

Figure 5.6 Embodied Energy Distributions – Medium Density

Figure 5.6 indicates the embodied energy within various elements of this medium density housing block. As mentioned before such a breakdown is vital to identify areas which need to be targeted in product and process improvements. As expected, in medium density housing, main load bearing structural elements such as double-brick external walls (32.0%),

suspended upper floor slabs (30.3%) and internal load bearing walls (12.7%) dominate the embodied energy distribution chart given in Figure 5.6. It must be noted that this study has adopted a special multiplying factor of 1.5, to account for the energy embedded in vertical transportation of material, labour and temporary structures such as scaffoldings. Factor 1.5 is calculated as the average ratio of the cost increase of placing concrete at different heights. It is obvious that the on-site vertical transportation of labour and material over a number of levels in building construction require more energy than on ground. This multiplication factor is only applied to the large volume materials such as concrete work and brick work. This tends to increase the embodied energy in structure group compared to services and finishes groups. For example, the ratio between the scheduled rate for a cube of concrete placed on the ground and at a height is an indicator of effort, and therefore the embodied energy, of that activity. Such ratios were then averaged to arrive at a single multiplying factor.

The results also show, as anticipated, that the external load bearing double-brick wall and the suspended floors, both being large volume items, have significant impact on the embodied energy in this case. Optimisation of such high intensity, high volume sectors should then become a top priority in application as well as in product innovation. However, it must be emphasised that process and product innovation is beneficial only if improvements do not increase the upstream/downstream embodied energy or shift embodied energy from one sector to another. Future studies on this special multiplying factor which could lead to an alternative system of grading the factors according to the factors in this investigation and the perception of builders in Melbourne is required.

5.1.5. Case Study III – High Density Housing

The high density domestic building investigated consists of twelve levels of two bedroom apartments. The ground floor comprises of carpark area and common amenities such as foyer, lift lobby, shop/office space, garbage disposal area etc. Apartment floors are starting from level one and each floor there on consisting of six units. There are twelve apartment floors and the mechanical services room is located on the roof. Six apartment units per floor comprise of four identical units and two marginally different units of 80m² each with ceiling height of 2.4m. This high density housing block is located in Melbourne CBD, Victoria, comprising 72 units in total and represents the lower end of the high density domestic sector.

Some as built details of the foundation and the structural framing of the building were difficult to obtain and therefore reasonable estimates, based on standard practices, were made in places of missing information as follows. Foundation system is considered as a suspended raft slab on piles. The main load bearing system is a shear wall system, which is constructed using tilt-up panels, carrying gravity and lateral loads. Lift shafts, stair wells and service shafts are cast in-situ reinforced concrete. The first floor slab over the carpark area is a transfer slab where loads from the load bearing walls above are transferred to the columns underneath. External façade of the building and separation walls between units and access corridors are reinforced concrete tilt-up panels. Internal partitions within the unit are dry wall construction. The roof is colorbond profiled sheets on timber framing and the single glazed windows are aluminium framed. The finishes and the appliances are similar to what is used in the medium density housing. The plans and elevations of the seventy two unit high density housing block investigated are shown in Figures 5.7(a) to 5.7(f). A summary of building specification is given in Table 5.3. BEE analysis output results providing bill of quantities, embodied energy estimates and cost estimates are given in Appendix D, Table D.3.

Figure 5.7 (a) Ground Floor Plan

Figure 5.7 (b) 1st Level – 12th Level Floor Plan

Figure 5.7 (c) Typical Two Bedroom Floor Plan

Figure 5.7 (d) Roof Plan

Figure 5.7 (e) Front Elevation

Figure 5.7(f) Side Elevation

Figure 5.7(a) – (f) High Density Case Study Drawings

Table 5.3 Building Specifications – High Density Case Study

Groups	Components
Structure	Foundation/Ground Floor <ul style="list-style-type: none"> - Pile foundation - Raft slab Upper floors <ul style="list-style-type: none"> - Reinforced concrete suspended slab External Walls/Façade <ul style="list-style-type: none"> - 200mm R/C Tilt-up panels (load bearing) Internal Walls <ul style="list-style-type: none"> - 200mm R/C Tilt-up panels (load bearing) - Timber framed plasterboards (non load bearing) Roof <ul style="list-style-type: none"> - Colorbond steel profiled sheets on timber frame
Finishes	<ul style="list-style-type: none"> - Aluminium sliding windows and timber internal doors - Carpet (living room, and bedrooms) - Plasterboard ceilings - Ceramic wall and floor tiling (kitchen, bathroom, toilet and laundry) - Paint on walls and ceiling

5.1.6. Case Study III – BEE Analysis Results

As in other two case studies the analysis is carried out using the BEE software tool. The total cost for the seventy two unit high density housing block is about \$9,359,072 and the estimated total embodied energy is about 120,784GJ. The complete bill of embodied energy with analysis results can be found in Appendix D, Table D.3. As mentioned before the typical housing unit has an area of 80m² and therefore the total living area of this seventy two units high density housing block is considered as 5760m². It must be noted that, similar to the medium density housing block, in the above living area calculation areas for common

amenities such as stair wells, lift shafts, access corridors, parking spaces, storage, cleaner's room etc are excluded. This means that when the cost and the embodied energy are normalised per unit area of the effective living area of 5760m^2 , respectively, the average cost is $\$1625/\text{m}^2$ and the average embodied energy is $21\text{GJ}/\text{m}^2$. Assuming an average family of three people (two parents and one child) or a young couple live in this house, the per capita embodied energy consumption is around 560 to $840\text{GJ}/\text{person}$. This outcome seems odd considering that the 80m^2 high density unit is two third of the medium density unit (120m^2) and one fourth of the single dwelling housing (320m^2). The reason is that, on the one hand, the non-tenable space allocated for common amenities and dead-space occupied by the lateral and gravity load resisting structural elements in these types of buildings are a considerable proportion of the total area of the building. On the other hand the large volume heavily reinforced structural members significantly increase the embodied energy.

Figure 5.8 summarises the embodied energy and the costs associated with each group of the building, namely structure, finishes and services, averaged per unit area. The results suggest that about 81.5% of the initial embodied energy is associated with the structural components, followed by 18.0% associated with the finishes and only 0.5% of initial embodied energy is associated with the services. A similar trend is evident when costs are compared as well where 63.7% invested on the structural components, followed by 34.8% invested on the finishes and 1.5% invested on the services.

Figure 5.8 Comparisons of Embodied Energy and Cost – High Density

Figure 5.9 Embodied Energy Distributions – High Density

Figure 5.9 indicates the embodied energy within various elements of this high density housing block. As mentioned before such a breakdown is vital to identify areas which need to be targeted in product and process improvements. It is interesting to note that, in high density housing compared to medium density housing, main load bearing structural walls (50.6%) and suspended upper floor slabs (27.8%) dominate the embodied energy distribution chart given in Figure 5.9. It must be noted that this study has adopted a special multiplying factor of 1.75, compared to 1.5 in the medium density sector, to account for the energy embedded in vertical transportation of material and temporary structures such as scaffoldings. It is because the on-site vertical transportation of labour and material over twelve levels in construction requires

more energy intensity than on ground or for a four level construction. This multiplication factor is only applied to the large volume materials such as concrete work in walls and floors. This tends to increase the embodied energy in structure group compared to services and finishes groups. In arriving at this factor, similar to the medium density construction, a simple rationale based on the average ratio of unit rates (costs) being adopted.

As pointed out before, the ratio between the scheduled rate for a cube of concrete placed on the ground and at a height is an indicator of effort, and therefore the embodied energy, of that activity. Such ratios were then averaged to arrive at a single multiplying factor similar to the approach taken in medium density evaluation. Following a similar trend to that of the medium density construction, the load bearing walls and the suspended floors, both being large volume items, have significant impact on the embodied energy in this case. Optimisation of such high intensity, high volume sectors should then become a top priority in application as well as in product innovation. Again, it must be emphasised that process and product innovation is beneficial only if improvements do not increase the upstream/downstream embodied energy or shift embodied energy from one sector to another.

5.2. Comparison of Three Domestic Sectors

Comparison of the embodied energy and cost analyses of the three domestic buildings representing single dwelling, medium density and high density construction are present in this section. Table 5.4 summarised case study results of the embodied energy and the cost of the three domestic sectors from previous study, Section 5.1.

Table 5.4 Summary of Case Study Results – All Three Domestic Sectors

Domestic Sector	Embodied Energy			
	Total (10 ³)	GJ/Unit	GJ/m ²	GJ/person
Single Dwelling	1.3	1312	4	262-328
Medium Density	36	1199	10	400-600
High Density	121	1678	21	560-840
Domestic Sector	Cost			
	Total (10 ³)	\$/Unit (10 ³)	\$/m ²	\$/person (10 ³)
Single Dwelling	206	206	642	41-51
Medium Density	2,781	93	773	31-46
High Density	9,359	130	1,625	43-65

As mention in Section 5.1.2., the estimated total embodied energy of the single dwelling is about 1312GJ and the total cost is around \$205,518. Section 5.1.4 indicated that the total embodied energy for medium density (30 units per block) is about 35,976GJ and the estimated total cost is about \$2,781,372. Case study III in Section 5.1.6 analysis the total embodied energy for the high density (72 units per block) is about 120,784GJ and the estimated total cost is about \$9,359,072. Figure 5.10 shows the comparison of total embodied energy and total cost per dwelling.

Figure 5.10 Comparisons of Total Embodied Energy and Total Cost per Dwelling

Figure 5.11 Comparisons of Embodied Energy and Cost per Unit of the Dwelling

Comparison of embodied energy and cost per unit of the dwelling can be seen from Figure 5.11. It is interesting to note that, medium density housing contributes around 1199GJ/unit with the lowest embodied energy, followed by single dwelling around 1312GJ/unit and high density around 1678GJ/unit. However, different trend is taking part when cost are compared where around \$93,000/unit estimated on thirty unit medium density housing block, followed by \$130,000/unit estimated on seventy two unit high density housing block and \$206,000/unit estimated on single dwelling. The high embodied energy per unit of

medium density and high density compare to the trend of the cost in Figure 5.11 proved that the large volume heavily reinforced structural members significantly increase the embodied energy as discussed in Section 5.1.6.

Figure 5.12 summaries the comparison of embodied energy and cost per unit area of the dwelling. The result suggest that about 4.1GJ of embodied energy is associated with per unit area of single dwelling, followed by 10GJ associated with per unit area of medium density and 21GJ associated with per unit area of high density. A similar trend is evident when cost are compared as well where \$642 invested on per unit area of single dwelling, followed by \$773 invested on per unit area of medium density and \$1,625 invested on per unit area of high density.

Figure 5.12 Comparisons of Embodied Energy and Cost per Unit Area of the Dwelling

The analysis indicated the initial embodied energy ranges between 262 to 328GJ/person and the cost ranges between \$41,000 to \$51,000/person respectively. An average family of three people (two parents and one child) or a young couple live in medium density is assumed in Section 5.1.4. The result suggests that the embodied energy consumption is around 400 to 600GJ/person and the cost consumption is around \$31,000 to \$46,000/person. As mentioned in Section 5.1.6, an average family of three people (two

parents and one child) or a young couple is assumed to live in high density. The embodied energy consumption is around 560 to 840GJ/person and the cost consumption is around \$43,000 to \$65,000/person respectively. The comparison of lower and upper bounds of embodied energy per occupant is shown in Figure 5.13 and the comparison of lower and upper bounds of cost per occupant is shown in Figure 5.14.

Figure 5.13 Comparisons of Lower and Upper Bounds of Embodied Energy per Occupant

Figure 5.14 Comparisons of Lower and Upper Bounds of Cost per Occupant

One interesting finding of this comparison is that the trend of embodied energy per person exhibits a standard parabolic behaviour where medium density housing appears to be reaching an optimum outcome. Obviously, this needs to be further examined and if this trend is true for many cases that would encourage towards a more sustainable outcome. The main reasons for this trend can be explained using tenable area per person, mass of structural elements (volume of dead space) in heavy construction and construction resources intensity of the sector. Trade-off between these three aspects is therefore vital in achieving the desired outcomes.

5.3. **Embodied Energy of Alternative Building Envelopes**

As demonstrated in all three cases above, the embodied energy of the structure group is the largest contributor to the total embodied energy. It is therefore obvious that any attempt to optimise embodied energy in the housing sector should focus on such high volume high intensity areas. In this section a further investigation has been carried out to quantify and compare the initial embodied energy estimates of alternative building envelopes appropriate for single dwelling construction as a demonstration case. However it must be emphasised that this comparison considers only the initial embodied energy. Maintenance and replacement embodied over the life span have not been incorporated in this comparison. The single dwelling used in the comparison is the same 123m² two storey townhouse discussed in Section 4.2.1. In this comparison the structural components such as the ground floor, external walls, internal load bearing walls, first floor and the roof are considered as the building envelope. Eight alternatives cases have been investigated with alternative materials for these components. It is important to conduct similar studies for a number of different cases for medium and high density as well to benchmark current values and consider possible alternative solutions to optimise embodied energy in the housing sector.

A large stock of new single dwellings in Australia adopts a building envelop comprising of single-brick-veneered façade, load bearing timber frame and internal plaster board finish. Prior to the popularity of the above method, load bearing timber frame with weatherboard façade and plasterboard interior finish was the most common single dwelling building envelope. Tilt-up reinforced concrete panels are also gaining popularity especially in the townhouse construction. Cold formed light gage steel frames are, to lesser volume, used as an alternative to the traditional timber frames. Table 5.5 provides a summary of the different structural configurations attempted.

The emphasis of this study is not to mimic the exact on-site configurations of current practice but to try out a number of hypothetical alternatives for a sensitivity analysis. Therefore results must not be interpreted without reservation especially considering the commercial sensitivity of different industry sectors. Also it must be noted that results does not reflect the whole of life embodied energy but only the initial embodied energy of materials used. Life cycle analysis is required to assemble the full embodied energy foot print of the materials used.

Table 5.5 Summary of Alternative Materials Used in the Structure Group

Type	Ground Floor	First Floor	Roof	External Walls	Internal Walls
H1	Reinforced concrete	Timber floor joists, particleboards	Concrete tiles, timber trusses	Brick veneered façade, timber frame, plasterboard interior	Timber frame, plasterboard
H2	Timber floor joists and particle boards	Timber floor joists, particleboards	Concrete tiles, timber trusses	Brick veneered façade, timber frame, plasterboard interior	Timber frame, plasterboard
H3	Steel floor joists, particleboards	Timber floor joists, particleboards	Concrete tiles, timber trusses	Brick veneered façade, timber frame, plasterboard interior	Timber frame, plasterboard
H4	Reinforced concrete	Steel floor joists, particleboards	Concrete tiles, timber trusses	Brick veneered façade, timber frame, plasterboard interior	Timber frame, plasterboard
H5	Reinforced concrete	Timber floor joists, particleboards	Concrete tiles, timber trusses	Timber frame, weatherboard external, plasterboard interior	Timber frame, plasterboard
H6	Reinforced concrete	Timber floor joists, particleboards	Concrete tiles, timber trusses	Steel frame, weatherboard external, plasterboard interior	Timber frame, plasterboard
H7	Reinforced concrete	Timber floor joists, particleboards	Concrete tiles, timber trusses	Concrete pre-cast walls	Timber frame, plasterboard
H8	Reinforced concrete	Timber floor joists, particleboards	Colorbond, timber trusses	Brick veneered façade, timber frame, plasterboard interior	Timber frame, plasterboard

5.3.1. Analysis Results

The quantities of the housing do not differ between the eight cases. Nevertheless, the different use of materials has a large influence on the embodied energy and the cost.

Figure 5.15 compares the value of embodied energy and cost of eight alternative (H1 to H8) structural material configurations averaged per unit area of the house. In the overall analysis, from the values presented below, the timber framed-weatherboard façade (H5) option has the least value in the initial embodied energy and initial cost, which represents the overall best single dwelling envelope construction method. As mentioned before the maintenance and replacement of the materials over whole of life is not included in this comparison and there is shared consensus that weatherboard houses need extensive maintenance. The colorbond roofing option (H8) has less initial embodied energy and initial cost than concrete tile roofing (H1).

The embodied energy results obtained in this exercise indicate that mass is a good indicator of embodied energy. Of the eight different structure material configurations heavier material types generally attracted more embodied energy. All three options involving steel framing – the steel framed-particleboard ground flooring (H3) and steel framed-timber façade (H6) – have larger embodied energy and cost values associated with them. It is widely acknowledged that metal products such as steel framing are high embodied energy intensive material compared to timber framing which is also evident through this analysis.

Figure 5.15 Comparisons of Embodied Energy and Costs for Alternative Structural Material Configurations H1 – H8.

Figure 5.16 shows the embodied energy versus cost of the domestic construction using these eight alternative configurations. The results indicate a reasonable linear relationship between cost and the embodied energy. The gradient of the graph provides a transfer factor of 0.01GJ/\$ which can be used in preliminary estimates of single dwelling where only cost data are available.

Figure 5.16 Embodied Energy vs. Cost of Structural Alternatives in Single Dwelling Construction

Given the small size of the sample, no generalised relationship can really be made between cost and embodied energy. However, what can be concluded is that for the samples used, embodied energy appears to be related to cost in a general way – as costs increase for a particular type of building or structural element, it is probable that embodied energy will also increase. It can also be stated that a relationship has been demonstrated for the specific buildings in the sample, and in particular to the single unit dwelling investigated in Section 5.3.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

Improved environmental sustainability of domestic buildings depends upon our ability to accurately assess the whole of life energy foot print of that industry and its optimisation. This would involve both the embodied energy and the operational energy during complete life cycle of that product. Embodied energy component can be further subdivided in to energy embedded in administration and financing of such a project, energy embedded in the construction and maintenance of the domestic building, and demolition and recycling after its life cycle. This investigation is limited to the assessment of embodied energy of the construction phase prior to the occupancy and possible ways to optimise that component. In other words, the energy embedded in the planing and financing processes, maintenance of the domestic building and demolishing and recycling are not included.

This study also attempted to rationalise and enhance the embodied energy estimating capabilities and to develop tools and procedures for that purpose. The tool allows selection in energy efficient building technologies and building systems based on the embodied energy and cost, thereby reducing embodied energy and cost of materials. A concise overview of the methodology and developed models are given in Section 6.1.

Despite the considerable improvement in our understanding of the energy required to produce building materials commonly used in domestic buildings, there is limited knowledge

as to the estimation of the energy consumed during the process of building and maintaining such buildings as well as the full building life-cycle. Significant further efforts needed in this area of research and some recommendations for further research are also suggested in Section 6.2 identified through this study.

6.1. Conclusions

In conclusion, aligning list of standard elements to have both cost and estimated embodied energy was a challenge. As discussed in Chapter 3, it is obvious that the key variables, the cost and the embodied energy estimates, bound to change over the years and need periodic updates. There are the usual doubts about the reliability of data in any study. Unavoidably, data has to be compiled from the best sources given the resources available. The accuracy of any energy analysis is going to have as much to do with the availability of good data as the analysis method used. A database that made information readily available from a wide range of reliable sources would be invaluable in reducing the variations in energy estimates that have always plagued embodied energy analysis.

Chapter 3 indicated that the embodied energy evaluation methodologies need significant improvement to ensure robust and readily available standardised approach. It must be noted that the major proportion of the research time has been therefore invested on the aspect of standardising available basic data leading to the development of the web based tool which are considered as the major contributions from this research. Such standardised embodied energy data and robust tools would influence the industry firstly towards the awareness and secondly towards optimisation.

In developing BEE tool, embodied energy data of an item takes much more details in to account in evaluation, because of the descriptions provided by the cost guides are more

specific although process is fairly straight forward. Evaluation of embodied energy of standard construction elements such as different standard foundation types and sizes, floor slabs, finishes etc, using the available basic embodied energy data aligned to standard bill items given in the widely accepted cost guides considered as the most effective way to move forward.

As presented in Chapter 4, an important goal for the domestic building sector and the community is to produce buildings with minimal environmental impact, from an embodied energy point of view, by selecting low embodied energy element for their buildings. Computer program BEE allows the user to trial out different options until a satisfactory outcome is found in selecting element of the embodied energy and the cost. The construction products and materials with low embodied energy contents and longer lifespan are encouraged in this study to be the main products during the section. As discussed in Chapter 3, if the industry recognises and influences the optimisation of the embodied energy at the early stage of planning, the resulting life-cycle energy becomes lower. This would also encourage the informed decision making in establishing even lower targets over a period and encourage policy changes for better products and processes.

This BEE tool can be made available through web for public access at no cost. This is one of many effective ways of disseminating the research outcomes of this study to a wider community. More importantly if the wider community acknowledges the concept of the “Bill of Embodied Energy (BEE)” as equally important as a “Bill of Quantities (BOQ)” in the design process of a domestic construction, this concept enhances the sustainable domestic industry as mentioned in Chapter 4.

There is a common consensus that cost is a reasonable qualitative indicator of the embodied energy, which is discussed in Chapter 5. It is worth noting that how the embodied energy and cost for the overall project as well as for each item is displayed alongside each

other. A factor of 0.01GJ/\$ is indicated in this research which can be used in preliminary estimates of single dwelling where only cost data are available. For high rise domestic construction like in the medium density and high density construction this basic value must be modified to account for energy consumption of vertical transportation of men and material. A factor of 1.5 was used in this study based on the standard rates for placement of concrete at higher elevations.

The three case study results comparing three building sectors, namely single dwellings, medium density and high density housing, suggest some interesting trends. In particular medium density housing appears to provide the desired outcome. The key influencing factors of this desirable outcome are, the gross area to tenable area is more efficient per person in medium density housing and the energy demand on vertical transportation of men and material is not intensive compared to high density construction. This finding reveals two robust performance indicators which can be used as measures of embodied energy in housing sector. They are the ratio of net tenable area to gross area per occupant and the elevation of the dwelling. Obviously, more case studies need to be investigated before proper relationships can be obtained.

6.2. Recommendations of Further Research

After a detailed assessment of current available best practices of embodied energy evaluation methods it was made apparent that availability of a standardised practice is lacking. In the case of comparing alternative building materials or components, a lack of consideration of potential error could lead to misleading conclusions. New sources of process analysis data are required in order to make sure the future applications to produce reliable embodied energy data results in to complete products.

It is interesting to note that basic embodied energy data for building services, building façades and some high quality finishes and domestic appliances are extremely hard to find or not available at all. On the other hand, considering that high embodied energy components are often subject to a wide range of replacement rates, further research to explore the role of design decisions to optimise placement of materials and renovation cycles in commercial buildings to improve environmental performance is important.

The cost and embodied energy analysis results in this study appear to be lower than anticipated for the building services sector. This could have resulted due to a number of possibilities. The two main reasons could be the current direct embodied energy data on record for building industry service sector and the domestic industry cost guides do not provide a true reflection of the intensity and the costs of work involved. This area is therefore identified as a potential area for further research.

This research presents the work completed in developing a web based software tool, incorporating the more robust form of embodied energy information proposed in Chapter 3. Upon performance, the proposed tool can be quite effective in minimising the embodied energy in the current domestic construction practice with a particular emphasis on establishing even lower targets for future developments.

As discussed in Chapter 4, due to the time constraints, BEE tool warranted in this research developing only user interactive optimisation capabilities but the tool can be further developed to automate the process. BEE software has a significant potential for further growth and expansion. This has been recognised in the design by selecting state-of the art coding languages and in the selection of code generation and debugging tools to provide maximum possible flexibility in further work.

BEE software treats three domestic sectors as three independent streams as shown in Figure 4.1. From the software development point of view, the reason for this is to provide more flexibility for future developments. From embodied energy evaluation point of view, it is important to recognise that these sectors of domestic construction industry differ significantly as they adopt different from the structure, finishes and building services.

Future studies on this research could introduce the perception of builders regarding the factors investigated, which could lead to an alternative system of grading the factors according to the factors in this investigation and the perception of builders in Melbourne. An investigation as such would allow for the best method of domestic building construction to be established, with both construction and builders' perception in mind. It is important to conduct similar studies for a number of different cases for medium and high density as well the benchmark current values and consider possible alternative solutions to optimise embodied energy in the domestic sector.

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APPENDIX A

EMBODIED ENERGY AND COST DATABASES

APPENDIX A

EMBODIED ENERGY AND COST DATABASES

The BEE software tool is developed in part to demonstrate the methodology and to introduce the concept of “Bill of Embodied Energy”. Chapters 2 and 4 have discussed in detail the challenges and limitations of the existing embodied energy data and regional and process dependency of the data. Cost data given in building cost guides are also regional and time dependent. Emma and Cordell (2004), “Building Cost Guide, Housing, Victoria”, which provided the cost data used in the BEE tool obviously only applicable to Victoria, Australia. However, the methodology, the data base and the program structure can be easily adapted to serve other regions and localities.

The purpose of this appendix is to detail the modification of embodied energy for the domestic building materials – single dwelling, medium density and high density construction. The lists and descriptions of materials are based on Building Cost Guide (Emma and Cordell, 2004). The calculations for the embodied energy presented, involving every detail of the description. Shading below shows the applicable material to the domestic building:

- ☐ - applicable to single dwelling, medium density and high density
- ☐ - applicable to single dwelling only
- ☐ - applicable to medium and high density only

Table A.1 List of Elements

<i>Element</i>	<i>Item</i>	<i>Component</i>
1	Piering & Piling	Cast In-Situ Piling
		Bored Concrete Piers Grout Injected Piles Driven Cast In-Situ Pile
		Prefabricated Driven Piling
		Precast Concrete Pile Steel Hollow Tube Pile Steel 'I' Section Pile Timber Pile
	Sheet Piling	Installation Extraction
2	Concrete In-Situ	Structural Concrete
		Pier Concrete Footing Concrete Slab Concrete Stair Concrete Wall Concrete Beam Concrete Block Filling Concrete
		Slab Bases
	Membranes	Sand Membranes
3	Concrete Composite Rates	Footings
		Strip Footings Pad Footings - Square Pad Pad Footings - Circular Pad
		Footing Beams Column Bases
		Slabs
		Raft Slabs Stiffened Raft Slabs
		Paving Suspended Slabs Grounds Slabs
		Beams
		Attached Beams Isolated Beams
		Walls
		Columns
		Attached Columns Isolated Columns
4	Masonry - Brickwork	Brickwork
		Clay Brickwork Concrete Brickwork
		Lintels
	Damp Proof Courses	Galvanised Steel Lintels
5	Structural Steel	Aluminium Core Bitumen Coated (0.45mm)
		Columns (Steel)
		Square Hollow Section Universal Section Steel Columns Compound Built Up Plate Steel Columns Square Hollow Section Steel Columns
		Beams (Steel)
		Universal Section Steel Beams Parallel Flange Steel Channel Beams Compound Built Up Plate Steel Beams
		Portal Frames
		Portal Frames Trusses (Steel)
		Trusses
6	Metalwork	Metal Furniture
7	Carpentry	Letter Box
		Ground Floor Framing
		Ground Floor Framing - Hardwood F8 Steel Framing
	Upper Floor Framing	Upper Floor Framing - Hardwood F8

<i>Element</i>	<i>Item</i>	<i>Component</i>
	Wall Framing	Upper Floor Framing - MGP10/F5 Pine Engineered Joists
		Wall Framing - Hardwood F8 Wall Framing - MGP10/F5 Pine Steel Framing Heads or Lintels - Hardwood F8 Heads or Lintels - MGP10/F5 Pine
	Ceiling Framing	Ceiling Framing - Hardwood F8 Ceiling Framing - MGP10/F5 Pine
	Conventional Roof Framing	Flat Roof Framing - Hardwood F8 Flat Roof Framing - MGP10/F5 Pine
		Pitched Roof Framing - Hardwood F8 Pitched Roof Framing - MGP10/F5 Pine
	Roof Trusses	Roof Truss
	Posts	Hardwood F8 - sawn Hardwood F8 - DAR
		Oregon F7 - sawn Oregon F7 - DAR Treated Pine F7 H3 - DAR
	Timber Beams	Hardwood F8 - sawn Hardwood F8 - DAR
		Oregon F7 - sawn Oregon F7 - DAR Treated Pine F7 H3 - DAR
	Battens	Hardwood F8 Battens Pine Battens
		Steel Battens
	Flooring	Particleboard Flooring Plywood Flooring
		Timber Decking - Hardwood
	Wall Linings	Particleboard Wall Linings Plywood Wall Linings - CD Grade
8	Insulation	Aluminium Insulation
		Light Weight (290 g/m ²) Medium Weight (368 g/m ²) Heavy Weight (378 g/m ²)
	Fibreglass Insulation	Ceiling/Roof Insulation Wall Insulation Floor Insulation
9	Joinery	Architrave & Skirting
		Architrave/Skirting - Pine
	External Staircase	Staircase Handrail
	Internal Staircase	Staircase Handrail
		Balustrade
	Cupboards	Cupboards
	Kitchen Cupboards	Benchtops - Square Edge Benchtops - Round Edge Splashbacks Modular Floor Design Cupboards Modular Wall Design Cupboards Custom Floor Design Cupboards Custom Wall Design Cupboards Custom Wall Oven Design Cupboards

<i>Element</i>	<i>Item</i>	<i>Component</i>
10	<i>Glazing</i>	Custom Pantry Design Cupboards
		Modular Wall Oven Design Cupboards
		Modular Pantry Design Cupboards
		Vanity Units
		Wardrobes
11	<i>Roofing</i>	Float Glass
		Toughened Glass
		Shower Screens
		Membrane Roofing
		Sheet Roofing
12	<i>Roof Plumbing</i>	Gutters
		Valley Gutters
		Sumps
		Rain Heads
		Downpipes
		Flashings
		Aluminium Windows
		Meranti Timber Windows
		Steel Windows
		External
13	<i>Windows</i>	Aluminium Windows
		Meranti Timber Windows
		Steel Windows
		External
		Internal
14	<i>Doors</i>	Bi-Fold & Multi-Fold Doors
		Disabled Person Doors
		Louver Doors & Shutters
		Security Doors
		Aluminium Doors
		Steel Doors
		Timber (Feature) Doors
		Timber (Flush) Doors
		Timber (Feature) Doors
		Timber (Flush) Doors
		Timber Doors
		Steel Doors
		3 hour Fire Rating
		Louver Doors
		Louver Shutters
		Security Doors
		Security Doors
		Security Doors

<i>Element</i>	<i>Item</i>	<i>Component</i>
	Roller Doors & Shutters	Zinc Aluminium Coated Steel Colour Coated Steel
15	Plastering	Plasterboard 10mm Standard Plasterboard 10mm Standard Light Weight Plasterboard 13mm Standard Plasterboard
16	Tiling	Wall Tiling Ceramic Wall Tiling Floor Tiling Ceramic Floor Tiling
17	Floorcoverings	Floorcoverings Carpet Vinyl Sheet
18	Painting	Woodwork Painting (Internal) Acrylic (Semi Gloss/Gloss) Alkyd (Semi Gloss/Gloss) Polyurethane (Flat/Semi Gloss/Gloss) Stain Brickwork & Blockwork & Concrete & Render Painting (Internal) Acrylic (Flat/Semi Gloss/Gloss) Alkyd (Flat) Alkyd (Semi Gloss/Gloss) Fibre Cement & Plaster & Plasterboard Painting (Internal) Acrylic (Flat/Semi Gloss/Gloss) Alkyd (Flat) Alkyd (Semi Gloss/Gloss) Woodwork Painting (External) Acrylic Latex (Low Sheen) Acrylic Latex (Gloss) Alkyd (Gloss) Stain Brickwork & Blockwork & Concrete & Render Painting (External) PVA (Flat) Acrylic Latex (Low Sheen/Gloss) Acrylic (Texture) Silicone Fibre Cement & Plaster & Plasterboard Painting (External) PVA (Flat) Acrylic Latex (Low Sheen/Gloss) Metalwork Painting (External) Acrylic Latex (Low Sheen/Gloss) Alkyd (Gloss)
19	Plumbing	Water Supply Pipework Copper Pipework PVC Pipework Gas Supply Pipework Copper Pipework Sanitary Pipework Copper Pipework Fixture Traps Copper Fixture Traps Floor Traps Copper Floor Traps Floor Waste Brass Floor Waste PVC Floor Waste Waste Outlet Brass Waste Outlet PVC Waste Outlet Flap Valves PVC Vent Cows Galvanised Steel Vent Cows PVC Vent Cows Valves Loose Screw Down Type Valves Gate Valves (Brass) Gate Valves (Cast Iron) Check Valves (Bronze) Ball Valves (Brass) Globe Valves (Bronze) Non Returning Isolating Valve (Brass) Taps Spouts & Roses Colour Coated Brass Taps Chrome Plated Brass Taps & Handles

<i>Element</i>	<i>Item</i>	<i>Component</i>	
		Polished Brass Taps & Handles Single Lever Mixing Taps Combination Handles & Spout Mixer Taps Hands Free Taps Hose Taps Cistern Taps	
	Water Tanks	Galvanised Steel Water Tanks Polyethylene Water Tanks Precast Concrete Water Tanks	
	Baths	Acrylic Baths Porcelain Enamel Steel Baths	
	Spa Baths	Water Jet Spa Baths Air Jet Spa Baths	
	Shower Cabinets	Shower Cabinets	
	Basins	Vanity Basins Wall Basins Pedestal Basins	
	Sinks	Kitchen Sinks	
	Laundry Tub	Laundry Tub	
	Toilet Suites	Toilet Suites	
	Shower Bases	Acrylic Shower Bases Copper Shower Trays Porcelain Enamel Steel Shower Bases	
	Hot Water Units	Electric Hot Water Unit Gas Hot Water Unit Solar Hot Water Unit	
	20	<i>Drainage</i>	
		Sewer Drains	Cast Iron Sewer Drains Earthenware Sewer Drains PVC Sewer Drains
		Stormwater Drains	Concrete Stormwater Drains Earthenware Stormwater Drains PVC Stormwater Drains
		Surface Drains	Insitu Concrete Surface Drains Plastic Surface Drains
		Mainholes, Sumps & Pits	Brick Manholes, Sumps & Pits Insitu Concrete Manholes, Sumps & Pits Precast Concrete Manholes, Sumps & Pits Plastic Sumps and Pits
		Sewer Pumping Station	Sewer Pumping Station
	Grease Traps	Precast Concrete Grease Traps Plastic Grease Traps	
	Stormwater Pits	Rubble Stormwater Soakaway Pit Polypropylene Stormwater Soakaway Pit	
	Pipe Connections	Pipe Connections	
	Pipe Encasement	Pipe Encasement	
21	<i>Electrical Services</i>		
	Mains Connection	Underground Mains Connection Overhead Mains Connection Switchboards Conduits Outlets & Switches Light Fittings Emergency Lighting Telephones	

<i>Element</i>	<i>Item</i>	<i>Component</i>
		Fire Alarms Burglar Alarms Fire Alarms Burglar Alarms Surveillance Systems Connection of Appliances Television Ceiling Sweep Fan
22	<i>Mechanical - Air Conditioning</i>	Cooling Equipment Heating Equipment Electric Heating Gas Heating Solid Fuel Heating
23	<i>Blinds & Curtains</i>	Awnings Aluminium Awning Fabric Awning Blinds Holland & Roller Blinds Pleated Folding Blinds Venetian Blinds Vertical Blinds Curtains Translucent Fabric Semi Translucent Fabric Opaque Fabric Cotton Fabric Reflective Fabric Blackout Type Fabric Curtain Tracks & Fittings
24	<i>Fire Protection</i>	Fire Detection Thermal Detection System Smoke Detection System Active Fire Protection Water Sprinkler System Sprinkler Control Valves Sprinkler Booster Pump Hydrant Point Fire Hose Fire Blankets Fire Extinguishers Cabinets Safes & Strong Room Doors Security Safes
25	<i>Sundry Appliances</i>	Domestic Appliances Ranges & Stoves Wall Ovens Cooktop Microwave Oven Dishwashers Exhaust Fan Range Hood Waste Disposal Unit
26	<i>Concrete Precast</i>	Precast Concrete (Composite Floor System) Tilt Up Concrete Wall Panels Precast Concrete Tilt Up Concrete Wall Panels
27	<i>Partitions</i>	Fixed Partitions Steel Framing Timber Framing Toilet Partitions Particle Board Partitions
28	<i>Mechanical - Lifts & Escalators</i>	Passenger Lifts Office and Hotel (Low Rise) Passenger Lifts Office and Hotel (High Rise) Passenger Lifts

Table A.2 Description of Components

Component		Material/Dimension/Methods of Construction	Description
1.1	Bored Concrete Piers	300mm diameter	Bored concrete piers (average depth 4.5 metres; 90 metre total)
		450mm diameter	
		600mm diameter	
		750mm diameter	
		900mm diameter	
1.2	Grout Injected Piles	400mm diameter; maximum load 50 tonnes	Grout cast in-situ pile (average depth 6 metres; 300 metre total)
		500mm diameter; maximum load 100 tonnes	
		600mm diameter; maximum load 150 tonnes	
1.3	Driven Cast In-Situ Pile	400mm diameter; maximum load 60 tonnes	Driven cast in-situ pile (average depth 6 metres; 300metre total)
		500mm diameter; maximum load 100 tonnes	
		600mm diameter; maximum load 150 tonnes	
1.4	Precast Concrete Pile	270mm (measured across flat) hexagonal section; maximum load 90 tonnes	Precast concrete pile (average depth 6 metres; 300metre total)
		300mm (measured across flat) hexagonal section; maximum load 120 tonnes	
1.5	Steel Hollow Tube Pile	320mm diameter; maximum load 40 tonnes	Steel hollow tube pile; closed end (average depth 6 metres; 300 metres total)
		350mm diameter; maximum load 45 tonnes	
		400mm diameter; maximum load 50 tonnes	
		450mm diameter; maximum load 55 tonnes	
1.6	Steel 'I' Section Pile	200UC46	Steel 'I' section pile; (average depth 6 metres; 300 metres total)
		200UC59	
		250UC72	
		250UC89	
		310UC96	
		310UC137	
		310UC198	
		310UC240	
1.7	Timber Pile	310UC283	Timber pile (average depth 6 metres; 300 metres total)
		180mm diameter; maximum load 30 tonnes	
		210mm diameter; maximum load 40 tonnes	
		230mm diameter; maximum load 50 tonnes	
		250mm diameter; maximum load 65 tonnes	
		280mm diameter; maximum load 80 tonnes	
1.8	Installation	300mm diameter; maximum load 95 tonnes	Interlocking steel sheet piling (500 m ² total)
		60.9kg/m ²	
1.9	Extraction	79.8kg/m ²	Interlocking steel sheet piling (500 m ² total)
		60.9kg/m ²	
2.1	Pier Concrete	79.8kg/m ²	Piers 20MPa concrete placed by
		Chute	
		Handle/barrow	
2.2	Footing Concrete	Pump	Footing beams/column bases/strip footings; 20MPa concrete placed by
		Chute	
		Handle/barrow	
2.3	Slab Concrete	Pump	Blinding slab 20 MPa concrete placed by
		Chute	
		Handle/barrow	

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
	Chute	Slab on ground; 20MPa concrete placed by
	Handle/barrow	
	Pump	
	Handle/barrow	
	Pump	
	Crane/kibble	
2.4	Stair Concrete	Stairs/landings; formwork; 80 kg/m ³ bar reinforcement; 25MPa concrete placed by pump
2.5	Wall Concrete	Walls; 25MPa concrete placed by
	Handle/barrow	
	Pump	
2.6	Beam Concrete	Columns/isolated beams; 25MPa concrete placed by
	Handle/barrow	
	Pump	
2.7	Block Filling Concrete	Block wall cores; 20MPa concrete placed by
	Handle/barrow	
	Pump	
2.8	Sand	Filling by hand to beds in
	50mm thick	
	75mm thick	
2.9	Membranes	Plastic membranes with taped joints
	200um	
3.1	Strip Footings	Reinforced concrete strip footing; including excavation; 20 MPa concrete placed by pump in to trenches; 2 layers of trench mesh
	300mm deep x 300mm wide with F8TM3	
	300mm deep x 400mm wide with F8TM4	
	400mm deep x 300mm wide with F8TM3	
	400mm deep x 300mm wide with F11TM3	
	400mm deep x 400mm wide with F11TM4	
	500mm deep x 300mm wide with F11TM3	
	500mm deep x 300mm wide with F12TM3	
	600mm deep x 400mm wide with F12TM4	
	600mm deep x 300mm wide with F12TM3 (encased in double layer of 200 um polythene)	
3.2	Pad Footings - Square Pad	Concrete pad footing; including excavation and backfilling; 20 MPa concrete placed by pump
	400 x 400 x 200mm depth (overall depth 300mm)	
	500 x 500 x 200mm depth (overall depth 300mm)	
	600 x 600 x 250mm depth (overall depth 300mm)	
	400 x 400 x 200mm depth (overall depth 400mm)	
	500 x 500 x 200mm depth (overall depth 400mm)	
	600 x 600 x 250mm depth (overall depth 400mm)	
	400 x 400 x 200mm depth (overall depth 500mm)	
	500 x 500 x 200mm depth (overall depth 500mm)	
	600 x 600 x 250mm depth (overall depth 500mm)	
	400 x 400 x 200mm depth (overall depth 600mm)	
	500 x 500 x 200mm depth (overall depth 600mm)	
	600 x 600 x 250mm depth (overall depth 600mm)	

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
3.3 Pad Footings - Circular Pad	500mm diameter x 200mm depth (overall depth 300mm)	Concrete pad footing; including excavation and backfilling; 20 MPa concrete placed by pump
	600mm diameter x 200mm depth (overall depth 300mm)	
	750mm diameter x 250mm depth (overall depth 300mm)	
	500mm diameter x 200mm depth (overall depth 400mm)	
	600mm diameter x 200mm depth (overall depth 400mm)	
	750mm diameter x 250mm depth (overall depth 400mm)	
	500mm diameter x 200mm depth (overall depth 500mm)	
	600mm diameter x 200mm depth (overall depth 500mm)	
	750mm diameter x 250mm depth (overall depth 500mm)	
	500mm diameter x 200mm depth (overall depth 600mm)	
	600mm diameter x 200mm depth (overall depth 600mm)	
	750mm diameter x 250mm depth (overall depth 600mm)	
3.4 Footing Beams	300mm deep x 300mm wide	Reinforced concrete footing beam; including excavation; 20 MPa concrete placed by pump; formwork; 80 kg/m ³ bar reinforcement
	450mm deep x 300mm wide	
	600mm deep x 300mm wide	
	300mm deep x 450mm wide	
	450mm deep x 450mm wide	
	600mm deep x 450mm wide	
	300mm deep x 600mm wide	
	450mm deep x 600mm wide	
	600mm deep x 600mm wide	
	300mm deep x 750mm wide	
	450mm deep x 750mm wide	
	600mm deep x 750mm wide	
3.5 Column Bases	300 x 300 x 300mm depth	Reinforced concrete column base; including excavation; 20 MPa concrete placed by pump; formwork; 80 kg/m ³ bar reinforcement
	450 x 450 x 300mm depth	
	450 x 450 x 450mm depth	
	450 x 450 x 600mm depth	
	600 x 600 x 300mm depth	
	600 x 600 x 450mm depth	
	600 x 600 x 600mm depth	
	750 x 750 x 300mm depth	
	750 x 750 x 450mm depth	
	750 x 750 x 600mm depth	
	900 x 900 x 300mm depth	
	900 x 900 x 450mm depth	
	900 x 900 x 600mm depth	

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
3.6 Raft Slabs	100mm thick with F8TM3 and F72 mesh	Reinforced concrete raft slab comprising slab with edge beams; including excavation for edge beams; 100mm sand base; 200um polythene underlay; termite soil barrier treatment; 20 MPa concrete placed by pump; steel trowel finish; formwork; 1 layer of trench mesh and 1 layer of square mesh
	125mm thick with F8TM3 and F72 mesh	
	150mm thick with F11TM3 and F82 mesh	
	200mm thick with F11TM3 and F82 mesh	
3.7 Stiffened Raft Slabs	300mm deep x 300mm wide @ 7.0 meter spacing; F11TM3 and F72 mesh	Reinforced concrete stiffened raft slab comprising 100mm thick slab with edge and internal beams; including excavation for beams; 100mm sand base; 200um polythene underlay; termite soil barrier treatment; 20 MPa concrete placed by pump; steel trowel finish; formwork; 1 layer of trench mesh and 1 layer of square mesh; with beams
	400mm deep x 300mm wide @ 6.0 meter spacing; F11TM3 and F72 mesh	
	500mm deep x 300mm wide @ 5.0 meter spacing; F12TM3 and F82 mesh	
	800mm deep x 300mm wide @ 4.0 meter spacing; F12TM3 and F92 mesh	
	400mm deep x 300mm wide @ 6.0 meter spacing; 5 x Y16 bars and F72 mesh	
	400mm deep x 300mm wide @ 4.0 meter spacing; 5 x Y12 bars and F72 mesh	
	500mm deep x 300mm wide @ 4.5 meter spacing; 5 x Y12 bars and F72 mesh	
	500mm deep x 300mm wide @ 4.0 meter spacing; 6 x Y12 bars and F72 mesh	
	625mm deep x 300mm wide @ 4.0 meter spacing; 4 x Y16 bars and F72 mesh	
	625mm deep x 300mm wide @ 4.0 meter spacing; 4 x Y16 bars to internal beams and 6 x Y16 bars to edge beams; F72 mesh	
	800mm deep x 300mm wide @ 4.0 meter spacing; 6 x Y16 bars and F72 mesh	
	800mm deep x 300mm wide @ 4.0 meter spacing; 6 x Y16 bars to internal beams; F72 mesh	
	1000mm deep x 300mm wide @ 4.0 meter spacing; 7 x Y16 bars and F72 mesh	
3.8 Paving	75mm thick with F72 mesh	Reinforced concrete paving; 20 MPa concrete placed by pump; broom finish; expansion joints @ 10.0 metre centres; formwork; 1 layer of mesh reinforcement
	100mm thick with F72 mesh	
	125mm thick with F72 mesh	
	150mm thick with F72 mesh	
3.9 Suspended Slabs	100mm thick	Reinforced concrete suspended slab; 25 MPa concrete placed by pump; steel trowel finish; formwork; 150 kg/m ³ reinforcement
	200mm thick	
	300mm thick	

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
	100mm thick	Prestressed concrete suspended slab; 32 MPa concrete placed by pump; steel trowel finish; formwork; prestressing system (based on an 8 metre x 8 metre grid); and reinforcement
	200mm thick	
	300mm thick	
3.10 Ground Slabs	200mm thick	Reinforced concrete ground slab; 20 MPa concrete placed by pump; steel trowel finish; formwork; 100 kg/m ³ reinforcement
	300mm thick	
3.11 Attached Beams	300 x 300mm wide	Reinforced concrete attached beams; 25 MPa concrete placed by pump; formwork; 150 kg/m ³ reinforcement
	450 x 300mm wide	
	600 x 300mm wide	
	450 x 450mm wide	
3.12 Isolated Beams	600 x 450mm wide	Reinforced concrete isolated beams; 25 MPa concrete placed by pump; formwork; 150 kg/m ³ reinforcement
	300 x 300mm wide	
	450 x 300mm wide	
	600 x 300mm wide	
3.13 Walls	450 x 450mm wide	Reinforced concrete walls; 25 MPa concrete placed by pump; formwork; 120 kg/m ³ reinforcement
	600 x 450mm wide	
	100mm thick	
	150mm thick	
3.14 Attached Columns	200mm thick	Reinforced concrete attached columns; 25 MPa concrete placed by pump; formwork; 150 kg/m ³ reinforcement
	300 x 300mm wide	
	450 x 450mm wide	
	600 x 600mm wide	
3.15 Isolated Columns	300 x 300mm wide	Reinforced concrete isolated columns; 25 MPa concrete placed by pump; formwork; 150 kg/m ³ reinforcement
	450 x 450mm wide	
	600 x 600mm wide	
4.1 Clay Brickwork	Walls - 110mm thick	Clay metric standard bricks; 230 x 110 x 76mm laid in 1:1:6 cement mortar
	Walls - 230mm thick	
	Walls - 350mm thick	
4.2 Concrete Brickwork	Walls - 110mm thick	Concrete metric standard bricks; 230 x 110 x 76mm laid in 1:1:6 cement mortar
	Walls - 230mm thick	
	Walls - 350mm thick	
4.3 Galvanised Steel Lintels	Galvanised steel flat bar; 75 x 10mm	Lintels built in to brickwork
	Galvanised steel flat bar; 85 x 8mm ribbed	
	Galvanised steel angle; 75 x 75 x 10mm	
	Galvanised steel angle; 100 x 75 x 10mm	

<i>Component</i>		<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
		Galvanised steel angle; 150 x 90 x 10mm	
		Galvanised steel angle; 100 x 100 x 6mm ribbed	
		Galvanised steel angle; 150 x 100 x 6mm ribbed	
		Galvanised steel T bar; 200 x 200 x 7mm ribbed	
		Galvanised steel T bar; 200 x 200 x 9mm ribbed	
4.4	Aluminium Core Bitumen Coated (0.45mm)	110mm wide	Damp proof course built in to brick/blockwork
		230mm wide	
		350mm wide	
5.1	Square Hollow Section	75 x 75 x 2.5mm (2400mm long)	Steel column with top and bottom plates; holed only for simple connection; shop primed (ROZC); fixed in position including bolts nuts and washers
		75 x 75 x 3.0mm (2400mm long)	
		75 x 75 x 3.5mm (2400mm long)	
		75 x 75 x 4.0mm (2400mm long)	
		75 x 75 x 5.0mm (2400mm long)	
		75 x 75 x 6.0mm (2400mm long)	
		89 x 89 x 3.5mm (2400mm long)	
		89 x 89 x 5.0mm (2400mm long)	
		89 x 89 x 6.0mm (2400mm long)	
		100 x 100 x 3.0mm (2400mm long)	
		100 x 100 x 4.0mm (2400mm long)	
		100 x 100 x 5.0mm (2400mm long)	
		100 x 100 x 6.0mm (2400mm long)	
		100 x 100 x 9.0mm (2400mm long)	
5.2	Universal Section Steel Columns	1 tonne	Universal section steel columns; holed only for simple connection; shop primed (ROZC); fixed in position including bolts nuts and washers
		5 tonne	
		20 tonne	
		1 tonne	Universal section steel columns with welded fitments; holed only for simple connection; shop primed (ROZC); fixed in position including bolts nuts and washers
		5 tonne	
		20 tonne	
		1 tonne	Universal section steel columns; prepared for rigid connection (welded; bolted/welded; bolted); shop primed (ROZC); fixed in position including bolts nuts and washers
		5 tonne	
		20 tonne	
5.3	Compound Built Up Plate Steel Columns	1 tonne	Compound built up plate steel columns; holed only for simple connection; shop primed (ROZC); fixed in position including bolts nuts and washers
		5 tonne	
		20 tonne	

Component		Material/Dimension/Methods of Construction	Description
5.4	Square Hollow Section Steel Columns	1 tonne	Square hollow section steel columns; holed only for simple connection; shop primed (ROZC); fixed in position including bolts nuts and washers
		5 tonne	
		20 tonne	
5.5	Universal Section Steel Beams	200 UB 18	Holed only for simple connection; shop primed (ROZC); fixed in position including bolts nuts and washers
		200 UB 22	
		200 UB 25	
		200 UB 29	
		250 UB 25	
		250 UB 31	
		250 UB 37	
		310 UB 32	
		310 UB 40	
		310 UB 46	
		1 tonne	Universal section steel beams; holed only for simple connection; shop primed (ROZC); fixed in position including bolts nuts and washers
		5 tonne	
		20 tonne	
		1 tonne	Universal section steel beams with welded fitments; holed only for simple connection; shop primed (ROZC); fixed in position including bolts nuts and washers
		5 tonne	
		20 tonne	
		1 tonne	Universal section steel beams; prepared for rigid connection (welded; bolted/welded; bolted); shop primed (ROZC); fixed in position including bolts nuts and washers
		5 tonne	
		20 tonne	
5.6	Parallel Flange Steel Channel Beams	150 x 75mm	Holed only for simple connection; shop primed (ROZC); fixed in position including bolts nuts and washers
		180 x 75mm	
		200 x 75mm	
		230 x 75mm	
		250 x 90mm	
		300 x 90mm	
		380 x 100mm	
		1 tonne	Parallel flange steel channel beams; holed only for simple connection; shop primed (ROZC); fixed in position including bolts nuts and washers
		5 tonne	
		20 tonne	

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
5.7 Compound Built Up Plate Steel Beams	1 tonne	Compound built up plate steel beams; holed only for simple connection; shop primed (ROZC); fixed in position including bolts nuts and washers
	5 tonne	
	20 tonne	
5.8 Portal Frames	Portal frames	Portal frame fabricated from universal steel sections; shop primed (ROZC); fixed in position including bolts nuts and washers
5.9 Trusses	Angle sections	Trusses fabricated from steel sections; shop primed (ROZC); fixed in position including all bolts nuts and washers
	Universal sections	
6.1 Letter Box	Cast aluminium	Single letter box with hooded front opening and hinged rear access panel built in to masonry
	Galvanised steel	
	5 bank	Aluminium multi bank letter boxes with front opening; hinged rear access panel with keyed lock; individually numbered; complete with separate paper tray build in to masonry
	11 bank	
	21 bank	
	31 bank	
7.1 Ground Floor Framing - Hardwood F8	100 x 75mm bearers @ 1800mm centres and 100 x 50mm joists @ 450mm centres	Standard framing to ground floor with
	100 x 75mm bearers @ 1800mm centres and 100 x 50mm joists @ 600mm centres	
	100 x 75mm bearers @ 2400mm centres and 125 x 50mm joists @ 450mm centres	
	100 x 75mm bearers @ 2400mm centres and 125 x 50mm joists @ 600mm centres	
	100 x 75mm bearers @ 3000mm centres and 150 x 50mm joists @ 450mm centres	
	100 x 75mm bearers @ 3000mm centres and 150 x 50mm joists @ 600mm centres	
	150 x 75mm bearers @ 1800mm centres and 100 x 50mm joists @ 450mm centres	
	150 x 75mm bearers @ 1800mm centres and 100 x 50mm joists @ 600mm centres	
	150 x 75mm bearers @ 2400mm centres and 125 x 50mm joists @ 450mm centres	
	150 x 75mm bearers @ 2400mm centres and 125 x 50mm joists @ 600mm centres	
	150 x 75mm bearers @ 3000mm centres and 150 x 50mm joists @ 450mm centres	
	150 x 75mm bearers @ 3000mm centres and 150 x 50mm joists @ 600mm centres	
	200 x 75mm bearers @ 1800mm centres and 100 x 50mm joists @ 450mm centres	
	100 x 50mm joists @ 450mm centres	

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
	200 x 75mm bearers @ 1800mm centres and 100 x 50mm joists @ 600mm centres	
	200 x 75mm bearers @ 2400mm centres and 125 x 50mm joists @ 450mm centres	
	200 x 75mm bearers @ 2400mm centres and 125 x 50mm joists @ 600mm centres	
	200 x 75mm bearers @ 3000mm centres and 150 x 50mm joists @ 450mm centres	
	200 x 75mm bearers @ 3000mm centres and 150 x 50mm joists @ 600mm centres	
7.2 Steel Framing	100 x 50 joists @ 450mm centres 100 x 50 joists @ 600mm centres	Ground floor framing comprising galvanised steel 100 x 75mm bearers @ 1800mm centres with;
7.3 Upper Floor Framing - Hardwood F8	150 x 50mm @ 450mm centres 150 x 50mm @ 600mm centres 200 x 50mm @ 450mm centres 200 x 50mm @ 600mm centres 250 x 50mm @ 450mm centres 250 x 50mm @ 600mm centres 300 x 50mm @ 450mm centres 300 x 50mm @ 600mm centres	Standard framing to upper floor including joists and solid blocking at 1800mm centres
7.4 Upper Floor Framing - MGP10/F5 Pine	140 x 45mm @ 450mm centres 140 x 45mm @ 600mm centres 190 x 45mm @ 450mm centres 190 x 45mm @ 600mm centres	Standard framing to upper floor including joists and solid blocking at 1800mm centres
7.5 Engineered Joists	200 x 47mm @ 600mm centres 246 x 57mm @ 600mm centres 300 x 63mm @ 600mm centres 360 x 63mm @ 600mm centres 248 x 70 mm @ 600mm centres 248 x 90 mm @ 600mm centres 302 x 70 mm @ 600mm centres 302 x 90 mm @ 600mm centres	Timber engineered joist (flange & web type) including standard strap bracing fixed in position Composite engineered timber & steel joist including standard blocking and bracing fixed in position; F8
7.6 Wall Framing - Hardwood F8	75 x 38mm @ 450mm centres 75 x 38mm @ 600mm centres 75 x 50mm @ 450mm centres 75 x 50mm @ 600mm centres 100 x 38mm @ 450mm centres 100 x 38mm @ 600mm centres 100 x 50mm @ 450mm centres 100 x 50mm @ 600mm centres 75 x 50mm @ 450mm centres 75 x 50mm @ 600mm centres 100 x 38mm @ 450mm centres 100 x 38mm @ 600mm centres 100 x 50mm @ 450mm centres 100 x 50mm @ 600mm centres	Wall frame 2400mm high comprising untrenched plates; studs; one row nogging and bracing Wall frame 2700mm high comprising untrenched plates; studs; one row nogging and bracing

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
7.7 Wall Framing - MGP10/F5 Pine	70 x 35mm @ 450mm centres	Wall frame 2400mm high comprising untrenched plates; studs; one row nogging and bracing
	70 x 35mm @ 600mm centres	
	70 x 45mm @ 450mm centres	
	70 x 45mm @ 600mm centres	
	90 x 35mm @ 450mm centres	
	90 x 35mm @ 600mm centres	
	90 x 45mm @ 450mm centres	
	90 x 45mm @ 600mm centres	
	70 x 45mm @ 450mm centres	Wall frame 2700mm high comprising untrenched plates; studs; one row nogging and bracing
	70 x 45mm @ 600mm centres	
	90 x 35mm @ 450mm centres	
	90 x 35mm @ 600mm centres	
	90 x 45mm @ 450mm centres	
	90 x 45mm @ 600mm centres	
7.8 Steel Framing	75 x 32mm studs @ 450mm centres	Wall framing; galvanised steel 2400mm high comprising 78 x 31mm plates; one row 72 x 34mm nogging; studs and bracing
	75 x 32mm studs @ 600mm centres	
	75 x 32mm studs @ 450mm centres	Wall framing; galvanised steel 3000mm high comprising 78 x 31mm plates; two row 72 x 34mm nogging; studs and bracing (non load bearing)
	75 x 32mm studs @ 600mm centres	
7.9 Heads or Lintels - Hardwood F8	150 x 50mm	-
	150 x 75mm	
	200 x 50mm	
	200 x 75mm	
	250 x 75mm	
	300 x 75mm	
7.10 Heads or Lintels - MGP10/F5 Pine	140 x 45mm	-
	140 x 70mm	
	190 x 45mm	
	190 x 70mm	
7.11 Ceiling Framing - Hardwood F8	100 x 38mm ceiling joist @ 450mm centres	Standard framing to ceiling including ceiling joists; trimmers and hanging beams @ 2100mm centres
	100 x 38mm ceiling joist @ 600mm centres	
	100 x 50mm ceiling joist @ 450mm centres	
	100 x 50mm ceiling joist @ 600mm centres	
	125 x 50mm ceiling joist @ 450mm centres	
	125 x 50mm ceiling joist @ 600mm centres	
7.12 Ceiling Framing - MGP10/F5 Pine	90 x 35mm ceiling joist @ 450mm centres	Standard framing to ceiling including ceiling joists; trimmers and hanging beams @ 2100mm centres
	90 x 35mm ceiling joist @ 600mm centres	
	90 x 45mm ceiling joist @ 450mm centres	
	90 x 45mm ceiling joist @ 600mm centres	
	140 x 45mm ceiling joist @ 450mm centres	
	140 x 45mm ceiling joist @ 600mm centres	
7.13 Flat Roof Framing - Hardwood F8	100 x 50mm rafters @ 450mm centres	Standard framing to flat roof including rafters
	100 x 50mm rafters @ 600mm centres	
	150 x 38mm rafters @ 450mm centres	
	150 x 38mm rafters @ 600mm centres	

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
7.14 Flat Roof Framing - MGP10/F5 Pine	150 x 50mm rafters @ 450mm centres	Standard framing to flat roof including rafters
	150 x 50mm rafters @ 600mm centres	
	200 x 50mm rafters @ 450mm centres	
	200 x 50mm rafters @ 600mm centres	
	250 x 50mm rafters @ 450mm centres	
	250 x 50mm rafters @ 600mm centres	
	300 x 50mm rafters @ 450mm centres	
	300 x 50mm rafters @ 600mm centres	
7.15 Pitched Roof Framing - Hardwood F8	90 x 45mm rafters @ 450mm centres	Standard framing 20' pitched roof; 600mm overhang; including rafters; ridge; underpurlins; struts and collar ties; (Calculated on flat plan area; measured to outer line of overhang)
	90 x 45mm rafters @ 600mm centres	
	140 x 35mm rafters @ 450mm centres	
	140 x 35mm rafters @ 600mm centres	
	140 x 45mm rafters @ 450mm centres	
	140 x 45mm rafters @ 600mm centres	
	190 x 45mm rafters @ 450mm centres	
	190 x 45mm rafters @ 600mm centres	
7.16 Pitched Roof Framing - MGP10/F5 Pine	100 x 38mm rafters @ 450mm centres	Standard framing 20' pitched roof; 600mm overhang; including rafters; ridge; underpurlins; struts and collar ties; (Calculated on flat plan area; measured to outer line of overhang)
	100 x 38mm rafters @ 600mm centres	
	100 x 50mm rafters @ 450mm centres	
	100 x 50mm rafters @ 600mm centres	
	125 x 38mm rafters @ 450mm centres	
	125 x 38mm rafters @ 600mm centres	
	125 x 50mm rafters @ 450mm centres	
	125 x 50mm rafters @ 600mm centres	
7.17 Roof Truss	150 x 38mm rafters @ 450mm centres	Standard framing 20' pitched roof; 600mm overhang; including rafters; ridge; underpurlins; struts and collar ties; (Calculated on flat plan area; measured to outer line of overhang)
	150 x 38mm rafters @ 600mm centres	
	150 x 50mm rafters @ 450mm centres	
	150 x 50mm rafters @ 600mm centres	
	90 x 35mm rafters @ 450mm centres	
	90 x 35mm rafters @ 600mm centres	
	90 x 45mm rafters @ 450mm centres	
	90 x 45mm rafters @ 600mm centres	
7.18 Hardwood F8 - sawn	140 x 35mm rafters @ 450mm centres	Type A timber roof truss; 20' pitch; 600mm overhang; fixed in position including bracing (Calculated on flat plan area; measured to outer line of overhang)
	140 x 35mm rafters @ 600mm centres	
	140 x 45mm rafters @ 450mm centres	
	140 x 45mm rafters @ 600mm centres	
	3600mm span @ 450mm centres	
	3600mm span @ 600mm centres	
	4800mm span @ 450mm centres	
	4800mm span @ 600mm centres	
7.18 Hardwood F8 - sawn	6000mm span @ 450mm centres	Posts
	6000mm span @ 600mm centres	
	7200mm span @ 450mm centres	
	7200mm span @ 600mm centres	
	9000mm span @ 450mm centres	
	9000mm span @ 600mm centres	
	12000mm span @ 450mm centres	
	12000mm span @ 600mm centres	
7.18 Hardwood F8 - sawn	75 x 75 mm	Posts
	100 x 100 mm	
	125 x 125mm	

<i>Component</i>		<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
7.19	Hardwood F8 - DAR	150 x 150mm	Posts
		75 x 75 mm	
		100 x 100 mm	
		125 x 125mm	
7.20	Oregon F7 – sawn	150 x 150mm	Posts
		75 x 75 mm	
		100 x 100 mm	
		125 x 125mm	
7.21	Oregon F7 – DAR	150 x 150mm	Posts
		75 x 75 mm	
		100 x 100 mm	
		125 x 125mm	
7.22	Treated Pine F7 H3 - DAR	150 x 150mm	Posts
		90 x 90mm	
		120 x 120mm	
		140 x 140mm	
7.23	Hardwood F8 - sawn	200 x 50mm	Beams
		200 x 75mm	
		200 x 100mm	
		250 x 50mm	
		250 x 75mm	
		250 x 100mm	
		300 x 50mm	
		300 x 75mm	
7.24	Hardwood F8 - DAR	300 x 100mm	Beams
		200 x 50mm	
		200 x 75mm	
		200 x 100mm	
		250 x 50mm	
		250 x 75mm	
		250 x 100mm	
		300 x 50mm	
7.25	Oregon F7 – sawn	300 x 75mm	Beams
		300 x 100mm	
		200 x 50mm	
		200 x 75mm	
		200 x 100mm	
		250 x 50mm	
		250 x 75mm	
		250 x 100mm	
7.26	Oregon F7 – DAR	300 x 50mm	Beams
		300 x 75mm	
		200 x 50mm	
		200 x 75mm	
		200 x 100mm	
		250 x 50mm	
		250 x 75mm	
		250 x 100mm	

300 x 100mm

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
7.27 Treated Pine F7 H3 - DAR	190 x 45mm 190 x 70mm 240 x 45mm 240 x 70mm	Beams
7.28 Hardwood F8 Battens	38 x 25mm with 450mm span @ 450mm centres 50 x 25mm with 600mm span @ 450mm centres 38 x 38mm with 450mm span @ 900mm centres 38 x 38mm with 450mm span @ 1200mm centres 38 x 38mm with 600mm span @ 600mm centres 38 x 38mm with 900mm span @ 450mm centres 50 x 38mm with 600mm span @ 900mm centres 50 x 38mm with 600mm span @ 1200mm centres 50 x 38mm with 900mm span @ 600mm centres 50 x 38mm with 1200mm span @ 450mm centres 50 x 50mm with 1200mm span @ 600mm centres 50 x 50mm with 1200mm span @ 900mm centres 50 x 50mm with 1200mm span @ 1200mm centres	-
7.29 Pine Battens	35 x 35mm with 600mm span @ 450mm centres 45 x 35mm with 450mm span @ 600mm centres 45 x 35mm with 450mm span @ 900mm centres 45 x 35mm with 450mm span @ 1200mm centres 45 x 35mm with 900mm span @ 450mm centres 45 x 45mm with 600mm span @ 900mm centres 45 x 45mm with 600mm span @ 1200mm centres 45 x 45mm with 900mm span @ 600mm centres 45 x 45mm with 1200mm span @ 450mm centres 70 x 35mm with 1200mm span @ 600mm centres 70 x 35mm with 1200mm span @ 900mm centres 70 x 35mm with 1200mm span @ 1200mm centres	-
7.30 Steel Battens	58 x 25 x 0.42mm	Galvanised steel ceiling batten fixed in position
7.31 Particleboard Flooring	19mm thick 22mm thick	Particleboard T&G flooring fixed to timber joists
7.32 Plywood Flooring	12mm thick 15mm thick 17mm thick 20mm thick	Plywood T&G flooring fixed to timber joists/existing flooring
7.33 Timber Decking – Hardwood	75 x 25mm pencil 100 x 25mm pencil	Timber decking close spaced fixed to timber joists
7.34 Particleboard Wall Linings	9mm thick 12mm thick 16mm thick 18mm thick 25mm thick 33mm thick	Particleboard sheeting fixed to vertical timber surface

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
7.35 Plywood Wall Linings - CD Grade	7.5mm thick 9mm thick 12mm thick 17mm thick 20mm thick	Exterior structural plywood sheeting fixed to vertical timber surface
8.1 Light Weight (290g/m ²)	Plain Anti glare	Aluminium fire resistant foil insulation fixed to rafters/purlins
8.2 Medium Weight (368g/m ²)	Plain Anti glare	Aluminium fire resistant foil insulation fixed to rafters/purlins
8.3 Heavy Weight (378g/m ²)	Plain Anti glare	Aluminium fire resistant foil insulation fixed to rafters/purlins
8.4 Ceiling/Roof Insulation	R1.5 (75 - 80mm thick) R2.0 (100 - 110mm thick) R2.5 (125 - 145mm thick) R3.0 (150 - 155mm thick) R3.5 (170 - 175mm thick)	Fibreglass insulation batts laid between ceiling joists
8.5 Wall Insulation	R1.5 (75 - 80mm thick) R2.0 (100 - 110mm thick) R2.5 (125 - 145mm thick) R3.0 (150 - 155mm thick) R3.5 (170 - 175mm thick)	Fibreglass insulation batts laid between studs
8.6 Floor Insulation	R1.5 (75 - 80mm thick) R2.0 (100 - 110mm thick) R2.5 (125 - 145mm thick) R3.0 (150 - 155mm thick) R3.5 (170 - 175mm thick)	Fibreglass insulation batts laid between floor joists supported on galvanised wire mesh
9.1 Architrave/Skirting - Pine	42 x 19mm bullnose/splay 70 x 19mm bullnose/splay 90 x 19mm bullnose/splay 140 x 19mm bullnose/splay 70 x 19mm colonial 90 x 19mm colonial 140 x 19mm colonial	-
9.2 Staircase	900mm wide (per meter rise) Landing 900mm x 900mm x 1000mm high	External straight flight open tread timber staircase (280mm going; 180mm riser)
9.3 Handrail	Handrail 900mm high comprising 100 x 100mm timber posts at 1000mm centres with 150 x 38mm handrail and midrail	-
9.4 Staircase	Closed tread design (per metre rise) Open tread design (per metre rise) Landing	Internal straight flight timber staircase (280mm going; 180mm riser) 900mm wide

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
	1250mm diameter (per metre rise)	Internal spiral flight timber open tread staircase mounted on steel centre string with simple pattern steel balustrade and patent plastic capping handrail
	1500mm diameter (per metre rise)	
	1800mm diameter (per metre rise)	
9.5 Handrail	Meranti/ Pacific maple	Internal staircase moulded handrail 75 x 50mm fixed to wall with metal handrail brackets at 1000mm centres
9.6 Balustrade	Meranti/ Pacific maple	Internal staircase balustrade 900mm high comprising 75 x 50mm moulded handrail with 38 x 38mm moulded balusters at 140mm centres
	Meranti/ Pacific maple	Internal staircase moulded newel post 100 x 100mm fixed in position
9.7 Cupboards	2400mm high x 900mm wide x 600mm deep 2400mm high x 1800mm wide x 600mm deep	Cupboard built in to recess including flush door; jambs; door hardware; architrave; skirting and four particleboard shelves
9.8 Benchtops - Square Edge	16mm thick and 450mm wide 16mm thick and 600mm wide 33mm thick and 450mm wide 33mm thick and 600mm wide	Laminated particleboard benchtop
9.9 Benchtops - Round Edge	33mm thick and 450mm wide 33mm thick and 600mm wide	Laminated particleboard benchtop
9.10 Splashbacks	Laminated particleboard	Splashback (150mm high); fixed in position
9.11 Modular Floor Design Cupboards	Standard cabinets with one shelf 450mm deep Standard cabinets with one shelf 600mm deep Four drawer cabinet; 450mm wide x 450mm deep Four drawer cabinet; 450mm wide x 600mm deep Pull out table cabinet; 600mm wide x 450mm deep Pull out table cabinet; 600mm wide x 600mm deep Vegetable storage cabinet; 600mm wide x 450mm deep	Modular floor cabinets; plastic laminated particleboard 900mm high; complete with doors (add extra for benchtop) fixed in position
9.12 Modular Wall Design Cupboards	700mm high 350mm high	Modular wall cabinets; plastic laminated particleboard 300mm deep; complete with doors; fixed in position

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
9.13 Modular Wall Oven Design Cupboards	800mm wide x 600mm deep	Modular wall oven cabinets; plastic laminated particleboard 2100mm high; complete with pot drawer; fixed in position
9.14 Modular Pantry Design Cupboards	2100mm high x 450mm wide x 450mm deep 2100mm high x 450mm wide x 600mm deep 2100mm high x 600mm wide x 450mm deep 2100mm high x 600mm wide x 600mm deep 2100mm high x 900mm wide x 450mm deep 2100mm high x 900mm wide x 600mm deep	Modular pantry cabinets; plastic laminated particleboard with 5 shelves; complete with doors; fixed in position
9.15 Custom Floor Design Cupboards	Standard cabinets with one shelf 450mm deep Standard cabinets with one shelf 600mm deep Four drawer cabinet; 450mm wide x 450mm deep Four drawer cabinet; 450mm wide x 600mm deep Pull out table cabinet; 600mm wide x 450mm deep Pull out table cabinet; 600mm wide x 600mm deep Vegetable storage cabinet; 600mm wide x 450mm deep Vegetable storage cabinet; 600mm wide x 600mm deep	Custom floor cabinets; plastic laminated particleboard 900mm high; complete with doors (add extra for benchtop) fixed in position
9.16 Custom Wall Design Cupboards	700mm high 350mm high	Custom wall cabinets; plastic laminated particleboard 300mm deep; complete with doors; fixed in position
9.17 Custom Wall Oven Design Cupboards	800mm wide x 600mm deep	Custom wall oven cabinets; plastic laminated particleboard 2100mm high; complete with pot drawer; fixed in position
9.18 Custom Pantry Design Cupboards	2100mm high x 450mm wide x 450mm deep 2100mm high x 450mm wide x 600mm deep 2100mm high x 600mm wide x 450mm deep 2100mm high x 600mm wide x 600mm deep 2100mm high x 900mm wide x 450mm deep 2100mm high x 900mm wide x 600mm deep	Custom pantry cabinets; plastic laminated particleboard with 5 shelves; complete with doors; fixed in position
9.19 Vanity units	750mm high x 750mm wide x 350mm deep; single basin 750mm high x 750mm wide x 450mm deep; single basin 750mm high x 900mm wide x 450mm deep; single basin 750mm high x 1200mm wide x 450mm deep; single basin 750mm high x 1500mm wide x 450mm deep; double basin	Vanity unit; moulded fibreglass one piece top and basin complete with plastic laminated particleboard cabinet; fixed in position (add extra for plumbing connection)

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
9.20 Wardrobes	750mm high x 750mm wide x 450mm deep; single basin	Vanity unit; plastic laminated particleboard top and cabinet complete with drop fibreglass basin; fixed in position (add extra for plumbing connection)
	750mm high x 900mm wide x 450mm deep; single basin	
	750mm high x 1200mm wide x 450mm deep; single basin	
	750mm high x 1500mm wide x 450mm deep; double basin	
	2400mm high x 900mm wide x 600mm deep	Wardrobe built in to recess; hung doors; door hardware; architrave; skirting; particleboard shelf and hanging rail
	2400mm high x 1800mm wide x 600mm deep	
10.1 Clear Float Glass	2400mm high x 900mm wide x 600mm deep	Wardrobe built in to recess; Surface sliding doors; door hardware; architrave; skirting; particleboard shelf and hanging rail
	2400mm high x 1800mm wide x 600mm deep	
	4mm	
	5mm	
	6mm	
10.2 Clear Toughened Glass	10mm	Clear float glass in pane sizes up to 2.0 m ² glazed in to timber or metal; fixed with putty
	12mm	
	4mm	
	5mm	
	6mm	
10.3 Framed Shower Screens	10mm	Clear toughened glass in pane sizes up to 2.0 m ² glazed in to timber or metal; fixed with putty
	12mm	
	Shower rod and half return panel	
	Shower rod and full return panel	
	Three door slider	
	Three door slider and half return panel	
	Three door slider and full return panel	
	Three door slider and two fixed panels (corner unit)	
	Pivot door	
10.4 Frameless Shower Screens	Pivot door and half return panel	Aluminium framed 6mm thick clear toughened glass shower screen fixed and sealed to wall
	Pivot door and full return panel	
	Pivot door and two full return panels (corner unit)	
	Hinged door	
	Hinged door and half return panel	
11.1 Sheet Membrane Roofing	Hinged door and full return panel	Frameless 10mm thick clear toughened glass shower screen fixed and sealed to wall using patch fittings
	Hinged door and two fixed panels (corner unit)	
	EPDM synthetic rubber - 100m ²	
	EPDM synthetic rubber - 500 m ²	
		EPDM synthetic rubber single layer membrane system 1.2mm thick; laid to concrete or timber roof substrate using contact adhesive; including perimeter detailing; upstands; outlets and penetrations

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
11.2 Aluminium Sheet Roofing	Square ribbed (10 ribs per sheet); 0.7mm thick	Square ribbed (10 ribs per sheet) stucco embossed aluminium roof sheeting; screw fixed
	Square ribbed (10 ribs per sheet); 0.9mm thick	
	Square ribbed (10 ribs per sheet); 1.2mm thick	
	Square ribbed (10 ribs per sheet); 0.7mm thick; colour coated	
	Square ribbed (10 ribs per sheet); 0.9mm thick; colour coated	
	Square rib/tray (5 ribs per sheet); 0.7mm thick	Square rib/tray (5 ribs per sheet) stucco embossed aluminium roof sheeting; screw fixed
	Square rib/tray (5 ribs per sheet); 0.9mm thick	
	Square rib/tray (5 ribs per sheet); 1.2mm thick	
	Square rib/tray (5 ribs per sheet); 0.7mm thick; colour coated	
	Square rib/tray (5 ribs per sheet); 0.9mm thick; colour coated	
11.3 Steel Sheet Roofing	Corrugated; 0.42mm BMT; zinc aluminium coated	Corrugated steel roof sheeting; screw fixed
	Corrugated; 0.48mm BMT; zinc aluminium coated	
	Corrugated; 0.61mm BMT; zinc aluminium coated	
	Corrugated; 0.80mm BMT; zinc aluminium coated	
	Corrugated; 0.42mm BMT; colour coated	
	Corrugated; 0.48mm BMT; colour coated	
	Corrugated; 0.60mm BMT; colour coated	
	Square ribbed (5 ribs per sheet); 0.42mm BMT; zinc aluminium coated	Square ribbed (5 ribs per sheet) steel roof sheeting; screw fixed
	Square ribbed (5 ribs per sheet); 0.48mm BMT; zinc aluminium coated	
	Square ribbed (5 ribs per sheet); 0.42mm BMT; colour coated	
	Square ribbed (5 ribs per sheet); 0.48mm BMT; colour coated	
	Square ribbed (9 ribs per sheet); 0.42mm BMT; zinc aluminium coated	Square ribbed (9 ribs per sheet) steel roof sheeting; screw fixed
	Square ribbed (9 ribs per sheet); 0.48mm BMT; zinc aluminium coated	
	Square ribbed (9 ribs per sheet); 0.42mm BMT; colour coated	
	Square ribbed (9 ribs per sheet); 0.48mm BMT; colour coated	
	Square rib/tray; 0.42mm BMT; zinc aluminium coated	Square rib/tray steel roof sheeting fixed with concealed clips
	Square rib/tray; 0.48mm BMT; zinc aluminium coated	
	Square rib/tray; 0.60mm BMT; zinc aluminium coated	
	Square rib/tray; 0.42mm BMT; colour coated	
	Square rib/tray; 0.48mm BMT; colour coated	
	Square rib/tray; 0.60mm BMT; colour coated	
11.4 Concrete Tile Roofing	Square edge pattern	Coloured concrete roof tiles including 50 x 25mm battens fixed in position up to 30° pitch; not exceeding 3.5 metres height above ground level at eaves
	Round edge pattern	
	Flat pattern	

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
11.5 Steel Tile Roofing	Steel roof tile	Steel acrylic/stone chip coated roof tiles; including barge ridge and hip capping; 50 x 38mm battens; fixed in position up to 30° pitch; not exceeding 3.5 metres height above ground level at eaves
11.6 Square Shape	500 x 500mm	Skylights comprising galvanised steel frame with permanent fixed ventilation; glazed with 3.175mm opaque acrylic dome; fixed in position including trimming between rafters and flashing (add extra for additional bracing or strutting as required)
	600 x 600mm	
	800 x 800mm	
	1000 x 1000mm	
	1200 x 1200mm	
11.7 Rectangular Shape	400 x 700mm	Skylights comprising galvanised steel frame with permanent fixed ventilation; glazed with 3.175mm opaque acrylic dome; fixed in position including trimming between rafters and flashing (add extra for additional bracing or strutting as required)
	400 x 1000mm	
	600 x 800mm	
	600 x 1100mm	
	800 x 1100mm	
	800 x 1400mm	
12.1 Aluminium Gutter	190 x 140mm fascia gutter	Aluminium (colour coated) gutter and fittings including fabrication and fixing with standard brackets
	Angle	
	Expansion joint	
	Outlet	
	Stop end	
12.2 Copper Gutter	125mm quad gutter	Copper gutter and fittings including fabrication and fixing with standard brackets
	Angle	
	Expansion joint	
	Outlet	
	Stop end	
12.3 Stainless Steel Gutter	125mm quad gutter	Stainless steel gutter and fittings including fabrication and fixing with standard brackets
	Angle	
	Expansion joint	
	Outlet	
	Stop end	
12.4 Aluminium	0.8mm thick	Valley gutter; 450mm wide; including fabrication and fixing
12.5 Copper	0.56mm thick	Valley gutter; 450mm wide; including fabrication and fixing

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
12.6 Stainless Steel	0.45mm thick	Valley gutter; 450mm wide; including fabrication and fixing
12.7 Aluminium Sump	300 x 300 x 150mm 450 x 450 x 150mm 600 x 600 x 150mm	Aluminium sump; 0.8mm thick including fabrication and fixing
12.8 Copper Sump	300 x 300 x 150mm 450 x 450 x 150mm 600 x 600 x 150mm	Copper sump; 0.56mm thick including fabrication and fixing
12.9 Stainless Steel Sump	300 x 300 x 150mm 450 x 450 x 150mm 600 x 600 x 150mm	Stainless steel sump; 0.45mm thick including fabrication and fixing
12.10 Aluminium	0.8mm thick	Rain heads 240mm high x 400mm long x 200mm wide including fabrication and fixing
12.11 Copper	0.56mm thick	Rain heads 240mm high x 400mm long x 200mm wide including fabrication and fixing
12.12 Stainless Steel	0.45mm thick	Rain heads 240mm high x 400mm long x 200mm wide including fabrication and fixing
12.13 Aluminium Downpipe	100 x 50mm rectangular downpipe 100 x 50mm rectangular bend; elbow or shoe 100 x 75mm rectangular downpipe 100 x 75mm rectangular bend; elbow or shoe	Aluminium colour downpipe and fittings including fabrication and fixing with standard brackets
12.14 Copper Downpipe	75mm diameter downpipe 75mm diameter bend; elbow or shoe 100mm diameter downpipe 100mm diameter bend; elbow or shoe 150mm diameter downpipe 150mm diameter bend; elbow or shoe 100 x 50mm rectangular downpipe 100 x 50mm rectangular bend; elbow or shoe 100 x 75mm rectangular downpipe 100 x 75mm rectangular bend; elbow or shoe 100 x 100mm rectangular downpipe 100 x 100mm rectangular bend; elbow or shoe 150 x 100mm rectangular downpipe 150 x 100mm rectangular bend; elbow or shoe	Copper downpipe and fittings including fabrication and fixing with standard brackets
12.15 Stainless Steel Downpipe	75mm diameter downpipe 75mm diameter bend; elbow or shoe 100mm diameter downpipe 100mm diameter bend; elbow or shoe 150mm diameter downpipe 150mm diameter bend; elbow or shoe 100 x 50mm rectangular downpipe 100 x 50mm rectangular bend; elbow or shoe 100 x 75mm rectangular downpipe	Stainless steel downpipe and fittings including fabrication and fixing with standard brackets

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
	100 x 75mm rectangular bend; elbow or shoe	
	100 x 100mm rectangular downpipe	
	100 x 100mm rectangular bend; elbow or shoe	
	150 x 100mm rectangular downpipe	
	150 x 100mm rectangular bend; elbow or shoe	
12.16 Flashing Straight Fixed	Aluminium; 0.55mm thick	-
	Copper; 0.56mm thick	
	Stainless steel; 0.45mm thick	
12.17 Flashing Step Fixed	Aluminium; 0.55mm thick	-
	Copper; 0.56mm thick	
	Stainless steel; 0.45mm thick	
13.1 Awning Windows	600 x 600mm wide	Aluminium domestic awning windows with colour coated frames and clear float glazing complete with timber reveals fixed in position
	600 x 1200mm wide	
	600 x 1800mm wide	
	600 x 2400mm wide	
	1200 x 600mm wide	
	1200 x 1200mm wide	
	1200 x 1800mm wide	
	1200 x 2400mm wide	
	2000 x 600mm wide	
	2000 x 1200mm wide	
	2000 x 1800mm wide	
	2000 x 2400mm wide	
13.2 Double Hung Windows	900 x 600mm wide	Aluminium domestic double hung windows with colour coated frames and clear float glazing complete with timber reveals fixed in position
	900 x 1200mm wide	
	900 x 1800mm wide	
	900 x 2400mm wide	
	1200 x 600mm wide	
	1200 x 1200mm wide	
	1200 x 1800mm wide	
	1200 x 2400mm wide	
	2000 x 600mm wide	
	2000 x 1200mm wide	
	2000 x 1800mm wide	
	2000 x 2400mm wide	
13.3 Sliding Windows	600 x 600mm wide	Aluminium domestic sliding windows with colour coated frames and clear float glazing complete with timber reveals fixed in position
	600 x 1200mm wide	
	600 x 1800mm wide	
	600 x 2400mm wide	
	1200 x 600mm wide	
	1200 x 1200mm wide	
	1200 x 1800mm wide	
	1200 x 2400mm wide	
	2000 x 600mm wide	
	2000 x 1200mm wide	
	2000 x 1800mm wide	
	2000 x 2400mm wide	
13.4 Awning Windows	600 x 600mm wide	Meranti timber awning windows with clear float glazing fixed in position
	600 x 1200mm wide	
	600 x 1800mm wide	
	600 x 2400mm wide	

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
13.5 Casement Windows	1200 x 600mm wide	Meranti timber casement windows with clear float glazing fixed in position
	1200 x 1200mm wide	
	1200 x 1800mm wide	
	1200 x 2400mm wide	
	2000 x 600mm wide	
	2000 x 1200mm wide	
	2000 x 1800mm wide	
	2000 x 2400mm wide	
	600 x 600mm wide	
	600 x 1200mm wide	
	600 x 1800mm wide	
	600 x 2400mm wide	
	1200 x 600mm wide	
	1200 x 1200mm wide	
	1200 x 1800mm wide	
	1200 x 2400mm wide	
	2000 x 600mm wide	
	2000 x 1200mm wide	
	2000 x 1800mm wide	
	2000 x 2400mm wide	
13.6 Double Hung Windows	900 x 600mm wide	Meranti timber double hung windows with clear float glazing fixed in position
	900 x 1200mm wide	
	900 x 1800mm wide	
	900 x 2400mm wide	
	1200 x 600mm wide	
	1200 x 1200mm wide	
	1200 x 1800mm wide	
	1200 x 2400mm wide	
	2000 x 600mm wide	
	2000 x 1200mm wide	
	2000 x 1800mm wide	
	2000 x 2400mm wide	
13.7 Steel Windows	Awning type	Steel domestic windows with galvanised frames and 6mm clear float glazing fixed in position
	Casement type	
	Fixed type	
14.1 Aluminium Doors	2100 x 900mm wide	Colour coated aluminium hung door and frame with clear toughened glazing (6mm); fixed in position
	2100 x 1800mm wide (1 x 900mm sliding panel)	Colour coated aluminium sliding door and frame with clear toughened glazing (6mm); fixed in position
	2100 x 2400mm wide (1 x 1200mm sliding panel)	
	2100 x 3000mm wide (1 x 1000mm sliding panel)	
	2100 x 3600mm wide (1 x 1200mm sliding panel)	

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
14.2 Steel Doors	2040 x 820mm wide	Zinc coated steel frame hung door clad with 1.0mm thick steel sheeting; cavity filled with rigid polystyrene sheet complete with frame and hinges; fixed in position
	2040 x 920mm wide	
	2040 x 1020mm wide	
14.3 Timber (Feature) Doors	4 panel design	External timber feature doors; solid construction with fielded panels; 2040 x 820 x 40mm; selected sliced veneers; fixed in position (hung)
	4 panel design with clear glazing (2 panels)	
	4 panel design with coloured glazing (2 panels)	
	4 panel design with lead light glazing (2 panels)	
	2 panel design with clear glazing (1 panels)	External timber feature sidelight; solid construction with fielded panels; 2040 x 400 x 40mm; selected sliced veneers; fixed in position
	2 panel design with coloured glazing (1 panels)	
	2 panel design with lead light glazing (1 panels)	
	Single light design with clear glazing	External timber fully glazed door; solid construction; 2040 x 820 x 40mm; selected sliced veneers; fixed in position (hung)
	2 light design with clear glazing	
	10 light design with clear glazing	
14.4 Timber (Flush) Doors	Hollow core construction	External timber flush face door; 2040 x 820 x 35mm; tempered hardboard; fixed in position (hung)
	Solid construction	
14.5 Timber (Feature) Doors	4 panel design	Internal timber feature doors; solid construction with fielded panels; 2040 x 820/770/720/620 x 35mm; selected sliced veneers; fixed in position (hung)
	4 panel design with clear glazing (2 panels)	
	4 panel design with coloured glazing (2 panels)	
	4 panel design with lead light glazing (2 panels)	
14.6 Timber (Flush) Doors	Hollow core construction	Internal timber flush face door; 2040 x 820/770/720/620/520 x 35mm; hardboard; fixed in position (hung)
	Solid construction	
	Hollow core construction	Internal timber flush face door; 2340 x 820/770/720/620/520 x 35mm; hardboard; fixed in position (hung)
	Solid construction	

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
14.7 Timber Doors	4 panel design 4 panel design with clear glazing (2 panels) 4 panel design with coloured glazing (2 panels) 4 panel design with lead light glazing (2 panels)	Internal timber bifold door (2 leaf set); solid construction with fielded panels; 2015 x 820/770/720 x 33mm; selected sliced veneers; fixed in position
14.8 Steel Doors	1970 x 985mm wide	Single action pivot door; zinc coated steel frame polystyrene core door; clad with steel sheeting; fitted to a steel door frame; complete with pivot mechanism; indicator bolt handles
14.9 1 hour fire rating	2040 x 820 x 45mm paint ply 2040 x 820 x 45mm sliced pacific maple	Flush face internal hung fire door and frame complete with hinges built in to 90/110mm thick concrete/masonry wall
14.10 2 hour fire rating	2040 x 820 x 45mm paint ply 2040 x 820 x 45mm sliced pacific maple	Flush face internal hung fire door and frame complete with hinges built in to 90/110mm thick concrete/masonry wall
14.11 3 hour fire rating	2040 x 820 x 45mm paint ply 2040 x 820 x 45mm sliced pacific maple	Flush face internal hung fire door and frame complete with hinges built in to 90/110mm thick concrete/masonry wall
14.12 Louver Doors	2040 x 720 x 33mm 2040 x 770 x 33mm 2040 x 820 x 33mm	Timber full louver door; solid construction; fixed in position (hung)
14.13 Louver Shutters	610 x 410 x 29mm 910 x 410 x 29mm 1210 x 310 x 29mm 1210 x 410 x 29mm 1505 x 310 x 29mm 1505 x 410 x 29mm 1800 x 410 x 29mm 1800 x 410 x 29mm 1800 x 520 x 29mm 1800 x 620 x 29mm 2040 x 310 x 29mm 2040 x 410 x 29mm 2040 x 520 x 29mm 2040 x 620 x 29mm	Timber full louver shutter; solid construction; fixed in position (hung)

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
14.14 Security Doors	Standard	Zinc coated steel hung security door; comprising steel frame and cladding with polystyrene core; complete with a welded steel door frame; heavy duty security hinges and locking system; 2040 x 820mm wide; fixed in position
	Heavy duty	
	Extra heavy duty	
14.15 Zinc Aluminium Coated Steel	2400 x 950mm wide	Ribbed profile domestic/commercial roller door/shutter fixed in position
	2400 x 2490mm wide	
	2400 x 3050mm wide	
	2400 x 4800mm wide	
14.16 Colour Coated Steel	2400 x 950mm wide	Ribbed profile domestic/commercial roller door/shutter fixed in position
	2400 x 2490mm wide	
	2400 x 3050mm wide	
	2400 x 4800mm wide	
	Automatic door opener	
15.1 10mm Standard Plasterboard	Wall; fixed to timber (glued and nailed)	10mm standard plasterboard up to 2.4m height with taped joints; stopped and sanded
	Ceilings; fixed to timber (glued and nailed)	
	Wall; fixed to metal (glued and screwed)	
15.2 10mm Standard Light Weight Plasterboard	Ceilings; fixed to metal (glued and screwed)	10mm light weight plasterboard up to 2.4m height with taped joints; stopped and sanded
	Ceilings; fixed to timber (glued and nailed)	
	Ceilings; fixed to metal (glued and screwed)	
15.3 13mm Standard Plasterboard	Wall; fixed to timber (glued and nailed)	13mm standard plasterboard up to 2.4m height with taped joints; stopped and sanded
	Ceilings; fixed to timber (glued and nailed)	
	Wall; fixed to metal (glued and screwed)	
	Ceilings; fixed to metal (glued and screwed)	
16.1 Ceramic Wall Tiling	25 x 25mm	Ceramic wall tiles with straight joints both ways; fixed with adhesive to floated backing and pointed with white grout to wall over 300mm wide
	50 x 50mm	
	100 x 100mm	
	150 x 150mm	
	200 x 100mm	
	200 x 200mm	
	200 x 300mm	
	300 x 300mm	
	25 x 25mm	Ceramic wall tiles with straight joints both ways; fixed with adhesive to floated backing and pointed with white grout to wall not exceeding 300mm wide
	50 x 50mm	
	100 x 100mm	
	150 x 150mm	
	200 x 100mm	
	200 x 200mm	
	200 x 300mm	
	300 x 300mm	

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
16.2 Ceramic Floor Tiling	25 x 25mm	Ceramic floor tiles with straight joints both ways; fixed including 20mm cement mortar bed; pointed with white grout to floor over 300mm wide laid lever
	50 x 50mm	
	100 x 100mm	
	150 x 150mm	
	200 x 100mm	
	200 x 200mm	
	200 x 300mm	
	300 x 300mm	Ceramic floor tiles with straight joints both ways; fixed including 20mm cement mortar bed; pointed with white grout to floor not exceeding 300mm wide laid lever
	25 x 25mm	
	50 x 50mm	
	100 x 100mm	
	150 x 150mm	
	200 x 100mm	
	200 x 200mm	
	200 x 300mm	
	300 x 300mm	
17.1 Carpet	Polypropylene	Broadloom carpet with hot bonded tape joints complete with underlay fixed to prepared surface with gripper edge fixing
	Nylon	
	Wool 100%	
	Wool/nylon 80/20%	
17.2 Vinyl Sheet	1.5mm thick	Vinyl sheet flooring with welded joints fixed to prepared surface with adhesive
	2.0mm thick	
	2.5mm thick	
18.1 Acrylic (Semi Gloss or Gloss)	Walls (timber panelling)	One coat acrylic primer; one coat undercoat; two coats acrylic interior semi gloss/gloss finish to internal woodwork
	Ceilings (timber panelling)	
	Doors	
	Windows	
18.2 Alkyd (Semi Gloss or Gloss)	Walls (timber panelling)	One coat oil primer; one coat undercoat and two coats enamel semi gloss/gloss finish to internal woodwork
	Ceilings (timber panelling)	
	Doors	
	Windows	
18.3 Polyurethane (Flat or Semi Gloss or Gloss)	Walls (timber panelling)	Two coats polyurethane flat/semi gloss/gloss finish to internal woodwork
	Ceilings (timber panelling)	
	Doors	
	Windows	
18.4 Stain	Walls (timber panelling)	Two coats interior oil stain finish to internal woodwork
	Ceilings (timber panelling)	
	Doors	
	Windows	
18.5 Acrylic (Flat or Semi Gloss or Gloss)	Walls	One coat acrylic sealer/undercoat and two coats acrylic interior flat/semi gloss/gloss finish to internal brickwork/blockwork/concrete/cement render
	Ceilings	

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
18.6 Alkyd (Flat)	Walls Ceilings	Two coats oil flat finish to internal brickwork/blockwork/concrete/cement render
18.7 Alkyd (Semi Gloss or Gloss)	Walls Ceilings	One coat oil sealer; one coat undercoat and two coats enamel semi gloss/gloss finish to internal brickwork/blockwork/concrete/cement render
18.8 Acrylic (Flat or Semi Gloss or Gloss)	Wall Ceilings	One coat acrylic sealer/undercoat and two coats acrylic interior flat/semi gloss/gloss finish to internal fibre cement/fibrous plaster/plaster/plasterboard
18.9 Alkyd (Flat)	Walls Ceilings	Two coats oil flat finish to internal fibre cement/fibrous plaster/plaster/plasterboard
18.10 Alkyd (Semi Gloss or Gloss)	Walls Ceilings	One coat oil sealer; one coat undercoat and two coats enamel semi gloss/gloss finish to internal fibrecement/fibrous plaster/plaster/plasterboard
18.11 Acrylic Latex (Low Sheen)	Walls (timber panelling) Ceilings (timber panelling) Doors Windows	Two coats acrylic latex exterior low sheen finish to external woodwork
18.12 Acrylic Latex (Gloss)	Walls (timber panelling) Ceilings (timber panelling) Doors Windows	One coat acrylic primer and two coats exterior acrylic gloss finish to external woodwork
18.13 Alkyd (Gloss)	Walls (timber panelling) Ceilings (timber panelling) Doors Windows	One coat oil primer; one coat undercoat and two coats enamel gloss finish to external woodwork
18.14 Stain	Walls (timber panelling) Ceilings (timber panelling) Doors Windows	Two coats exterior oil stain finish to external woodwork

Component	Material/Dimension/Methods of Construction	Description
18.15 PVA (Flat)	Walls Ceilings	Two coats PVA flat finish to external brickwork/ blockwork/concrete/ cement render in undercover areas
18.16 Acrylic Latex (Low Sheen or Gloss)	Walls Ceilings	Two coats acrylic latex exterior low sheen/gloss finish to external brickwork/blockwork/ concrete/cement render
18.17 Acrylic (Texture)	Walls Ceilings	One coat acrylic sealer/undercoat and one coat acrylic texture finish to external brickwork/ blockwork/concrete/ cement render
18.18 Silicone	Walls Ceilings	One coat silicone flat finish to external brickwork/ blockwork/concrete/ cement render
18.19 PVA (Flat)	Walls Ceilings	Two coats PVA flat finish to external fibrecement in undercover areas
18.20 Acrylic Latex (Low Sheen or Gloss)	Walls Ceilings	Two coats acrylic latex exterior low sheen/gloss finish to external fibrecement
18.21 Acrylic Latex (Low Sheen or Gloss)	General surfaces Open balustrades/railings/fencing/grilles (per side) Gutters/pipes/conduits/flashings	Two coats oil primer; two coats acrylic latex exterior low sheen/gloss finish to external metalwork
18.22 Alkyd (Gloss)	General surfaces Open balustrades/railings/fencing/grilles (per side) Gutters/pipes/conduits/flashings	One coat primer; two coats enamel gloss finish to exterior metalwork
19.1 Copper Pipework	15mm (12.70mm actual) diameter x 0.91mm pipe 15mm 90 degree elbow 15 x 15 x 15mm 90 degree tee 15mm straight connection 15mm end cap 18mm (15.88mm actual) diameter x 1.02mm pipe 18mm 90 degree elbow 18 x 18 x 18mm 90 degree tee 18 x 15mm concentric reducer 18mm straight connection 18mm end cap 20mm (19.05mm actual) diameter x 1.02mm pipe 20mm 90 degree elbow 20 x 20 x 20mm 90 degree tee 20 x 18mm concentric reducer	Copper pipe with brazed joint; laid in trench (add extra for excavation; back filling and earthwork support as required)

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
	20mm straight connection	
	20mm end cap	
	25mm (25.40mm actual) diameter x 122mm pipe	
	25mm 90 degree elbow	
	25 x 25 x 25mm 90 degree tee	
	25 x 20mm concentric reducer	
	25mm straight connection	
	25mm end cap	
	32mm (31.75mm actual) diameter x 1.22mm pipe	
	32mm 90 degree elbow	
	32 x 32 x 32mm 90 degree tee	
	32 x 25mm concentric reducer	
	32mm straight connection	
	32mm end cap	
	40mm (38.10mm actual) diameter x 1.22mm pipe	
	40mm 90 degree elbow	
	40 x 40 x 40mm 90 degree tee	
	40 x 32mm concentric reducer	
	40mm straight connection	
	40mm end cap	
	15mm (12.70mm actual) diameter x 0.91mm pipe	Copper pipe with brazed joint; fixed with bracket to masonry; fixed with bracket to masonry
	18mm (15.88mm actual) diameter x 1.02mm pipe	
	20mm (19.05mm actual) diameter x 1.02mm pipe	
	25mm (25.40mm actual) diameter x 1.22mm pipe	
	32mm (31.75mm actual) diameter x 1.22mm pipe	
	40mm (38.10mm actual) diameter x 1.22mm pipe	
	15mm (12.70mm actual) diameter x 0.91mm pipe	Copper pipe with brazed joint; fixed with saddle to timber; fixed with saddle to timber
	18mm (15.88mm actual) diameter x 1.02mm pipe	
	20mm (19.05mm actual) diameter x 1.02mm pipe	
	25mm (25.40mm actual) diameter x 1.22mm pipe	
	32mm (31.75mm actual) diameter x 1.22mm pipe	
	40mm (38.10mm actual) diameter x 1.22mm pipe	
19.2 PVC Pipework	20mm diameter pipe	PVC pressure pipe (class 12) with solvent welded joint; laid in trench
	25mm diameter pipe	
	32mm diameter pipe	
	32mm 90 degree elbow	
	32 x 32mm 90 degree tee	
	32 x 25mm concentric reducer	
	40mm diameter pipe	
	40mm 90 degree elbow	
	40 x 40mm 90 degree tee	
	40 x 32mm concentric reducer	
19.3 Copper Pipework	6mm (6.35mm actual) diameter x 0.91mm pipe	Copper gas pipe (hard drawn type A) - with brazed joint; fixed with bracket to masonry
	8mm (7.94mm actual) diameter x 0.91mm pipe	
	10mm (9.52mm actual) diameter x 1.22mm pipe	
	15mm (12.70mm actual) diameter x 1.02mm pipe	
	8mm (15.90mm actual) diameter x 1.22mm pipe	
	20mm (19.05mm actual) diameter x 1.42mm pipe	
	25mm (25.40mm actual) diameter x 1.63mm pipe	

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
19.4 Copper Pipework	6mm (6.35mm actual) diameter x 0.91mm pipe	Copper gas pipe (hard drawn type A) - with brazed joint; fixed with saddle to timber
	8mm (7.94mm actual) diameter x 0.91mm pipe	
	10mm (9.52mm actual) diameter x 1.22mm pipe	
	15mm (12.70mm actual) diameter x 1.02mm pipe	
	8mm (15.90mm actual) diameter x 1.22mm pipe	
	20mm (19.05mm actual) diameter x 1.42mm pipe	
	25mm (25.40mm actual) diameter x 1.63mm pipe	
	32mm (31.75mm actual) diameter x 1.22mm pipe	Copper pipe (hard drawn type B) with soldered joint; fixed with bracket to masonry
	32mm 85 degree bend	
	32mm 85 degree bend with inspection opening	
	32 x 32mm 85 degree junction	
	32 x 32mm 85 degree junction with inspection opening	
	32mm expansion joint	
	40mm (38.10mm actual) diameter x 1.22mm pipe	
	40mm 85 degree bend	
	40mm 85 degree bend with inspection opening	
	40 x 40mm 85 degree junction	
	40 x 40mm 85 degree junction with inspection opening	
	40 x 32mm concentric reducer	
	40mm expansion joint	
	50mm (50.88mm actual) diameter x 1.22mm pipe	
	50mm 85 degree bend	
	50mm 85 degree bend with inspection opening	
	50 x 50mm 85 degree junction	
	50 x 50mm 85 degree junction with inspection opening	
	50 x 40mm concentric reducer	
	50mm expansion joint	
	65mm (63.50mm actual) diameter x 1.22mm pipe	
	65mm 85 degree bend	
	65mm 85 degree bend with inspection opening	
	65 x 65mm 85 degree junction	
	65 x 65mm 85 degree junction with inspection opening	
	65 x 50mm concentric reducer	
	65mm expansion joint	
	80mm (76.20mm actual) diameter x 1.63mm pipe	
	80mm 85 degree bend	
	80mm 85 degree bend with inspection opening	
	80 x 80mm 85 degree junction	
	80 x 80mm 85 degree junction with inspection opening	
	80 x 65mm concentric reducer	
	80mm expansion joint	
	100mm (101.60mm actual) diameter x 1.63mm pipe	
	100mm 85 degree bend	
	100mm 85 degree bend with inspection opening	
	100 x 100mm 85 degree junction	
	100 x 100mm 85 degree junction with inspection opening	
	100mm expansion joint	

Component		Material/Dimension/Methods of Construction	Description
19.5	Copper Fixture Traps	32mm	Copper P trap fixed in position
		40mm	
		50mm	
		32mm	Copper S trap fixed in position
		40mm	
		50mm	
19.6	Copper Floor Traps	80 x 65mm	Copper floor waste gully with 300mm riser fixed in position
		80 x 65mm chrome plated	
19.7	Brass Floor Waste	65mm	Brass floor waste and grate fixed in position
		80mm	
		100mm	
19.8	PVC Floor Waste	50mm	PVC floor waste and grate fixed in position
		65mm	
		80mm	
		100mm	
19.9	Brass Waste Outlet	32mm	Brass waste outlet and plug fixed in position
		40mm	
		50mm	
19.10	PVC Waste Outlet	32mm	PVC waste outlet with stainless steel flange and plug fixed in position
		40mm	
		50mm	
19.11	PVC	50mm	Flap valve fixed in position
19.12	Galvanised Steel Vent Cowls	Chinamans cap 75mm diameter throat	Galvanised steel cowl fixed in position
		Chinamans cap 100mm diameter throat	
19.13	PVC Vent Cowls	40mm	PVC vent cowl (plain) fixed in position
		50mm	
		65mm	
		80mm	
		100mm	
19.14	Loose Screw Down Type Valves	Chrome plated brass - 13mm	Loose screw down type valve with "T" handle fixed in position
		Chrome plated brass - 20mm	
		Chrome plated brass - 25mm	
		Polished brass - 13mm	
		Polished brass - 20mm	
		Rough brass - 13mm	
		Rough brass - 20mm	
		Rough brass - 25mm	
		Rough brass - 32mm	
19.15	Gate Valves (Brass)	Rough brass - 40mm	Brass Gate valve with end connection female pipe thread fixed in position
		Screw connection (1400 kPa) - 15mm	
		Screw connection (1400 kPa) - 20mm	
		Screw connection (1400 kPa) - 25mm	
		Screw connection (1400 kPa) - 32mm	
		Screw connection (1400 kPa) - 40mm	
		Screw connection (2100 kPa) - 15mm	
		Screw connection (2100 kPa) - 20mm	
		Screw connection (2100 kPa) - 25mm	
		Screw connection (2100 kPa) - 32mm	
		Screw connection (2100 kPa) - 40mm	

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
	Screw connection (3500 kPa) - 8mm	Brass End Gate valve featuring inside screw and non rising spindle fixed in position
	Screw connection (3500 kPa) - 10mm	
	Screw connection (3500 kPa) - 15mm	
	Screw connection (3500 kPa) - 20mm	
	Screw connection (3500 kPa) - 25mm	
	Screw connection (3500 kPa) - 32mm	
	Screw connection (3500 kPa) - 40mm	
	Compression connections (1700 kPa) - 15mm	
	Compression connections (1700 kPa) - 20mm	
19.16 Gate Valves (Cast Iron)	Flange connection (14mm kPa) - 40mm	Cast Iron gate valve featuring inside screw and non rising spindle fixed in position
19.17 Check Valves (Bronze)	Screw connection (2100 kPa) - 15mm	Bronze Swing check valve featuring metal seating fixed in position
	Screw connection (2100 kPa) - 20mm	
	Screw connection (2100 kPa) - 25mm	
	Screw connection (2100 kPa) - 32mm	
	Screw connection (2100 kPa) - 40mm	
19.18 Ball Valves (Brass)	Screw connection (2100 kPa) - 8mm	Brass Ball valve featuring metal to metal seating fixed in position
	Screw connection (2100 kPa) - 10mm	
	Screw connection (2100 kPa) - 15mm	
	Screw connection (2100 kPa) - 20mm	
	Screw connection (2100 kPa) - 25mm	
	Screw connection (2100 kPa) - 32mm	
	Screw connection (2100 kPa) - 40mm	
19.19 Globe Valves (Bronze)	Screw connection (1400 kPa) - 8mm	Bronze Globe valve featuring metal to metal seating fixed in position
	Screw connection (1400 kPa) - 15mm	
	Screw connection (1400 kPa) - 20mm	
	Screw connection (1400 kPa) - 32mm	
	Screw connection (1400 kPa) - 40mm	
19.20 Non Returning Isolating Valve (Brass)	15mm	Non returning isolating valve fixed in position
19.21 Colour Coated Brass Taps	Basin set	Colour coated brass taps with plastic handles fixed in position
	Bath set	
	Shower set	
	Sink set	
	Bib tap	
	Cistern tap	
	Pillar tap	
	Washing machine tap	
19.22 Chrome Plated Brass Taps & Handles	Basin set	Chrome plated brass tap and handles fixed in position
	Bath set	
	Shower set	
	Sink set	
	Bib tap	
	Cistern tap	
	Pillar tap	
	Washing machine tap	

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
19.23 Polished Brass Taps & Handles	Basin set	Polished brass taps and handles fixed in position
	Bath set	
	Shower set	
	Sink set	
	Bib tap	
	Cistern tap	
	Pillar tap	
19.24 Single Lever Mixing Taps	Washing machine tap	Single lever mixing tap in chrome plated brass fixed in position
	Sink mixer	
	Basin mixer	
	Bidette mixer	
19.25 Combination Handles & Spout Mixer Taps	Combination handles and spout mixer taps	Combination handles and spout mixer tap in chrome plated brass fixed in position
19.26 Hands Free Taps	Hands free taps	Hands free tap with infra-red sensor in chrome plated brass fixed in position
19.27 Hose Taps	13mm	Hose tap (rough brass) fixed in position
	20mm	
	25mm	
19.28 Cistern Taps	Black chrome plated	Cistern tap including pipe fixed in position
	Colour coated	
	Chrome plated	
	Gold plated	
19.29 Galvanised Steel Water Tanks	400 litre	Corrugated galvanised steel rain water tank
	1000 litre	
	2250 litre	
	4500 litre	
19.30 Polyethylene Water Tanks	400 litre	Polyethylene rain water tank
	1000 litre	
	2250 litre	
	4500 litre	
19.31 Precast Concrete Water Tanks	2250 litre	Precast concrete rain water tank
	4500 litre	
19.32 Acrylic Baths	915 x 915 x 325mm white	Acrylic baths complete with 50mm chrome plated brass waste outlet and plug; fixed in position including connection to pipes
	1300 x 1300 x 4500mm white	
	1470 x 1470 x 450mm white	
	1525 x 725 x 410mm white	
	1655 x 725 x 410mm white	
	1830 x 760 x 410mm white	
19.33 Porcelain Enamel Steel Baths	915 x 915 x 285mm white	Porcelain enamel steel baths complete with 50mm chrome plated brass outlet and plug; fixed in position including connection to pipes
	1125 x 1125 x 340mm white	
	1295 x 760 x 330mm white	
	1525 x 760 x 330mm white	
	1675 x 760 x 330mm white	

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
19.34 Water Jet Spa Baths	1470 x 1470 x 450mm (4 plastic jets)	Acrylic water jet spa bath in white or colour; complete with pump; spa pipework and controls; 50mm chrome plated brass waste outlet and plug fixed in position including connection to pipes
	1525 x 725 x 410mm (4 plastic jets)	
	1690 x 920 x 470mm (5 plastic jets)	
	1675mm diameter x 470mm (6 plastic jets)	
19.35 Air Jet Spa Baths	1470 x 1470 x 450mm (16 chrome plated brass jets)	Acrylic air jet spa bath in white or colour; complete with pump; spa pipework and controls; 50mm chrome plated brass waste outlet and plug fixed in position including connection to pipes
	1525 x 725 x 410mm (12 chrome plated brass jets)	
	1690 x 920 x 470mm (12 chrome plated brass jets)	
	1675mm diameter x 470mm (16 chrome plated brass jets)	
19.36 Shower Cabinets	1935 x 900 x 900mm (2 wall shower unit) white	Acrylic shower/bath cabinets complete with stainless steel curtain rail; 50mm chrome plated brass waste outlet and plug fixed in position including connection to pipes
	1950 x 900 x 750mm (3 wall shower/bath unit) white	
	1945 x 1200 x 800mm (3 wall shower/bath unit) white	
	1945 x 1675 x 800mm (3 wall shower/bath unit) white	
19.37 Vanity Basins	530 x 380 x 165mm white	Acrylic vanity basin complete with 40mm chrome plated brass waste outlet and plug fixed in position including connection to pipe
	550 x 430 x 200mm white	
	553 x 406 x 160mm	Porcelain enamel steel vanity basin complete with 40mm chrome plated brass waste outlet and plug fixed in position including connection to pipes
	540 x 415mm; white	Vitreous china vanity basin complete with 40mm chrome plated brass waste outlet and plug fixed in position including connection to pipes
	540 x 415mm; coloured	
19.38 Wall Basins	510 x 305mm; white	Vitreous china wall basin complete with 40mm chrome plated brass waste outlet and plug fixed to wall with brackets including connection to pipes
	510 x 305mm; coloured	

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
19.39 Pedestal Basins	510 x 400mm; white 510 x 400mm; coloured	Vitreous china pedestal basin complete with 40mm chrome plated brass waste outlet and plug fixed in position including connection to pipes
19.40 Kitchen Sinks	Drop in' type; 900mm single bowl Drop in' type; 1200mm single bowl Drop in' type; 1350mm single bowl Drop in' type; 1500mm single bowl Drop in' type; 1200mm 1 1/2 bowl Drop in' type; 1200mm 1 1/2 bowl (designer model) Drop in' type; 1350mm 1 1/2 bowl Drop in' type; 1500mm 1 1/2 bowl Drop in' type; 1350mm twin bowl Drop in' type; 1500mm twin bowl Drop in' type; 1800mm twin bowl Fascia' type; 900mm single bowl Fascia' type; 1200mm single bowl Fascia' type; 1350mm single bowl Fascia' type; 1500mm single bowl Fascia' type; 1500mm twin bowl Drop in' type; 380 x 380mm single bowl Drop in' type; 500 x 450mm single bowl Drop in' type; 450mm diameter single bowl Drop in' type; 450mm diameter single drainer bowl Drop in' type; 830 x 480mm single bowl with drainer bowl Drop in' type; 960 x 500mm twin bowl	Stainless steel kitchen sink complete with 50mm chrome plated brass waste outlet and plug fixed in position including connection to pipes; complete with drainer
19.41 Laundry Tub	45/46 litre single compartment 45/46 litre double compartment 70 litre single compartment 70 litre double compartment	Stainless steel laundry tubs on tubular stand complete with 50mm chrome plated brass waste outlet and plug fixed in position including connection to pipes
19.42 Toilet Suites	Close coupled S or P trap; white Close coupled S or P trap; coloured Close coupled concealed S or P trap; white Close coupled concealed S or P trap; coloured Wall face close coupled concealed trap; white Wall face close coupled concealed trap; coloured	Vitreous china toilet suite complete with cistern; pan and medium weight plastic double flap toilet seat fixed in position including connection to pipes
19.43 Acrylic Shower Bases	910 x 910 x 115mm; white 910 x 910 x 115mm; coloured 910 x 910 x 115mm; white (corner unit) 910 x 910 x 115mm; coloured (corner unit)	Acrylic shower base complete with 80mm chrome plated brass waste outlet including connection to pipes

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
19.44 Copper Shower Trays	900 x 900 x 100mm 1500 x 900 x 100mm	Copper shower tray complete with 80mm chrome plated brass waste outlet including connection to pipes
19.45 Porcelain Enamel Steel Shower Bases	915 x 915 x 100mm	Porcelain enamel steel shower base complete with 80mm chrome plated brass waste outlet including connection to pipes
19.46 Electric Hot Water Unit	50 litre 80 litre 125 litre 160 litre 250 litre 315 litre	Domestic electric mains pressure storage hot water unit; vitreous enamel lined complete with non return isolating valve fixed in position including connection to pipes
19.47 Gas Hot Water Unit	90 litre 135 litre 170 litre	Domestic gas mains pressure storage hot water unit; vitreous enamel lined complete with non return isolating valve fixed in position including connection to pipes
19.48 Solar Hot Water Unit	300 litre	Solar hot water system comprising 300 litre roof mounted tank and 2 solar collector panels complete with electric booster and non return isolating valve fixed in position including connection to pipes
20.1 Cast Iron Sewer Drains	100mm diameter pipe 100mm 85 degree bend 100 x 100mm 85 degree junction 100mm straight coupling 150mm diameter pipe 150mm 85 degree bend 150 x 100mm 85 degree junction 150mm straight coupling	Cast iron sewer pipe with rubber ring joints
20.2 Earthenware Sewer Drains	100mm diameter pipe 100mm 85 degree bend 100 x 100mm 45 degree junction 100mm inspection opening 100mm disconnector trap 100mm boundary trap 150mm diameter pipe 150mm 85 degree bend 150 x 150mm 45 degree junction 150mm inspection opening 150mm disconnector trap 150mm boundary trap	Earthenware sewer pipe (tested) with rubber wing joint; laid in trench

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
20.3 PVC Sewer Drains	100mm diameter pipe	PVC DWV sewer pipe with solvent welded joint; laid in trench
	100mm straight connector	
	100mm 85 degree bend	
	100 x 100mm 45 degree junction	
	100 x 100mm 85 degree junction	
	100mm inspection opening	
	100mm disconnector trap	
	100mm boundary trap	
	100mm push on cap	
	100mm threaded cap	
	150mm diameter pipe	
	150mm straight connector	
	150mm 85 degree bend	
	150 x 150mm 45 degree junction	
	150mm inspection opening	
	150mm disconnector trap	
	150mm push on cap	
	150mm threaded cap	
20.4 Concrete Stormwater Drains	150mm diameter pipe	Concrete drainage pipe (class 2) with rubber ring joint; laid in trench
	150mm 85 degree bend	
	150 x 100mm 45 degree junction	
20.5 Earthenware Stormwater Drains	100mm diameter pipe	Earthenware stormwater pipes (untested) with rubber ring joint; laid in trench
	100mm 85 degree bend	
	100 x 100mm 85 degree junction	
	150mm diameter pipe	
	150mm 85 degree bend	
	150 x 100mm 85 degree junction	
20.6 PVC Stormwater Drains	90mm diameter pipe	PVC stormwater pipe with solvent welded joint; laid in trench
	90mm 45 degree bend	
	90mm 90 degree bend	
	90 x 90mm 90 degree junction	
	90mm straight coupling	
	90mm push on cap	
	90 x 110 x 50mm rectangular down pipe adaptor	
	110mm diameter pipe	
	110mm 45 degree bend	
	110mm 90 degree bend	
	110 x 110mm 90 degree junction	
	110mm straight coupling	
	110mm push on cap	
	110 x 110 x 50mm rectangular down pipe adaptor	
	160mm diameter pipe	
	160mm 45 degree bend	
	160mm 90 degree bend	
	160 x 160mm 90 degree junction	
	160mm straight coupling	
	160mm push on cap	
	160 x 160 x 110mm rectangular down pipe adaptor	

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
20.7 Insitu Concrete Surface Drains	200mm wide x 150mm deep overall (150mm wide grate)	Insitu concrete surface drain; rebated to accept trench grate; laid to falls including hand excavation in other rock
	275mm wide x 150mm deep overall (225mm wide grate)	
	350mm wide x 150mm deep overall (300mm wide grate)	
20.8 Plastic Surface Drains	100mm wide x 100mm deep	Moulded resin aggregate and sand surface drainage channel; laid to falls including hand excavation in other than rock
	100mm wide x 150mm deep	
	100mm wide x 225mm deep	
	100mm wide x 300mm deep	
	100mm wide x 500mm long x 470mm deep sump	
20.9 Brick Manholes, Sumps & Pits	370 x 370 x 500mm	Brick pit; 370 x 370 x 500mm internally with 150mm concrete base; 110mm brick walls; internal bagged finish
	370 x 370 x 1000mm	Brick pit; 370 x 370 x 1000mm internally with 150mm concrete base; 110mm brick walls; internal bagged finish
	490 x 490 x 500mm	Brick manhole; 490 x 490 x 500mm internally with 150mm concrete base; 230mm brick walls; internal bagged finish
	490 x 490 x 1000mm	Brick manhole; 490 x 490 x 1000mm internally with 150mm concrete base; 230mm brick walls; internal bagged finish
	610 x 610 x 500mm	Brick manhole; 610 x 610 x 500mm internally with 150mm concrete base; 230mm brick walls; internal bagged finish
	610 x 610 x 1000mm	Brick manhole; 610 x 610 x 1000mm internally with 150mm concrete base; 230mm brick walls; internal bagged finish
	970 x 970 x 500mm	Brick manhole; 970 x 970 x 500mm internally with 150mm concrete base; 230mm brick walls; internal bagged finish

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
	970 x 970 x 1000mm	Brick manhole; 970 x 970 x 1000mm internally with 150mm concrete base; 230mm brick walls; internal bagged finish
20.10 Insitu Concrete Manholes, Sumps & Pits	450 x 450 x 500mm	Insitu concrete pit; 450 x 450 x 500mm internally with 150mm concrete base and walls
	450 x 450 x 1000mm	Insitu concrete pit; 450 x 450 x 1000mm internally with 150mm concrete base and walls
	600 x 600 x 500mm	Insitu concrete pit; 600 x 600 x 500mm internally with 150mm concrete base and walls
	600 x 600 x 1000mm	Insitu concrete pit; 600 x 600 x 1000mm internally with 150mm concrete base and walls
	900 x 900 x 500mm	Insitu concrete pit; 900 x 900 x 500mm internally with 150mm concrete base and walls
	900 x 900 x 1000mm	Insitu concrete pit; 900 x 900 x 1000mm internally with 150mm concrete base and walls
20.11 Precast Concrete Manholes, Sumps & Pits	450 x 450 x 600mm	Precast concrete pit; 450 x 450 x 600mm internally with 80 - 90mm base and walls
	450 x 450 x 900mm	Precast concrete pit; 450 x 450 x 900mm internally with 80 - 90mm base and walls
	600 x 600 x 600mm	Precast concrete pit; 600 x 600 x 600mm internally with 80 - 90mm base and walls
	600 x 600 x 900mm	Precast concrete pit; 600 x 600 x 900mm internally with 80 - 90mm base and walls
	600 x 600 x 1200mm	Precast concrete pit; 600 x 600 x 1200mm internally with 80 - 90mm base and walls

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
	900 x 900 x 600mm	Precast concrete pit; 900 x 900 x 600mm internally with 80 - 90mm base and walls
	900 x 900 x 900mm	Precast concrete pit; 900 x 900 x 900mm internally with 80 - 90mm base and walls
	900 x 900 x 1200mm	Precast concrete pit; 900 x 900 x 1200mm internally with 80 - 90mm base and walls
	1000/1050/1100mm diameter x 700mm depth	Precast concrete pit; 1000/1050/1100mm diameter x 700mm depth internally with 150mm insitu concrete base; precast concrete walls
	1000/1050/1100mm diameter x 1050mm depth	Precast concrete pit; 1000/1050/1100mm diameter x 1050mm depth internally with 150mm insitu concrete base; precast concrete walls
	1000/1050/1100mm diameter x 1400mm depth	Precast concrete pit; 1000/1050/1100mm diameter x 1400mm depth internally with 150mm insitu concrete base; precast concrete walls
20.12 Plastic Sumps and Pits	305 x 305 x 450mm deep 460 x 460 x 600mm deep	Moulded resin aggregate and sand pit
20.13 Sewer Pumping Station	1000 litre with 2 LPS submersible cutter 0.075 kW 240 volt automatic sewerage pump	Package pump station including reinforced concrete bed and side grout
20.14 Precast Concrete Grease Traps	18 litre	Precast concrete grease traps
20.15 Plastic Grease Traps	18 litre	Plastic grease traps
20.16 Rubble Stormwater Soakaway Pit	300mm wide x 600mm deep 450mm wide x 600mm deep 600mm wide x 600mm deep	Sullage/stormwater soakaway pit; rubble filled with 200mm soil cover complete including machine excavation in other than rock
20.17 Polypropylene Stormwater Soakaway Pit	70 ltr/metre storage	Sullage/stormwater soakaway pit; polypropylene inverted 'u' shape laid in and including machine excavation in other than rock

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
20.18 Pipe Connections	100mm diameter pipe 150mm diameter pipe	Connection of pipe to mains/sump/pit/manhole/inspection chamber/septic tank
20.19 Pipe Encasement	100mm diameter pipe 150mm diameter pipe	Pipe encasement with 20MPa concrete to a depth of 200mm all around
21.1 Underground Mains Connection	Single phase 3 phase	Underground consumer mains
21.2 Overhead Mains Connection	Overhead mains connection	Overhead consumer mains supply pole
21.3 Switchboards	Houses Home units (6 x 2 bed units) Add extra for home unit sub board	Switchboard including meter box and wiring; fixed in position
21.4 Conduits	Light duty 20mm diameter Light duty 25mm diameter Light duty 32mm diameter	PVC conduit including allowance for fittings; fixed to concrete/masonry
21.5 Outlets & Switches	Single switch; concrete/ masonry Single switch; timber Double switch; concrete/masonry Double switch; timber Single switch; concrete/ masonry Single switch; timber Double switch; concrete/masonry Double switch; timber Single switch; concrete/ masonry Single switch; timber	Light point complete with batten holder and single witch; fixed in position Light point complete with batten holder and double witch; fixed in position Power outlet single phase; fixed in position Power outlet 3 phase; fixed in position
21.6 Light Fittings	Batten fitting; 20 watt single Batten fitting; 20 watt double Batten fitting; 40 watt single Batten fitting; 40 watt double Batten fitting with diffuser; 20 watt single Batten fitting with diffuser; 20 watt double Batten fitting with diffuser; 40 watt single Batten fitting with diffuser; 40 watt double Tougher fitting with diffuser; 20 watt double Tougher fitting with diffuser; 40 watt double	Fluorescent light fittings; fixed in position
21.7 Emergency Lighting	Emergency lighting 8 watt fluorescent Illuminated exit sign; single sided Illuminated exit sign; double sided	Emergency lighting 8 watt fluorescent including (non maintained); fixed in position Illuminated exit sign; 8 watt fluorescent including inverter and battery; fixed in position

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
21.8 Telephones	Fixed to concrete/masonry Fixed to timber	Telephone outlet; fixed in position
21.9 Fire Alarms	Thermal detection system	Thermal detection system comprising ceiling mounted thermal detectors complete with control panel and all associated wiring; fixed in position
21.10 Burglar Alarms	Passive infra-red detection system	Passive infra-red detection system comprising 10 wall mounted sensors complete with control unit with alarm and tamper relay outputs; zone indicator plate and mode selector switch; fixed in position including all wiring
	Ultrasonic detection system	Ultrasonic detection system comprising 10 ceiling mounted sensors complete with control unit with alarm and tamper relay outputs; zone indicator plate and mode selector switch; fixed in position including all wiring
21.11 Surveillance Systems	Closed circuit television surveillance system	Closed circuit television surveillance system comprising 3 television monitors mounted on wall complete with electronic image transfer system with photo recording facilities; fixed in position including all wiring and connection to alarm
	Video telephone call system	Video telephone call system comprising single external television camera; lights and speaker in vandal proof casing complete with single internal monitoring unit with built in television monitor; telephone handset and remote door release mechanism

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
21.12 Connection of Appliances	Range/stove	-
	Oven	
	Cooktop	
	Hot water system; 50 litre	
	Hot water system; 250 litre	
21.13 Television	Fixed to concrete/masonry	Television outlet complete with co-axial cable; fixed in position
	Fixed to timber	
21.14 Ceiling Sweep Fan	3 blade (plain); 1200mm diameter	-
	4 blade (rattan insert); 1200mm diameter	
22.1 Cooling Equipment	Self contained type; 2hp; 4.7 kW (40 m ² area)	Individual electric reverse cycle air conditioning units; fixed in position
	Self contained type; 2hp; 6.2 kW (50 m ² area)	
	Split system type; 1hp; 2.46 kW cooling/3.28 kW heating (30 m ² area)	
	Split system type; 1.5hp; 3.75 kW cooling/4.2 kW heating (40 m ² area)	
	Split system type; 2hp; 5.2 kW cooling/6.07 kW heating (55 m ² area)	
	Split system type; 2.5hp; 6.15 kW cooling/7.16 kW heating (65 m ² area)	
22.2 Electric Heating	Portable electric heaters; 800w/1600w (radiant type)	-
	Portable electric heaters; 1000w/1400w (fan convection type)	
	In-built electric heaters; 2400w (fan assisted type)	
	In-built electric heaters; 3500w (fan assisted type)	
22.3 Gas Heating	50 m ² area (portable flueless type)	Gas heaters fixed in position; including 3.6m of stainless steel flue if required
	70 m ² area (in-built flued type)	
	120 m ² area (in-built flued type)	
	120 m ² area (in-built log fire type)	
22.4 Solid Fuel Heating	Radiant type (free standing); 10/15 kW (140 m ² area)	Solid fuel heaters; fixed in position including 3.6m of stainless steel flue
	Radiant type (free standing); 16/20 kW (190 m ² area)	
	Convection type (free standing); 10/15 kW (140 m ² area)	
	Convection type (free standing); 16/20 kW (190 m ² area)	
	Convection type (free standing); 25+ kW (280 m ² area)	
	Convection type (in-built); 15/20 kW (190 m ² area)	
23.1 Aluminium Awning	Convection type (in-built); 25+ kW (230 m ² area)	Aluminium fixed awning (painted finish) complete; fixed in position
	Aluminium fixed awning; 900mm deep	
	Aluminium fixed awning; 1500mm deep	Aluminium louver awning (painted finish) complete; fixed in position
	Aluminium louver awning; fixed louver; 1200mm high	
	Aluminium louver awning; fixed louver; 2000mm high	
	Aluminium louver awning; fixed louver; 2400mm high	
	Aluminium louver awning; adjustable louver (hand crank operation); 1200mm high	
	Aluminium louver awning; adjustable louver (hand crank operation); 2000mm high	
	Aluminium louver awning; adjustable louver (hand crank operation); 2400mm high	

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
23.2 Fabric Awning	Aluminium interlocking slat roller awning; fixed guides; 1200mm high	Aluminium interlocking slat roller awning (painted finish); hand crank operated complete; fixed in position
	Aluminium interlocking slat roller awning; fixed guides; 2000mm high	
	Aluminium interlocking slat roller awning; fixed guides; 2400mm high	
	Aluminium interlocking slat roller awning; pivoting frame; 1200mm high	
	Aluminium interlocking slat roller awning; pivoting frame; 2000mm high	
	Aluminium interlocking slat roller awning; pivoting frame; 2400mm high	
	Canvas fabric roller awning; fixed guides; 1200mm high	Canvas fabric roller awning with aluminium frame; hand crank operated complete; fixed in position
	Canvas fabric roller awning; fixed guides; 2000mm high	
	Canvas fabric roller awning; fixed guides; 2400mm high	
	Canvas fabric roller awning; pivoting frame; 1200mm high	
	Canvas fabric roller awning; pivoting frame; 2000mm high	
	Canvas fabric roller awning; pivoting frame; 2400mm high	
	Canvas fabric awning; 1750mm deep	Canvas fabric awning with aluminium folding arm supports; hand crank operated complete; fixed in position
	Canvas fabric awning; 2100mm deep	
	Canvas fabric awning; 2600mm deep	
	Canvas fabric awning; 3100mm deep	
	Canvas fabric awning; barrel walkway; 900mm wide	Canvas fabric awning with fixed aluminium frame complete; fixed in position
	Canvas fabric awning; barrel walkway; 1200mm wide	
	Canvas fabric awning; cupola; 900mm wide x 600mm deep	
	Canvas fabric awning; cupola; 900mm wide x 900mm deep	
	Canvas fabric awning; cupola; 1200mm wide x 600mm deep	
	Canvas fabric awning; cupola; 1200mm wide x 900mm deep	
23.3 Holland & Roller Blinds	Semi translucent fabric; 600mm high	Plain design holland/roller blinds complete; fixed in position
	Semi translucent fabric; 1200mm high	
	Semi translucent fabric; 2000mm high	
	Semi translucent fabric; 2400mm high	
	Opaque fabric with reflective lining; 600mm high	
	Opaque fabric with reflective lining; 1200mm high	
	Opaque fabric with reflective lining; 2000mm high	
	Opaque fabric with reflective lining; 2400mm high	
	Reflective tinted film; 600mm high	
	Reflective tinted film; 1200mm high	
	Reflective tinted film; 2000mm high	
	Reflective tinted film; 2400mm high	

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
23.4 Pleated Folding Blinds	600mm high	Pleated fabric folding blinds; cord operated complete fixed in position
	1200mm high	
	2000mm high	
	2400mm high	
23.5 Venetian Blinds	Aluminium Slats - 15mm wide; 600mm high	Standard design venetian blinds cord operated complete; fixed in position
	Aluminium Slats - 15mm wide; 1200mm high	
	Aluminium Slats - 15mm wide; 2000mm high	
	Aluminium Slats - 15mm wide; 2400mm high	
	Aluminium Slats - 25mm wide; 600mm high	
	Aluminium Slats - 25mm wide; 1200mm high	
	Aluminium Slats - 25mm wide; 2000mm high	
	Aluminium Slats - 25mm wide; 2400mm high	
23.6 Vertical Blinds	Semi translucent fabric; 600mm high	Standard design vertical blinds; slats 127mm wide; cord operated complete; fixed in position
	Semi translucent fabric; 1200mm high	
	Semi translucent fabric; 2000mm high	
	Semi translucent fabric; 2400mm high	
	Opaque fabric; 600mm high	
	Opaque fabric; 1200mm high	
	Opaque fabric; 2000mm high	
	Opaque fabric; 2400mm high	
	Reflective tinted film; 600mm high	
	Reflective tinted film; 1200mm high	
	Reflective tinted film; 2000mm high	
	Reflective tinted film; 2400mm high	
23.7 Translucent Fabric	600mm high	Plain design curtains with pinch pleated tops (300% cover) complete with tape and curtain hooks; fixed in position
	1200mm high	
	2000mm high	
	2400mm high	
23.8 Semi Translucent Fabric	600mm high	Plain design curtains with pinch pleated tops (300% cover) complete with tape and curtain hooks; fixed in position
	1200mm high	
	2000mm high	
	2400mm high	
23.9 Opaque Fabric	600mm high	Plain design curtains with pinch pleated tops (300% cover) complete with tape and curtain hooks; fixed in position
	1200mm high	
	2000mm high	
	2400mm high	
23.10 Cotton Fabric	600mm high	-
	1200mm high	
	2000mm high	
	2400mm high	
23.11 Reflective Fabric	600mm high	-
	1200mm high	
	2000mm high	
	2400mm high	
23.12 Blackout Type Fabric	600mm high	-
	1200mm high	
	2000mm high	
	2400mm high	

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
23.13 Curtain Tracks & Fittings	Aluminium; hand traversed Aluminium; cord traversed - single Aluminium; cord traversed - double Aluminium; motorised Plastic; hand traversed Steel rob (painted finish) Timber rob including rings and decorative rod ends	-
24.1 Thermal Detection System	Thermal detection system	Thermal detection system comprising ceiling mounted thermal detectors complete with control panel and all associated wiring; fixed in position
24.2 Smoke Detection System	Mains operated with battery back up Battery operated	Domestic smoke detector/alarm; ionization type; fixed in position
24.3 Water Sprinkler System	Water sprinkler system	Automatic water sprinkler system fixed in position
24.4 Sprinkler Control Valves	100mm 150mm	Sprinkler control valves including all testing and maintenance; fixed in position
24.5 Sprinkler Booster Pump	Diesel Electric	Sprinkler booster pump fixed in position
24.6 Hydrant Point	Hydrant point	Hydrant point comprising 64mm diameter landing valve including pipe and tee connection complete with blanking cap; fixed in position
24.7 Fire Hose	36 metre	Fire hose (19mm diameter) complete with reel; fixed in position on wall including connection to fire service
24.8 Fire Blankets	1000 x 1000mm 1200 x 1800mm 1800 x 1800mm	Fire blanket fixed in position
24.9 Fire Extinguishers	Carbon dioxide; 2.0 kg Carbon dioxide; 3.5 kg Carbon dioxide; 5.0 kg Dry chemical (foam compatible); 2.25 kg Dry chemical (foam compatible); 4.5 kg Dry chemical (foam compatible); 9.0 kg Foam - 9.1 litre Water - 9.1 litre	Fire extinguisher fixed in position

Component	Material/Dimension/Methods of Construction	Description
24.10 Security Safes	Medium risk; 100 litres	Security safe fixed in position
	Medium risk; 200 litres	
	High risk; 200 litres	
	High risk; 400 litres	
25.1 Ranges & Stoves	Electric standard oven (540mm wide) with mechanical timer	Domestic range/stove comprising low level oven; grill and 4 coil or solid hotplates/burners; fixed in position including electrical/gas connection
	Electric forced air oven (540mm wide) with electronic timer	
	Electric forced air oven (600mm wide) with electronic timer	
	Gas standard oven (540mm wide) with mechanical timer	
	Gas forced air oven (540mm wide) with electronic timer	
	Gas forced air oven (600mm wide) with electronic timer	
	Electric standard oven (1070mm wide) with mechanical timer	Domestic elevated range/stove comprising oven; grill and 4 coil or solid hotplates/burners; fixed in position including electrical/gas connection
	Electric forced air oven (1070mm wide) with electronic timer	
	Gas standard oven (1070mm wide) with mechanical timer	
	Gas forced air oven (1070mm wide) with electronic timer	
25.2 Wall Ovens	Electric standard oven (540mm wide) with mechanical timer	Domestic wall ovens comprising oven and grill; fixed in position including electrical/gas connection
	Electric forced air oven (540mm wide) with electronic timer	
	Electric forced air oven (600mm wide) with electronic timer	
	Gas standard oven (540mm wide) with mechanical timer	
	Gas forced air oven (540mm wide) with electronic timer	
	Gas forced air oven (600mm wide) with electronic timer	
	Electric forced air oven (600mm wide) with electronic timer	Domestic underbench oven comprising oven and grill; fixed in position including electrical/gas connection
	Gas forced air oven (600mm wide) with electronic timer	
25.3 Cooktop	Electric enamel hob (rectangular)	Domestic cooktop comprising 4 coil or solid hotplates/burners; fixed in position including electrical/gas connection
	Electric enamel hob (square)	
	Electric ceramic hob (rectangular)	
	Electric ceramic hob (square)	
	Gas enamel hob (rectangular)	
	Gas enamel hob (square)	
	Gas ceramic hob (rectangular)	
	Gas ceramic hob (square)	
25.4 Microwave Oven	Microwave oven	Domestic microwave oven; 600mm wide; fixed in position

<i>Component</i>	<i>Material/Dimension/Methods of Construction</i>	<i>Description</i>
25.5 Dishwashers	Standard Programmable	Domestic automatic dishwasher; 600mm wide; fixed in position including connection to pipes
25.6 Exhaust Fan	Ceiling mounted (plasterboard); 200mm diameter Ceiling mounted (plasterboard); 250mm diameter Wall mounted (brick veneer); 200mm diameter Window mounted (glass); 200mm diameter Window mounted (glass); 250mm diameter	Domestic exhaust fans; fixed in position including cutting of hole and electrical connection
25.7 Range Hood	Standard type 600mm wide Standard type 900mm wide	Domestic range hood; fixed in position
25.8 Waste Disposal Unit	Waste disposal unit	Domestic waste disposal unit; 1/2 hp; complete with air switch; fixed in position
26.1 Precast Concrete	150mm depth (overall excluding topping) 200mm depth (overall excluding topping) 250mm depth (overall excluding topping)	Precast prestressed concrete permanent formwork system for suspended floors with smooth off form soffit finish; comprising slab and ribs with polystyrene void formers including craneage
26.2 Tilt Up Concrete Wall Panels	100mm thick 125mm thick 150mm thick 175mm thick 200mm thick	30MPa precast concrete tilt up wall panels (30 m ²) with smooth off form finish cast on site and fixed in position including craneage
27.1 Steel Framing	52mm frame 64mm frame 75mm frame 94mm frame	Steel frame with studs at 600mm centres; faced both sides with 13mm plasterboard and set joints; complete with aluminium ceiling plate and 100mm black vinyl bonded aluminium skirting; up to 2700mm high
27.2 Timber Framing	75 x 50mm	Timber frames with 75 x 50mm studs at 600mm centres; faced both sides with 13mm plasterboard and set joints; complete with aluminium ceiling plate and 100mm black vinyl bonded aluminium skirting; up to 2700mm high

Component		Material/Dimension/Methods of Construction	Description
27.3	Particle Board Partitions	18mm thick	1800mm high x 1500mm long x 900mm wide cubicle out of 18mm thick particle board faced with laminated plastic sheeting; fixed with aluminium sections including door and hardware
28.1	Office and Hotel (Low Rise) Passenger Lifts	11 - 12 person; 1.0 m/s speed 14 - 17 person; 1.0 m/s speed Add/deduct for additional floors	Gearless traction passenger lift with 2 speed control; 6 floor
28.2	Office and Hotel (High Rise) Passenger Lifts	16 person; 1.75 m/s speed 20 person; 1.75 m/s speed 23 person; 1.75 m/s speed	Gearless traction passenger lift with variable speed control; 10 floors
		16 person; 2.5 m/s speed 16 person; 3.5 m/s speed 20 person; 2.5 m/s speed 20 person; 3.5 m/s speed 20 person; 5.0 m/s speed 20 person; 6.0 m/s speed 20 person; 7.0 m/s speed 20 person; 8.0 m/s speed 23 person; 2.5 m/s speed 23 person; 3.5 m/s speed 23 person; 5.0 m/s speed 23 person; 6.0 m/s speed 23 person; 7.0 m/s speed 23 person; 8.0 m/s speed Add/deduct for additional floors	Gearless traction passenger lift with variable speed control 15 floors

Table A.3 Value of Material/Dimension/Methods of Construction

	<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
1.1	300mm diameter	m	22.78	0.0140
	450mm diameter	m	38.04	0.0315
	600mm diameter	m	59.68	0.0560
	750mm diameter	m	86.72	0.0875
	900mm diameter	m	118.99	0.1260
1.2	400mm diameter; maximum load 50 tonnes	m	120.00	0.0249
	500mm diameter; maximum load 100 tonnes	m	148.00	0.0389
	600mm diameter; maximum load 150 tonnes	m	183.00	0.0560
1.3	400mm diameter; maximum load 60 tonnes	m	211.00	0.0249
	500mm diameter; maximum load 100 tonnes	m	239.00	0.0389
	600mm diameter; maximum load 150 tonnes	m	296.00	0.0560
1.4	270mm (measured across flat) hexagonal section; maximum load 90 tonnes	m	117.00	0.0217
	300mm (measured across flat) hexagonal section; maximum load 120 tonnes	m	151.00	0.0261
1.5	320mm diameter; maximum load 40 tonnes	m	222.00	1.8971
	350mm diameter; maximum load 45 tonnes	m	233.00	3.0752
	400mm diameter; maximum load 50 tonnes	m	257.00	4.6511
	450mm diameter; maximum load 55 tonnes	m	280.00	6.5023
1.6	200UC46	m	192.00	2.2402
	200UC59	m	215.00	2.8733
	250UC72	m	251.00	3.5064
	250UC89	m	288.00	4.3343
	310UC96	m	306.00	4.6752
	310UC137	m	401.00	6.6719
	310UC198	m	539.00	9.6426
	310UC240	m	611.00	11.6880
	310UC283	m	695.00	13.7821
1.7	180mm diameter; maximum load 30 tonnes	m	74.00	0.1288
	210mm diameter; maximum load 40 tonnes	m	78.00	0.1753
	230mm diameter; maximum load 50 tonnes	m	82.00	0.2102
	250mm diameter; maximum load 65 tonnes	m	91.00	0.2484
	280mm diameter; maximum load 80 tonnes	m	101.00	0.3116
	300mm diameter; maximum load 95 tonnes	m	106.00	0.3577
1.8	60.9kg/ m ²	m ²	382.00	0.0438
	79.8kg/ m ²	m ²	407.50	0.0584
1.9	60.9kg/ m ²	m ²	61.00	0.0438
	79.8kg/ m ²	m ²	81.50	0.0584
2.1	Chute	m ³	172.21	0.1760
	Handle/barrow	m ³	186.21	0.1760
	Pump	m ³	185.41	0.1760
2.2	Chute	m ³	172.21	0.1760
	Handle/barrow	m ³	186.21	0.1760
	Pump	m ³	185.41	0.1760
2.3	Chute	m ³	183.41	0.1760
	Handle/barrow	m ³	203.01	0.1760
	Pump	m ³	196.61	0.1760
	Chute	m ³	183.41	0.1760
	Handle/barrow	m ³	203.01	0.1760

	<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
	Pump	m ³	196.61	0.1760
	Handle/barrow	m ³	227.84	0.1980
	Pump	m ³	201.84	0.1980
	Crane/kibble	m ³	194.24	0.1980
2.4	Stairs	m	154.84	2.9000
	Landings	m ²	54.44	1.5006
2.5	Handle/barrow	m ³	250.24	0.1980
	Pump	m ³	213.04	0.1980
	Crane/kibble	m ³	208.24	0.1980
2.6	Handle/barrow	m ³	267.04	0.1980
	Pump	m ³	221.44	0.1980
	Crane/kibble	m ³	216.64	0.1980
2.7	Chute	m ³	373.81	0.1760
	Handle/barrow	m ³	272.21	0.1760
	Pump	m ³	259.01	0.1760
2.8	50mm thick	m ²	3.04	0.0130
	75mm thick	m ²	4.55	0.0195
	100mm thick	m ²	6.08	0.0260
2.9	200um	m ²	2.70	0.0029
3.1	300mm deep x 300mm wide with F8TM3	m	38.61	0.1305
	300mm deep x 400mm wide with F8TM4	m	50.10	0.1740
	400mm deep x 300mm wide with F8TM3	m	48.52	0.1358
	400mm deep x 300mm wide with F11TM3	m	54.04	0.2505
	400mm deep x 400mm wide with F11TM4	m	66.98	0.3340
	500mm deep x 300mm wide with F11TM3	m	63.94	0.2558
	500mm deep x 300mm wide with F12TM3	m	67.08	0.3093
	600mm deep x 400mm wide with F12TM4	m	101.24	0.4169
	600mm deep x 300mm wide with F12TM3 (encased in double layer of 200 um polythene)	m	85.11	0.3146
3.2	400 x 400 x 200mm depth (overall depth 300mm)	no	8.16	0.0056
	500 x 500 x 200mm depth (overall depth 300mm)	no	12.64	0.0088
	600 x 600 x 250mm depth (overall depth 300mm)	no	21.30	0.0158
	400 x 400 x 200mm depth (overall depth 400mm)	no	8.90	0.0056
	500 x 500 x 200mm depth (overall depth 400mm)	no	13.63	0.0088
	600 x 600 x 250mm depth (overall depth 400mm)	no	22.79	0.0158
	400 x 400 x 200mm depth (overall depth 500mm)	no	9.51	0.0056
	500 x 500 x 200mm depth (overall depth 500mm)	no	14.75	0.0088
	600 x 600 x 250mm depth (overall depth 500mm)	no	24.27	0.0158
	400 x 400 x 200mm depth (overall depth 600mm)	no	10.14	0.0056
	500 x 500 x 200mm depth (overall depth 600mm)	no	15.73	0.0088
	600 x 600 x 250mm depth (overall depth 600mm)	no	25.75	0.0158
3.3	500mm diameter x 200mm depth (overall depth 300mm)	no	9.78	0.0069
	600mm diameter x 200mm depth (overall depth 300mm)	no	14.13	0.0100
	750mm diameter x 250mm depth (overall depth 300mm)	no	26.23	0.0194
	500mm diameter x 200mm depth (overall depth 400mm)	no	10.52	0.0069
	600mm diameter x 200mm depth (overall depth 400mm)	no	15.36	0.0100
	750mm diameter x 250mm depth (overall depth 400mm)	no	28.08	0.0194
	500mm diameter x 200mm depth (overall depth 500mm)	no	11.38	0.0069
	600mm diameter x 200mm depth (overall depth 500mm)	no	16.48	0.0100
	750mm diameter x 250mm depth (overall depth 500mm)	no	29.81	0.0194
	500mm diameter x 200mm depth (overall depth 600mm)	no	12.12	0.0069

	<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
	600mm diameter x 200mm depth (overall depth 600mm)	no	17.59	0.0100
	750mm diameter x 250mm depth (overall depth 600mm)	no	31.66	0.0194
3.4	300mm deep x 300mm wide	m	71.65	0.3665
	450mm deep x 300mm wide	m	107.48	0.5497
	600mm deep x 300mm wide	m	163.32	0.7330
	300mm deep x 450mm wide	m	90.00	0.5497
	450mm deep x 450mm wide	m	135.00	0.8246
	600mm deep x 450mm wide	m	180.01	1.0994
	300mm deep x 600mm wide	m	108.36	0.7330
	450mm deep x 600mm wide	m	162.53	1.0994
	600mm deep x 600mm wide	m	216.71	1.4659
	300mm deep x 750mm wide	m	126.70	0.9162
	450mm deep x 750mm wide	m	190.04	1.3743
	600mm deep x 750mm wide	m	253.42	1.8324
3.5	300 x 300 x 300mm depth	no	32.05	0.1099
	450 x 450 x 300mm depth	no	56.32	0.2474
	450 x 450 x 450mm depth	no	84.38	0.3711
	450 x 450 x 600mm depth	no	112.62	0.4947
	600 x 600 x 300mm depth	no	86.08	0.4398
	600 x 600 x 450mm depth	no	129.06	0.6597
	600 x 600 x 600mm depth	no	172.01	0.8796
	750 x 750 x 300mm depth	no	121.24	0.6872
	750 x 750 x 450mm depth	no	181.97	1.0307
	750 x 750 x 600mm depth	no	242.47	1.3743
	900 x 900 x 300mm depth	no	162.10	0.9895
	900 x 900 x 450mm depth	no	243.09	1.4842
	900 x 900 x 600mm depth	no	324.06	1.9790
3.6	300mm deep x 300mm wide; F8TM3 and F72 mesh	m ²	69.02	0.2035
	300mm deep x 300mm wide; F8TM3 and F82 mesh	m ²	70.45	0.2473
	400mm deep x 300mm wide; F8TM3 and F72 mesh	m ²	74.27	0.2045
	400mm deep x 300mm wide; F8TM3 and F82 mesh	m ²	75.69	0.2483
	400mm deep x 300mm wide; F11TM3 and F72 mesh	m ²	75.46	0.2102
	400mm deep x 300mm wide; F11TM3 and F82 mesh	m ²	76.89	0.2501
	100mm thick with F8TM3 and F72 mesh	m ²	74.27	0.1832
	125mm thick with F8TM3 and F72 mesh	m ²	79.19	0.1876
	150mm thick with F11TM3 and F82 mesh	m ²	86.75	0.2473
	200mm thick with F11TM3 and F82 mesh	m ²	96.60	0.2561
3.7	300mm deep x 300mm wide @ 7.0 meter spacing; F11TM3 and F72 mesh	m ²	72.86	0.2304
	400mm deep x 300mm wide @ 6.0 meter spacing; F11TM3 and F72 mesh	m ²	82.70	0.2381
	500mm deep x 300mm wide @ 5.0 meter spacing; F12TM3 and F82 mesh	m ²	96.94	0.3034
	800mm deep x 300mm wide @ 4.0 meter spacing; F12TM3 and F92 mesh	m ²	132.05	0.3276
	400mm deep x 300mm wide @ 6.0 meter spacing; 5 x Y16 bars and F72 mesh	m ²	85.85	0.2699
	400mm deep x 300mm wide @ 4.0 meter spacing; 5 x Y12 bars and F72 mesh	m ²	102.90	0.3076
	500mm deep x 300mm wide @ 4.5 meter spacing; 5 x Y12 bars and F72 mesh	m ²	93.17	0.2974
	500mm deep x 300mm wide @ 4.0 meter spacing; 6 x Y12 bars and F72 mesh	m ²	104.43	0.3313

	<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
	625mm deep x 300mm wide @ 4.0 meter spacing; 4 x Y16 bars and F72 mesh	m ²	118.08	0.3613
	625mm deep x 300mm wide @ 4.0 meter spacing; 4 x Y16 bars to internal beams and 6 x Y16 bars to edge beams; F72 mesh	m ²	120.80	0.3528
	800mm deep x 300mm wide @ 4.0 meter spacing; 6 x Y16 bars and F72 mesh	m ²	140.76	0.4424
	800mm deep x 300mm wide @ 4.0 meter spacing; 6 x Y16 bars to internal beams; F72 mesh	m ²	143.48	0.4292
	1000mm deep x 300mm wide @ 4.0 meter spacing; 7 x Y16 bars and F72 mesh	m ²	162.94	0.4859
3.8	75mm thick with F72 mesh	m ²	37.44	0.1642
	100mm thick with F72 mesh	m ²	42.35	0.1686
	125mm thick with F72 mesh	m ²	50.16	0.1730
	150mm thick with F72 mesh	m ²	55.07	0.2390
3.9	100mm thick	m ²	122.23	0.7481
	200mm thick	m ²	180.43	1.4962
	300mm thick	m ²	238.62	2.2267
	100mm thick	m ²	123.17	0.7503
	200mm thick	m ²	182.31	1.5006
	300mm thick	m ²	241.44	2.2509
3.10	200mm thick	m ²	91.59	0.1326
	300mm thick	m ²	133.01	0.1989
3.11	300 x 300mm wide	m	127.91	0.6733
	450 x 300mm wide	m	178.29	1.0099
	600 x 300mm wide	m	228.52	1.3466
	450 x 450mm wide	m	226.42	1.5149
	600 x 450mm wide	m	288.17	2.0199
3.12	300 x 300mm wide	m	133.47	0.6733
	450 x 300mm wide	m	186.01	1.0099
	600 x 300mm wide	m	238.36	1.3466
	450 x 450mm wide	m	236.09	1.5149
	600 x 450mm wide	m	300.43	2.0199
3.13	100mm thick	m ²	212.03	0.7525
	150mm thick	m ²	236.06	1.1288
	200mm thick	m ²	259.09	1.5050
3.14	300 x 300mm wide	m	149.87	0.6733
	450 x 450mm wide	m	260.70	1.5149
	600 x 600mm wide	m	395.31	2.6932
3.15	300 x 300mm wide	m	178.84	0.6733
	450 x 450mm wide	m	304.15	1.5149
	600 x 600mm wide	m	453.24	2.6932
4.1	Walls - 110mm thick	m ²	71.77	1.1069
	Walls - 230mm thick	m ²	143.26	2.3144
	Walls - 350mm thick	m ²	252.65	3.5220
4.2	Walls - 110mm thick	m ²	85.19	1.1069
	Walls - 230mm thick	m ²	169.62	2.3144
	Walls - 350mm thick	m ²	243.15	3.5220
4.3	Galvanised steel flat bar; 75 x 10mm	m	18.18	0.2867
	Galvanised steel flat bar; 85 x 8mm ribbed	m	18.48	0.2600
	Galvanised steel angle; 75 x 75 x 10mm	m	23.69	0.5734
	Galvanised steel angle; 100 x 75 x 10mm	m	49.36	0.6690
	Galvanised steel angle; 150 x 90 x 10mm	m	66.37	0.9175

	<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
	Galvanised steel angle; 100 x 100 x 6mm ribbed	m	30.76	0.4588
	Galvanised steel angle; 150 x 100 x 6mm ribbed	m	37.79	0.5734
	Galvanised steel T bar; 200 x 200 x 7mm ribbed	m	75.35	1.0704
	Galvanised steel T bar; 200 x 200 x 9mm ribbed	m	104.94	1.3763
4.4	110mm wide	m	1.67	0.0252
	230mm wide	m	3.21	0.0527
	350mm wide	m	4.84	0.0802
5.1	75 x 75 x 2.5mm (2400mm long)	no	243.22	0.6881
	75 x 75 x 3.0mm (2400mm long)	no	250.41	0.8258
	75 x 75 x 3.5mm (2400mm long)	no	255.20	0.9634
	75 x 75 x 4.0mm (2400mm long)	no	262.39	1.1010
	75 x 75 x 5.0mm (2400mm long)	no	271.97	1.3763
	75 x 75 x 6.0mm (2400mm long)	no	283.94	1.6515
	89 x 89 x 3.5mm (2400mm long)	no	282.71	1.1432
	89 x 89 x 5.0mm (2400mm long)	no	304.27	1.6332
	89 x 89 x 6.0mm (2400mm long)	no	316.24	1.9598
	100 x 100 x 3.0mm (2400mm long)	no	300.02	1.1010
	100 x 100 x 4.0mm (2400mm long)	no	311.99	1.4680
	100 x 100 x 5.0mm (2400mm long)	no	328.77	1.8350
	100 x 100 x 6.0mm (2400mm long)	no	340.74	2.2020
	100 x 100 x 9.0mm (2400mm long)	no	381.47	3.3030
5.2	1 tonne	tonne	3273.76	48.7000
	5 tonne	tonne	3135.31	48.7000
	20 tonne	tonne	2889.68	48.7000
	1 tonne	tonne	4116.31	48.7000
	5 tonne	tonne	3858.71	48.7000
	20 tonne	tonne	3688.22	48.7000
	1 tonne	tonne	4152.65	48.7000
	5 tonne	tonne	3895.05	48.7000
	20 tonne	tonne	3724.56	48.7000
5.3	1 tonne	tonne	7180.54	48.7000
	5 tonne	tonne	6597.95	48.7000
	20 tonne	tonne	6382.94	48.7000
5.4	1 tonne	tonne	4140.69	48.7000
	5 tonne	tonne	4030.29	48.7000
	20 tonne	tonne	3859.80	48.7000
5.5	200 UB 18	m	91.24	0.8766
	200 UB 22	m	97.53	1.0714
	200 UB 25	m	101.94	1.2175
	200 UB 29	m	109.18	1.4123
	250 UB 25	m	103.83	1.2175
	250 UB 31	m	111.70	1.5097
	250 UB 37	m	121.46	1.8019
	310 UB 32	m	112.65	1.5584
	310 UB 40	m	126.82	1.9480
	310 UB 46	m	136.26	2.2402
	1 tonne	tonne	3425.73	48.7000
	5 tonne	tonne	3168.13	48.7000
	20 tonne	tonne	3032.14	48.7000
	1 tonne	tonne	3900.28	48.7000
	5 tonne	tonne	3642.68	48.7000

	<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
	20 tonne	tonne	3614.22	48.7000
	1 tonne	tonne	4083.82	48.7000
	5 tonne	tonne	3929.72	48.7000
	20 tonne	tonne	3690.23	48.7000
5.6	150 x 75mm	m	118.72	4.3008
	180 x 75mm	m	129.42	5.1610
	200 x 75mm	m	136.05	5.7344
	230 x 75mm	m	143.42	6.5946
	250 x 90mm	m	178.08	8.6016
	300 x 90mm	m	193.38	10.3220
	380 x 100mm	m	243.72	14.5272
	1 tonne	tonne	3596.74	48.7000
	5 tonne	tonne	3339.14	48.7000
	20 tonne	tonne	3310.68	48.7000
5.7	1 tonne	tonne	6774.99	48.7000
	5 tonne	tonne	6370.19	48.7000
	20 tonne	tonne	6234.20	48.7000
5.8	Portal frames	tonne	3835.15	48.7000
5.9	Angle sections	tonne	4031.97	48.7000
	Universal sections	tonne	3835.15	48.7000
6.1	Cast aluminium	no	93.34	1.0714
	Galvanised steel	no	66.99	1.0714
	5 bank	no	496.63	3.5713
	11 bank	no	786.56	7.8569
	21 bank	no	1374.21	14.9996
	31 bank	no	1925.71	22.1423
7.1	100 x 75mm bearers @ 1800mm centres and 100 x 50mm joists @ 450mm centres	m ²	18.15	0.0773
	100 x 75mm bearers @ 1800mm centres and 100 x 50mm joists @ 600mm centres	m ²	14.92	0.0633
	100 x 75mm bearers @ 2400mm centres and 125 x 50mm joists @ 450mm centres	m ²	19.19	0.0861
	100 x 75mm bearers @ 2400mm centres and 125 x 50mm joists @ 600mm centres	m ²	15.50	0.0685
	100 x 75mm bearers @ 3000mm centres and 150 x 50mm joists @ 450mm centres	m ²	20.63	0.0970
	100 x 75mm bearers @ 3000mm centres and 150 x 50mm joists @ 600mm centres	m ²	16.40	0.0759
	150 x 75mm bearers @ 1800mm centres and 100 x 50mm joists @ 450mm centres	m ²	20.22	0.0878
	150 x 75mm bearers @ 1800mm centres and 100 x 50mm joists @ 600mm centres	m ²	16.98	0.0738
	150 x 75mm bearers @ 2400mm centres and 125 x 50mm joists @ 450mm centres	m ²	20.95	0.0940
	150 x 75mm bearers @ 2400mm centres and 125 x 50mm joists @ 600mm centres	m ²	17.28	0.0764
	150 x 75mm bearers @ 3000mm centres and 150 x 50mm joists @ 450mm centres	m ²	22.11	0.1033
	150 x 75mm bearers @ 3000mm centres and 150 x 50mm joists @ 600mm centres	m ²	17.87	0.0822

	<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
	200 x 75mm bearers @ 1800mm centres and 100 x 50mm joists @ 450mm centres	m ²	22.83	0.0984
	200 x 75mm bearers @ 1800mm centres and 100 x 50mm joists @ 600mm centres	m ²	19.59	0.0843
	200 x 75mm bearers @ 2400mm centres and 125 x 50mm joists @ 450mm centres	m ²	23.20	0.1019
	200 x 75mm bearers @ 2400mm centres and 125 x 50mm joists @ 600mm centres	m ²	19.52	0.0843
	200 x 75mm bearers @ 3000mm centres and 150 x 50mm joists @ 450mm centres	m ²	23.98	0.1096
	200 x 75mm bearers @ 3000mm centres and 150 x 50mm joists @ 600mm centres	m ²	19.74	0.0886
7.2	100 x 50 joists @ 450mm centres	m ²	46.85	1.8939
	100 x 50 joists @ 600mm centres	m ²	39.53	1.5151
7.3	150 x 50mm @ 450mm centres	m ²	21.12	0.0843
	150 x 50mm @ 600mm centres	m ²	16.91	0.0633
	200 x 50mm @ 450mm centres	m ²	27.51	0.1124
	200 x 50mm @ 600mm centres	m ²	21.72	0.0843
	250 x 50mm @ 450mm centres	m ²	32.38	0.1406
	250 x 50mm @ 600mm centres	m ²	25.88	0.1054
	300 x 50mm @ 450mm centres	m ²	37.94	0.1687
	300 x 50mm @ 600mm centres	m ²	30.33	0.1265
7.4	140 x 45mm @ 450mm centres	m ²	23.50	0.0708
	140 x 45mm @ 600mm centres	m ²	18.82	0.0531
	190 x 45mm @ 450mm centres	m ²	30.72	0.0961
	190 x 45mm @ 600mm centres	m ²	24.57	0.0721
7.5	200 x 47mm @ 600mm centres	m ²	24.53	0.0126
	246 x 57mm @ 600mm centres	m ²	26.45	0.0174
	300 x 63mm @ 600mm centres	m ²	30.41	0.0433
	360 x 63mm @ 600mm centres	m ²	38.68	0.0243
	248 x 70 mm @ 600mm centres	m ²	40.91	0.0174
	248 x 90 mm @ 600mm centres	m ²	42.49	0.0174
	302 x 70 mm @ 600mm centres	m ²	42.93	0.0217
	302 x 90 mm @ 600mm centres	m ²	44.29	0.0217
7.6	75 x 38mm @ 450mm centres	m	45.59	0.1617
	75 x 38mm @ 600mm centres	m	42.34	0.1321
	75 x 50mm @ 450mm centres	m	58.27	0.1996
	75 x 50mm @ 600mm centres	m	53.81	0.1639
	100 x 38mm @ 450mm centres	m	61.61	0.2017
	100 x 38mm @ 600mm centres	m	56.90	0.1657
	100 x 50mm @ 450mm centres	m	71.22	0.2523
	100 x 50mm @ 600mm centres	m	65.80	0.2082
	75 x 50mm @ 450mm centres	m	62.97	0.2173
	75 x 50mm @ 600mm centres	m	57.94	0.2246
	100 x 38mm @ 450mm centres	m	66.60	0.2196
	100 x 38mm @ 600mm centres	m	61.27	0.1791
	100 x 50mm @ 450mm centres	m	76.94	0.2742
	100 x 50mm @ 600mm centres	m	70.83	0.2246
7.7	70 x 35mm @ 450mm centres	m	41.83	0.1448
	70 x 35mm @ 600mm centres	m	38.88	0.1179
	70 x 45mm @ 450mm centres	m	50.40	0.1743

	<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
	70 x 45mm @ 600mm centres	m	46.76	0.1427
	90 x 35mm @ 450mm centres	m	58.78	0.1743
	90 x 35mm @ 600mm centres	m	54.25	0.1427
	90 x 45mm @ 450mm centres	m	68.22	0.2123
	90 x 45mm @ 600mm centres	m	62.99	0.1746
	70 x 45mm @ 450mm centres	m	54.24	0.1900
	70 x 45mm @ 600mm centres	m	50.14	0.1544
	90 x 35mm @ 450mm centres	m	63.57	0.1900
	90 x 35mm @ 600mm centres	m	58.45	0.1544
	90 x 45mm @ 450mm centres	m	73.73	0.2309
	90 x 45mm @ 600mm centres	m	67.84	0.1886
7.8	75 x 32mm studs @ 450mm centres	m ²	73.87	2.4020
	75 x 32mm studs @ 600mm centres	m ²	63.08	1.9281
	75 x 32mm studs @ 450mm centres	m ²	92.69	2.3027
	75 x 32mm studs @ 600mm centres	m ²	79.21	1.8266
7.9	150 x 50mm	m	11.86	0.0380
	150 x 75mm	m	14.81	0.0569
	200 x 50mm	m	14.81	0.0506
	200 x 75mm	m	18.55	0.0759
	250 x 75mm	m	22.23	0.0949
	300 x 75mm	m	25.91	0.1139
7.10	140 x 45mm	m	12.72	0.0319
	140 x 70mm	m	16.27	0.0496
	190 x 45mm	m	16.07	0.0433
	190 x 70mm	m	20.63	0.0673
7.11	100 x 38mm ceiling joist @ 450mm centres	m ²	22.20	0.0427
	100 x 38mm ceiling joist @ 600mm centres	m ²	18.12	0.0320
	100 x 50mm ceiling joist @ 450mm centres	m ²	27.33	0.0562
	100 x 50mm ceiling joist @ 600mm centres	m ²	22.06	0.0422
	125 x 50mm ceiling joist @ 450mm centres	m ²	30.28	0.0703
	125 x 50mm ceiling joist @ 600mm centres	m ²	24.33	0.0527
7.12	90 x 35mm ceiling joist @ 450mm centres	m ²	20.55	0.0354
	90 x 35mm ceiling joist @ 600mm centres	m ²	16.96	0.0266
	90 x 45mm ceiling joist @ 450mm centres	m ²	25.65	0.0455
	90 x 45mm ceiling joist @ 600mm centres	m ²	20.84	0.0342
	140 x 45mm ceiling joist @ 450mm centres	m ²	36.70	0.0708
	140 x 45mm ceiling joist @ 600mm centres	m ²	29.37	0.0531
7.13	100 x 50mm rafters @ 450mm centres	m ²	19.37	0.2277
	100 x 50mm rafters @ 600mm centres	m ²	14.52	0.3036
	150 x 38mm rafters @ 450mm centres	m ²	22.57	0.2596
	150 x 38mm rafters @ 600mm centres	m ²	16.92	0.3461
	150 x 50mm rafters @ 450mm centres	m ²	26.95	0.3416
	150 x 50mm rafters @ 600mm centres	m ²	20.22	0.4554
	200 x 50mm rafters @ 450mm centres	m ²	32.31	0.4554
	200 x 50mm rafters @ 600mm centres	m ²	24.23	0.6072
	250 x 50mm rafters @ 450mm centres	m ²	39.47	0.5693
	250 x 50mm rafters @ 600mm centres	m ²	29.59	0.7590
	300 x 50mm rafters @ 450mm centres	m ²	46.76	0.6831
	300 x 50mm rafters @ 600mm centres	m ²	35.06	0.9108
7.14	90 x 45mm rafters @ 450mm centres	m ²	18.27	0.1844
	90 x 45mm rafters @ 600mm centres	m ²	13.71	0.2459

			<i>Embodied energy (GJ/unit)</i>
<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	
140 x 35mm rafters @ 450mm centres	m ²	23.92	0.2231
140 x 35mm rafters @ 600mm centres	m ²	17.94	0.2975
140 x 45mm rafters @ 450mm centres	m ²	28.14	0.2869
140 x 45mm rafters @ 600mm centres	m ²	21.10	0.3825
190 x 45mm rafters @ 450mm centres	m ²	35.20	0.3894
190 x 45mm rafters @ 600mm centres	m ²	26.40	0.5192
7.15 100 x 38mm rafters @ 450mm centres	m ²	31.51	0.0702
100 x 38mm rafters @ 600mm centres	m ²	25.67	0.0535
100 x 50mm rafters @ 450mm centres	m ²	34.49	0.0913
100 x 50mm rafters @ 600mm centres	m ²	27.91	0.0693
125 x 38mm rafters @ 450mm centres	m ²	34.62	0.0869
125 x 38mm rafters @ 600mm centres	m ²	28.03	0.0660
125 x 50mm rafters @ 450mm centres	m ²	37.94	0.1133
125 x 50mm rafters @ 600mm centres	m ²	30.52	0.0858
150 x 38mm rafters @ 450mm centres	m ²	38.31	0.1036
150 x 38mm rafters @ 600mm centres	m ²	30.86	0.0786
150 x 50mm rafters @ 450mm centres	m ²	43.00	0.1353
150 x 50mm rafters @ 600mm centres	m ²	34.38	0.1023
7.16 90 x 35mm rafters @ 450mm centres	m ²	30.72	0.0588
90 x 35mm rafters @ 600mm centres	m ²	25.22	0.0449
90 x 45mm rafters @ 450mm centres	m ²	33.65	0.0746
90 x 45mm rafters @ 600mm centres	m ²	27.42	0.0568
140 x 35mm rafters @ 450mm centres	m ²	40.12	0.0895
140 x 35mm rafters @ 600mm centres	m ²	32.39	0.0680
140 x 45mm rafters @ 450mm centres	m ²	44.63	0.1142
140 x 45mm rafters @ 600mm centres	m ²	35.77	0.0865
7.17 3600mm span @ 450mm centres	m ²	58.69	0.2441
3600mm span @ 600mm centres	m ²	44.48	0.1831
4800mm span @ 450mm centres	m ²	53.06	0.2441
4800mm span @ 600mm centres	m ²	40.15	0.1831
6000mm span @ 450mm centres	m ²	50.97	0.2441
6000mm span @ 600mm centres	m ²	38.51	0.1831
7200mm span @ 450mm centres	m ²	47.22	0.2441
7200mm span @ 600mm centres	m ²	35.65	0.1831
9000mm span @ 450mm centres	m ²	46.21	0.2441
9000mm span @ 600mm centres	m ²	34.86	0.1831
12000mm span @ 450mm centres	m ²	45.23	0.2441
12000mm span @ 600mm centres	m ²	34.08	0.1831
7.18 75 x 75 mm	m	13.32	0.0285
100 x 100 mm	m	16.66	0.0506
125 x 125mm	m	20.37	0.0791
150 x 150mm	m	25.17	0.1139
7.19 75 x 75 mm	m	14.58	0.0285
100 x 100 mm	m	18.61	0.0506
125 x 125mm	m	23.20	0.0791
150 x 150mm	m	29.08	0.1139
7.20 75 x 75 mm	m	13.15	0.0285
100 x 100 mm	m	17.81	0.0506
125 x 125mm	m	23.19	0.0791
150 x 150mm	m	30.05	0.1139

	<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
7.21	75 x 75 mm	m	14.47	0.0285
	100 x 100 mm	m	19.86	0.0506
	125 x 125mm	m	26.18	0.0791
	150 x 150mm	m	34.20	0.1139
7.22	90 x 90mm	m	24.90	0.0410
	120 x 120mm	m	34.06	0.0729
	140 x 140mm	m	45.52	0.0992
7.23	200 x 50mm	m	16.66	0.0506
	200 x 75mm	m	22.62	0.0759
	200 x 100mm	m	27.78	0.1012
	250 x 50mm	m	19.61	0.0633
	250 x 75mm	m	26.30	0.0949
	250 x 100mm	m	32.25	0.1265
	300 x 50mm	m	22.62	0.0759
	300 x 75mm	m	29.98	0.1139
	300 x 100mm	m	36.67	0.1518
7.24	200 x 50mm	m	16.66	0.0506
	200 x 75mm	m	22.62	0.0759
	200 x 100mm	m	30.93	0.1012
	250 x 50mm	m	21.95	0.0633
	250 x 75mm	m	29.63	0.0949
	250 x 100mm	m	36.56	0.1265
	300 x 50mm	m	25.36	0.0759
	300 x 75mm	m	33.89	0.1139
	300 x 100mm	m	41.76	0.1518
7.25	200 x 50mm	m	17.81	0.0506
	200 x 75mm	m	25.27	0.0759
	200 x 100mm	m	31.91	0.1012
	250 x 50mm	m	21.50	0.0633
	250 x 75mm	m	30.06	0.0949
	250 x 100mm	m	39.37	0.1265
	300 x 50mm	m	25.27	0.0759
	300 x 75mm	m	34.86	0.1139
	300 x 100mm	m	46.75	0.1518
7.26	200 x 50mm	m	19.86	0.0506
	200 x 75mm	m	28.17	0.0759
	200 x 100mm	m	35.64	0.1012
	250 x 50mm	m	23.96	0.0633
	250 x 75mm	m	33.59	0.0949
	250 x 100mm	m	42.47	0.1265
	300 x 50mm	m	28.17	0.0759
	300 x 75mm	m	39.01	0.1139
	300 x 100mm	m	49.20	0.1518
7.27	190 x 45mm	m	20.17	0.0433
	190 x 70mm	m	28.96	0.0673
	240 x 45mm	m	34.18	0.0546
	240 x 70mm	m	34.57	0.0850
7.28	38 x 25mm with 450mm span @ 450mm centres	m ²	3.22	0.0107
	50 x 25mm with 600mm span @ 450mm centres	m ²	3.67	0.0141
	38 x 38mm with 450mm span @ 900mm centres	m ²	2.38	0.0081
	38 x 38mm with 450mm span @ 1200mm centres	m ²	1.83	0.0061

<i>Material/Dimension/Methods of Construction</i>		<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
	38 x 38mm with 600mm span @ 600mm centres	m ²	3.30	0.0122
	38 x 38mm with 900mm span @ 450mm centres	m ²	4.40	0.0162
	50 x 38mm with 600mm span @ 900mm centres	m ²	2.76	0.0107
	50 x 38mm with 600mm span @ 1200mm centres	m ²	2.12	0.0080
	50 x 38mm with 900mm span @ 600mm centres	m ²	3.81	0.0160
	50 x 38mm with 1200mm span @ 450mm centres	m ²	5.09	0.0214
	50 x 50mm with 1200mm span @ 600mm centres	m ²	4.49	0.0211
	50 x 50mm with 1200mm span @ 900mm centres	m ²	3.49	0.0141
	50 x 50mm with 1200mm span @ 1200mm centres	m ²	2.68	0.0105
7.29	35 x 35mm with 600mm span @ 450mm centres	m ²	3.91	0.0138
	45 x 35mm with 450mm span @ 600mm centres	m ²	3.43	0.0133
	45 x 35mm with 450mm span @ 900mm centres	m ²	2.72	0.0089
	45 x 35mm with 450mm span @ 1200mm centres	m ²	2.09	0.0066
	45 x 35mm with 900mm span @ 450mm centres	m ²	5.02	0.0177
	45 x 45mm with 600mm span @ 900mm centres	m ²	3.20	0.0114
	45 x 45mm with 600mm span @ 1200mm centres	m ²	2.46	0.0085
	45 x 45mm with 900mm span @ 600mm centres	m ²	4.42	0.0171
	45 x 45mm with 1200mm span @ 450mm centres	m ²	5.91	0.0228
	70 x 35mm with 1200mm span @ 600mm centres	m ²	5.15	0.0207
	70 x 35mm with 1200mm span @ 900mm centres	m ²	3.75	0.0138
	70 x 35mm with 1200mm span @ 1200mm centres	m ²	2.86	0.0103
7.30	58 x 25 x 0.42mm	m	5.77	0.0218
7.31	19mm thick	m ²	18.20	0.0844
	22mm thick	m ²	21.96	0.0977
7.32	12mm thick	m ²	20.07	0.3312
	15mm thick	m ²	22.06	0.4140
	17mm thick	m ²	27.64	0.4692
	20mm thick	m ²	30.32	0.5520
7.33	75 x 25mm pencil	m ²	55.28	0.1265
	100 x 25mm pencil	m ²	52.98	0.1265
7.34	9mm thick	m ²	21.73	0.0400
	12mm thick	m ²	24.36	0.0533
	16mm thick	m ²	26.67	0.0710
	18mm thick	m ²	28.63	0.0799
	25mm thick	m ²	32.82	0.1110
	33mm thick	m ²	38.54	0.1465
7.35	7.5mm thick	m ²	23.08	0.2070
	9mm thick	m ²	25.98	0.2484
	12mm thick	m ²	29.97	0.3312
	17mm thick	m ²	37.17	0.4692
	20mm thick	m ²	48.78	0.5520
8.1	Plain	m ²	1.70	0.2290
	Anti glare	m ²	1.80	0.2290
8.2	Plain	m ²	1.90	0.2290
	Anti glare	m ²	2.10	0.2290
8.3	Plain	m ²	2.20	0.2290
	Anti glare	m ²	2.30	0.2290
8.4	R1.5 (75 - 80mm thick)	m ²	6.64	0.1610
	R2.0 (100 - 110mm thick)	m ²	8.02	0.1610
	R2.5 (125 - 145mm thick)	m ²	9.09	0.1610
	R3.0 (150 - 155mm thick)	m ²	9.95	0.1610
	R3.5 (170 - 175mm thick)	m ²	10.19	0.1610

	<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
8.5	R1.5 (75 - 80mm thick)	m ²	7.76	0.1610
	R2.0 (100 - 110mm thick)	m ²	9.14	0.1610
	R2.5 (125 - 145mm thick)	m ²	10.21	0.1610
	R3.0 (150 - 155mm thick)	m ²	11.07	0.1610
	R3.5 (170 - 175mm thick)	m ²	11.31	0.1610
8.6	R1.5 (75 - 80mm thick)	m ²	10.47	0.1610
	R2.0 (100 - 110mm thick)	m ²	11.84	0.1610
	R2.5 (125 - 145mm thick)	m ²	12.92	0.1610
	R3.0 (150 - 155mm thick)	m ²	13.77	0.1610
	R3.5 (170 - 175mm thick)	m ²	14.02	0.1610
9.1	42 x 19mm bullnose/splay	m	5.69	0.0220
	70 x 19mm bullnose/splay	m	6.54	0.0367
	90 x 19mm bullnose/splay	m	8.12	0.0472
	140 x 19mm bullnose/splay	m	10.75	0.0734
	70 x 19mm colonial	m	6.91	0.0367
	90 x 19mm colonial	m	8.49	0.0472
	140 x 19mm colonial	m	11.49	0.0734
9.2	900mm wide (per meter rise)	m	311.45	0.4151
	Landing 900mm x 900mm x 1000mm high	no	343.71	0.8197
9.3	Handrail 900mm high comprising 100 x 100mm timber posts at 1000mm centres with 150 x 38mm handrail and midrail	m	69.44	0.0653
9.4	Closed tread design (per metre rise)	m	452.00	3.1586
	Open tread design (per metre rise)	m	357.00	2.2643
	Landing	m ²	102.00	4.8438
	1250mm diameter (per metre rise)	m	1437.00	6.9997
	1500mm diameter (per metre rise)	m	1437.00	8.9270
	1800mm diameter (per metre rise)	m	1537.00	11.6953
9.5	Meranti/ Pacific maple	m	48.57	0.0059
9.6	Meranti/ Pacific maple	m	124.16	0.3546
	Meranti/ Pacific maple	no	94.25	0.2484
9.7	2400mm high x 900mm wide x 600mm deep	no	423.11	1.0695
	2400mm high x 1800mm wide x 600mm deep	no	731.84	1.6618
9.8	16mm thick and 450mm wide	m	114.57	0.0571
	16mm thick and 600mm wide	m	149.06	0.0756
	33mm thick and 450mm wide	m	129.62	0.0935
	33mm thick and 600mm wide	m	169.89	0.1236
9.9	33mm thick and 450mm wide	m	173.15	0.0935
	33mm thick and 600mm wide	m	199.54	0.1236
9.10	Laminated particleboard	m	74.29	0.0105
9.11	Standard cabinets with one shelf 450mm deep	m	430.59	0.6818
	Standard cabinets with one shelf 600mm deep	m	450.12	0.8057
	Four drawer cabinet; 450mm wide x 450mm deep	no	459.93	0.6275
	Four drawer cabinet; 450mm wide x 600mm deep	no	199.27	0.8987
	Pull out table cabinet; 600mm wide x 450mm deep	no	637.43	1.0350
	Pull out table cabinet; 600mm wide x 600mm deep	no	674.56	1.2395
	Vegetable storage cabinet; 600mm wide x 450mm deep	no	357.40	0.4689
	Vegetable storage cabinet; 600mm wide x 600mm deep	no	369.17	0.5236
9.12	700mm high	m	400.04	0.4845
	350mm high	m	314.38	0.3456
9.13	800mm wide x 600mm deep	no	624.31	1.9398

	<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
9.14	2100mm high x 450mm wide x 450mm deep	no	481.63	0.8122
	2100mm high x 450mm wide x 600mm deep	no	513.99	0.9904
	2100mm high x 600mm wide x 450mm deep	no	590.06	0.9745
	2100mm high x 600mm wide x 600mm deep	no	620.22	1.1759
	2100mm high x 900mm wide x 450mm deep	no	793.31	1.2990
	2100mm high x 900mm wide x 600mm deep	no	836.31	1.5469
9.15	Standard cabinets with one shelf 450mm deep	m	627.94	0.6818
	Standard cabinets with one shelf 600mm deep	m	654.88	0.8057
	Four drawer cabinet; 450mm wide x 450mm deep	no	676.02	0.6275
	Four drawer cabinet; 450mm wide x 600mm deep	no	734.10	0.8987
	Pull out table cabinet; 600mm wide x 450mm deep	no	943.93	1.0350
	Pull out table cabinet; 600mm wide x 600mm deep	no	997.59	1.2395
	Vegetable storage cabinet; 600mm wide x 450mm deep	no	522.77	0.4689
	Vegetable storage cabinet; 600mm wide x 600mm deep	no	538.96	0.5236
9.16	700mm high	m	531.59	0.4845
	350mm high	m	473.91	0.3456
9.17	800mm wide x 600mm deep	no	915.38	1.9398
9.18	2100mm high x 450mm wide x 450mm deep	no	706.54	0.8122
	2100mm high x 450mm wide x 600mm deep	no	754.34	0.9904
	2100mm high x 600mm wide x 450mm deep	no	869.00	0.9745
	2100mm high x 600mm wide x 600mm deep	no	912.39	1.1759
	2100mm high x 900mm wide x 450mm deep	no	1171.47	1.2990
	2100mm high x 900mm wide x 600mm deep	no	1229.90	1.5469
9.19	750mm high x 750mm wide x 350mm deep; single basin	no	230.90	0.4456
	750mm high x 750mm wide x 450mm deep; single basin	no	290.01	0.5597
	750mm high x 900mm wide x 450mm deep; single basin	no	381.78	0.7368
	750mm high x 1200mm wide x 450mm deep; single basin	no	444.19	0.8573
	750mm high x 1500mm wide x 450mm deep; double basin	no	848.92	1.6384
	750mm high x 750mm wide x 450mm deep; single basin	no	563.59	1.0877
	750mm high x 900mm wide x 450mm deep; single basin	no	655.36	1.2648
	750mm high x 1200mm wide x 450mm deep; single basin	no	717.77	1.3853
	750mm high x 1500mm wide x 450mm deep; double basin	no	1122.50	2.1664
9.20	2400mm high x 900mm wide x 600mm deep	no	332.65	1.0093
	2400mm high x 1800mm wide x 600mm deep	no	518.57	1.5410
	2400mm high x 900mm wide x 600mm deep	no	401.00	1.0093
	2400mm high x 1800mm wide x 600mm deep	no	78.00	1.4950
10.1	4mm	m ²	88.24	1.8700
	5mm	m ²	98.22	1.8700
	6mm	m ²	101.89	1.8700
	10mm	m ²	184.80	1.8700
	12mm	m ²	193.47	1.8700
10.2	4mm	m ²	144.94	4.5400
	5mm	m ²	148.62	4.5400
	6mm	m ²	158.59	4.5400
	10mm	m ²	300.57	4.5400
	12mm	m ²	328.92	4.5400
10.3	Shower rod and half return panel	no	198.00	1.6060
	Shower rod and full return panel	no	198.00	7.9429
	Three door slider	no	293.00	10.3273
	Three door slider and half return panel	no	432.00	11.8948
	Three door slider and full return panel	no	440.00	18.2316

<i>Material/Dimension/Methods of Construction</i>		<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
	Three door slider and two fixed panels (corner unit)	no	477.00	20.1575
	Pivot door	no	321.00	9.7299
	Pivot door and half return panel	no	464.00	11.3978
	Pivot door and full return panel	no	473.00	17.7346
	Pivot door and two full return panels (corner unit)	no	541.00	19.9568
10.4	Hinged door	no	848.00	15.9177
	Hinged door and half return panel	no	1453.00	18.3390
	Hinged door and full return panel	no	1856.00	28.6297
	Hinged door and two fixed panels (corner unit)	no	2299.00	31.8077
11.1	EPDM synthetic rubber - 100m ²	m ²	69.80	0.0029
	EPDM synthetic rubber - 500m ²	m ²	60.10	0.0029
11.2	Square ribbed (10 ribs per sheet); 0.7mm thick	m ²	26.56	0.5920
	Square ribbed (10 ribs per sheet); 0.9mm thick	m ²	31.74	0.5920
	Square ribbed (10 ribs per sheet); 1.2mm thick	m ²	39.50	0.5920
	Square ribbed (10 ribs per sheet); 0.7mm thick; colour coated	m ²	30.06	0.5920
	Square ribbed (10 ribs per sheet); 0.9mm thick; colour coated	m ²	35.30	0.5920
	Square rib/tray (5 ribs per sheet); 0.7mm thick	m ²	27.45	0.5920
	Square rib/tray (5 ribs per sheet); 0.9mm thick	m ²	32.76	0.5920
	Square rib/tray (5 ribs per sheet); 1.2mm thick	m ²	40.73	0.5920
	Square rib/tray (5 ribs per sheet); 0.7mm thick; colour coated	m ²	31.03	0.5920
	Square rib/tray (5 ribs per sheet); 0.9mm thick; colour coated	m ²	36.42	0.5920
11.3	Corrugated; 0.42mm BMT; zinc aluminium coated	m ²	16.06	0.5920
	Corrugated; 0.48mm BMT; zinc aluminium coated	m ²	18.35	0.5920
	Corrugated; 0.61mm BMT; zinc aluminium coated	m ²	21.71	0.5920
	Corrugated; 0.80mm BMT; zinc aluminium coated	m ²	24.86	0.5920
	Corrugated; 0.42mm BMT; colour coated	m ²	19.63	0.5920
	Corrugated; 0.48mm BMT; colour coated	m ²	22.66	0.5920
	Corrugated; 0.60mm BMT; colour coated	m ²	27.07	0.5920
	Square ribbed (5 ribs per sheet); 0.42mm BMT; zinc aluminium coated	m ²	15.99	0.5920
	Square ribbed (5 ribs per sheet); 0.48mm BMT; zinc aluminium coated	m ²	18.29	0.5920
	Square ribbed (5 ribs per sheet); 0.42mm BMT; colour coated	m ²	19.55	0.5920
	Square ribbed (5 ribs per sheet); 0.48mm BMT; colour coated	m ²	22.64	0.5920
	Square ribbed (9 ribs per sheet); 0.42mm BMT; zinc aluminium coated	m ²	17.90	0.5920
	Square ribbed (9 ribs per sheet); 0.48mm BMT; zinc aluminium coated	m ²	19.56	0.5920
	Square ribbed (9 ribs per sheet); 0.42mm BMT; colour coated	m ²	22.06	0.5920
	Square ribbed (9 ribs per sheet); 0.48mm BMT; colour coated	m ²	23.63	0.5920
	Square rib/tray; 0.42mm BMT; zinc aluminium coated	m ²	20.40	0.5920
	Square rib/tray; 0.48mm BMT; zinc aluminium coated	m ²	21.76	0.5920
	Square rib/tray; 0.60mm BMT; zinc aluminium coated	m ²	28.01	0.5920
	Square rib/tray; 0.42mm BMT; colour coated	m ²	26.12	0.5920
	Square rib/tray; 0.48mm BMT; colour coated	m ²	27.79	0.5920
	Square rib/tray; 0.60mm BMT; colour coated	m ²	35.74	0.5920
11.4	Square edge pattern	m ²	36.00	0.2400
	Round edge pattern	m ²	36.00	0.2400
	Flat pattern	m ²	57.70	0.2400
11.5	Steel roof tile	m ²	60.00	1.3000

	<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
11.6	500 x 500mm	no	261.65	1.1809
	600 x 600mm	no	267.17	1.6895
	800 x 800mm	no	320.59	2.9790
	1000 x 1000mm	no	385.70	4.6318
	1200 x 1200mm	no	446.91	6.6477
11.7	400 x 700mm	no	245.38	1.3217
	400 x 1000mm	no	307.38	1.8802
	600 x 800mm	no	288.35	2.2343
	600 x 1100mm	no	314.93	3.0744
	800 x 1100mm	no	360.59	4.0824
	800 x 1400mm	no	418.34	5.1857
12.1	190 x 140mm fascia gutter	m	25.73	0.0283
	Angle	no	27.99	0.0113
	Expansion joint	no	25.18	0.0033
	Outlet	no	12.66	0.0033
	Stop end	no	6.98	0.0033
12.2	125mm quad gutter	m	35.09	0.3838
	Angle	no	71.08	0.1530
	Expansion joint	no	34.67	0.0450
	Outlet	no	18.71	0.0450
	Stop end	no	14.56	0.0450
12.3	125mm quad gutter	m	30.70	0.0283
	Angle	no	16.71	0.0113
	Expansion joint	no	33.57	0.0033
	Outlet	no	18.39	0.0033
	Stop end	no	8.28	0.0033
12.4	0.8mm thick	m	21.81	0.0122
12.5	0.56mm thick	m	74.37	0.1217
12.6	0.45mm thick	m	52.35	0.0069
12.7	300 x 300 x 150mm	no	109.07	0.1101
	450 x 450 x 150mm	no	111.66	0.2064
	600 x 600 x 150mm	no	137.01	0.3303
12.8	300 x 300 x 150mm	no	116.80	1.0951
	450 x 450 x 150mm	no	125.05	2.0532
	600 x 600 x 150mm	no	134.05	3.2852
12.9	300 x 300 x 150mm	no	80.37	0.0619
	450 x 450 x 150mm	no	91.44	0.0148
	600 x 600 x 150mm	no	115.74	0.0237
12.10	0.8mm thick	no	93.43	0.1125
12.11	0.56mm thick	no	212.75	1.1194
12.12	0.45mm thick	no	157.49	0.0633
12.13	100 x 50mm rectangular downpipe	m	20.25	0.0211
	100 x 50mm rectangular bend; elbow or shoe	no	18.03	0.0001
	100 x 75mm rectangular downpipe	m	21.04	0.0211
	100 x 75mm rectangular bend; elbow or shoe	no	28.53	0.0001
12.14	75mm diameter downpipe	m	51.97	0.2854
	75mm diameter bend; elbow or shoe	no	25.80	0.0001
	100mm diameter downpipe	m	61.29	0.2854
	100mm diameter bend; elbow or shoe	no	29.65	0.0001
	150mm diameter downpipe	m	62.82	0.2854
	150mm diameter bend; elbow or shoe	no	36.20	0.0001

<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
100 x 50mm rectangular downpipe	m	60.27	0.2854
100 x 50mm rectangular bend; elbow or shoe	no	17.74	0.0001
100 x 75mm rectangular downpipe	m	66.58	0.2854
100 x 75mm rectangular bend; elbow or shoe	no	28.53	0.0001
100 x 100mm rectangular downpipe	m	54.51	0.2854
100 x 100mm rectangular bend; elbow or shoe	no	27.98	0.0001
150 x 100mm rectangular downpipe	m	66.96	0.2854
150 x 100mm rectangular bend; elbow or shoe	no	30.68	0.0001
12.15 75mm diameter downpipe	m	37.06	0.0211
75mm diameter bend; elbow or shoe	no	23.00	0.0001
100mm diameter downpipe	m	41.69	0.0211
100mm diameter bend; elbow or shoe	no	25.03	0.0001
150mm diameter downpipe	m	60.26	0.0211
150mm diameter bend; elbow or shoe	no	35.32	0.0001
100 x 50mm rectangular downpipe	m	42.24	0.0211
100 x 50mm rectangular bend; elbow or shoe	no	22.66	0.0001
100 x 75mm rectangular downpipe	m	47.42	0.0211
100 x 75mm rectangular bend; elbow or shoe	no	24.92	0.0001
100 x 100mm rectangular downpipe	m	54.30	0.0211
100 x 100mm rectangular bend; elbow or shoe	no	27.98	0.0001
150 x 100mm rectangular downpipe	m	64.17	0.0211
150 x 100mm rectangular bend; elbow or shoe	no	30.08	0.0001
12.16 Aluminium; 0.55mm thick	no	32.30	0.0100
Copper; 0.56mm thick	no	76.17	0.1358
Stainless steel; 0.45mm thick	no	47.00	0.0100
12.17 Aluminium; 0.55mm thick	no	53.05	0.0651
Copper; 0.56mm thick	no	96.92	0.8827
Stainless steel; 0.45mm thick	no	67.75	0.0651
13.1 600 x 600mm wide	no	150.26	0.6963
600 x 1200mm wide	no	194.87	1.3836
600 x 1800mm wide	no	396.78	2.0708
600 x 2400mm wide	no	558.78	2.7580
1200 x 600mm wide	no	247.69	1.3787
1200 x 1200mm wide	no	301.69	2.7391
1200 x 1800mm wide	no	504.78	4.0995
1200 x 2400mm wide	no	566.99	5.4599
2000 x 600mm wide	no	528.25	2.2884
2000 x 1200mm wide	no	615.12	4.5464
2000 x 1800mm wide	no	997.81	6.8045
2000 x 2400mm wide	no	1056.51	9.0625
13.2 900 x 600mm wide	no	208.95	1.0396
900 x 1200mm wide	no	259.43	2.0634
900 x 1800mm wide	no	464.86	3.0873
900 x 2400mm wide	no	671.47	4.1111
1200 x 600mm wide	no	226.56	1.3815
1200 x 1200mm wide	no	280.56	2.7419
1200 x 1800mm wide	no	483.65	4.1023
1200 x 2400mm wide	no	732.51	5.4627
2000 x 600mm wide	no	302.87	2.2931
2000 x 1200mm wide	no	397.95	4.5511
2000 x 1800mm wide	no	751.30	6.8091
2000 x 2400mm wide	no	1070.60	9.0672

	<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
13.3	600 x 600mm wide	no	123.26	0.6976
	600 x 1200mm wide	no	156.13	1.3830
	600 x 1800mm wide	no	181.95	2.0685
	600 x 2400mm wide	no	210.13	2.7540
	1200 x 600mm wide	no	173.74	1.3829
	1200 x 1200mm wide	no	196.04	2.7415
	1200 x 1800mm wide	no	232.43	4.1002
	1200 x 2400mm wide	no	286.43	5.4589
	2000 x 600mm wide	no	328.69	2.2966
	2000 x 1200mm wide	no	343.95	4.5529
	2000 x 1800mm wide	no	428.47	6.8091
	2000 x 2400mm wide	no	612.78	9.0654
13.4	600 x 600mm wide	no	176.20	0.7071
	600 x 1200mm wide	no	242.19	1.4014
	600 x 1800mm wide	no	300.44	2.0957
	600 x 2400mm wide	no	385.14	2.7900
	1200 x 600mm wide	no	260.33	1.3930
	1200 x 1200mm wide	no	361.88	2.7605
	1200 x 1800mm wide	no	460.58	4.1280
	1200 x 2400mm wide	no	603.56	5.4956
	2000 x 600mm wide	no	361.31	2.3076
	2000 x 1200mm wide	no	515.93	4.5727
	2000 x 1800mm wide	no	681.47	6.8378
	2000 x 2400mm wide	no	903.55	9.1030
13.5	600 x 600mm wide	no	319.98	0.7192
	600 x 1200mm wide	no	585.14	1.4135
	600 x 1800mm wide	no	695.53	2.1079
	600 x 2400mm wide	no	733.40	2.8022
	1200 x 600mm wide	no	345.35	1.4173
	1200 x 1200mm wide	no	643.64	2.7849
	1200 x 1800mm wide	no	785.37	4.1524
	1200 x 2400mm wide	no	853.91	5.5199
	2000 x 600mm wide	no	524.10	2.3482
	2000 x 1200mm wide	no	952.28	4.6133
	2000 x 1800mm wide	no	1096.03	6.8784
	2000 x 2400mm wide	no	1179.48	9.1435
13.6	900 x 600mm wide	no	406.40	1.0814
	900 x 1200mm wide	no	453.98	2.1318
	900 x 1800mm wide	no	637.28	3.1822
	900 x 2400mm wide	no	1012.69	4.2325
	1200 x 600mm wide	no	404.15	1.4284
	1200 x 1200mm wide	no	454.41	2.8153
	1200 x 1800mm wide	no	638.58	4.2023
	1200 x 2400mm wide	no	1017.63	5.5893
	2000 x 600mm wide	no	494.68	2.3536
	2000 x 1200mm wide	no	729.60	4.6381
	2000 x 1800mm wide	no	1172.28	6.9227
	2000 x 2400mm wide	no	1251.14	9.2073
13.7	Awning type	m ²	417.43	1.3533
	Casement type	m ²	417.43	1.3899
	Fixed type	m ²	342.43	1.3168

	<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
14.1	2100 x 900mm wide	no	1206.44	5.5337
	2100 x 1800mm wide (1 x 900mm sliding panel)	no	599.00	5.8712
	2100 x 2400mm wide (1 x 1200mm sliding panel)	no	685.00	7.6997
	2100 x 3000mm wide (1 x 1000mm sliding panel)	no	897.00	6.5829
	2100 x 3600mm wide (1 x 1200mm sliding panel)	no	958.00	7.8224
14.2	2040 x 820mm wide	no	532.00	0.2017
	2040 x 920mm wide	no	548.00	0.2220
	2040 x 1020mm wide	no	572.00	0.2423
14.3	4 panel design	no	207.20	0.3386
	4 panel design with clear glazing (2 panels)	no	287.70	1.0745
	4 panel design with coloured glazing (2 panels)	no	280.70	1.0745
	4 panel design with lead light glazing (2 panels)	no	548.10	1.0745
	2 panel design with clear glazing (1 panels)	no	195.05	0.5488
	2 panel design with coloured glazing (1 panels)	no	191.55	0.5488
	2 panel design with lead light glazing (1 panels)	no	325.25	0.5488
	Single light design with clear glazing	no	284.90	0.6510
	2 light design with clear glazing	no	322.70	0.6510
	10 light design with clear glazing	no	352.10	1.9209
14.4	Hollow core construction	no	52.50	0.2936
	Solid construction	no	106.75	1.6159
14.5	4 panel design	no	189.00	1.6159
	4 panel design with clear glazing (2 panels)	no	270.90	2.0148
	4 panel design with coloured glazing (2 panels)	no	263.90	2.0148
	4 panel design with lead light glazing (2 panels)	no	531.30	2.0148
14.6	Hollow core construction	no	28.70	0.2936
	Solid construction	no	106.75	1.8536
	Hollow core construction	no	55.65	0.2936
	Solid construction	no	192.85	1.8536
14.7	4 panel design	no	268.80	0.2759
	4 panel design with clear glazing (2 panels)	no	350.70	1.0182
	4 panel design with coloured glazing (2 panels)	no	407.40	1.0182
	4 panel design with lead light glazing (2 panels)	no	621.60	1.0182
14.8	1970 x 985mm wide	no	812.68	0.2282
14.9	2040 x 820 x 45mm paint ply	no	641.60	3.6659
	2040 x 820 x 45mm sliced pacific maple	no	672.60	3.6659
14.10	2040 x 820 x 45mm paint ply	no	735.60	3.6659
	2040 x 820 x 45mm sliced pacific maple	no	765.60	3.6659
14.11	2040 x 820 x 45mm paint ply	no	817.60	3.6659
	2040 x 820 x 45mm sliced pacific maple	no	848.60	3.6659
14.12	2040 x 720 x 33mm	no	127.90	1.3378
	2040 x 770 x 33mm	no	127.90	1.4307
	2040 x 820 x 33mm	no	138.40	1.5236
14.13	610 x 410 x 29mm	no	66.79	0.2002
	910 x 410 x 29mm	no	74.49	0.2986
	1210 x 310 x 29mm	no	75.89	0.3002
	1210 x 410 x 29mm	no	81.49	0.3971
	1505 x 310 x 29mm	no	84.04	0.3734
	1505 x 410 x 29mm	no	92.44	0.4939
	1800 x 410 x 29mm	no	87.54	0.4466
	1800 x 410 x 29mm	no	96.64	0.5907
	1800 x 520 x 29mm	no	106.44	0.7492

<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
1800 x 620 x 29mm	no	114.14	0.8932
2040 x 310 x 29mm	no	86.59	0.5062
2040 x 410 x 29mm	no	94.99	0.6695
2040 x 520 x 29mm	no	103.39	0.8491
2040 x 620 x 29mm	no	109.69	1.0123
14.14 Standard	no	632.35	1.2786
Heavy duty	no	698.50	2.3942
Extra heavy duty	no	907.98	3.1025
14.15 2400 x 950mm wide	no	701.50	0.9525
2400 x 2490mm wide	no	740.00	1.0330
2400 x 3050mm wide	no	869.50	1.2202
2400 x 4800mm wide	no	1536.50	1.8311
14.16 2400 x 950mm wide	no	767.50	1.1247
2400 x 2490mm wide	no	808.00	1.1889
2400 x 3050mm wide	no	949.50	1.4417
2400 x 4800mm wide	no	1692.50	2.0048
Automatic door opener	no	655.50	1.2521
15.1 Wall; fixed to timber (glued and nailed)	m ²	14.69	0.0870
Ceilings; fixed to timber (glued and nailed)	m ²	16.66	0.0870
Wall; fixed to metal (glued and screwed)	m ²	15.65	0.0870
Ceilings; fixed to metal (glued and screwed)	m ²	17.96	0.0870
15.2 Ceilings; fixed to timber (glued and nailed)	m ²	17.51	0.0870
Ceilings; fixed to metal (glued and screwed)	m ²	18.81	0.0870
15.3 Wall; fixed to timber (glued and nailed)	m ²	15.63	0.1131
Ceilings; fixed to timber (glued and nailed)	m ²	17.60	0.1131
Wall; fixed to metal (glued and screwed)	m ²	16.59	0.1131
Ceilings; fixed to metal (glued and screwed)	m ²	18.90	0.1131
16.1 25 x 25mm	m ²	88.41	1.3000
50 x 50mm	m ²	90.78	1.3000
100 x 100mm	m ²	86.93	1.3000
150 x 150mm	m ²	69.71	1.3000
200 x 100mm	m ²	70.02	1.3000
200 x 200mm	m ²	68.21	1.3000
200 x 300mm	m ²	73.93	1.3000
300 x 300mm	m ²	65.77	1.3000
25 x 25mm	m ²	119.91	1.3000
50 x 50mm	m ²	122.28	1.3000
100 x 100mm	m ²	118.43	1.3000
150 x 150mm	m ²	94.21	1.3000
200 x 100mm	m ²	94.52	1.3000
200 x 200mm	m ²	89.21	1.3000
200 x 300mm	m ²	94.93	1.3000
300 x 300mm	m ²	83.27	1.3000
16.2 25 x 25mm	m ²	74.95	1.3000
50 x 50mm	m ²	78.62	1.3000
100 x 100mm	m ²	75.47	1.3000
150 x 150mm	m ²	68.75	1.3000
200 x 100mm	m ²	68.94	1.3000
200 x 200mm	m ²	67.25	1.3000
200 x 300mm	m ²	73.01	1.3000
300 x 300mm	m ²	65.01	1.3000

			<i>Embodied energy (GJ/unit)</i>
<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	
25 x 25mm	m ²	99.45	1.3000
50 x 50mm	m ²	103.12	1.3000
100 x 100mm	m ²	99.97	1.3000
150 x 150mm	m ²	93.25	1.3000
200 x 100mm	m ²	93.46	1.3000
200 x 200mm	m ²	91.75	1.3000
200 x 300mm	m ²	97.57	1.3000
300 x 300mm	m ²	86.01	1.3000
17.1 Polypropylene	m ²	35.24	0.3640
Nylon	m ²	40.37	0.3640
Wool 100%	m ²	55.74	0.3640
Wool/nylon 80/20%	m ²	55.74	0.3640
17.2 1.5mm thick	m ²	21.25	0.0897
2.0mm thick	m ²	21.25	0.0897
2.5mm thick	m ²	31.76	0.0897
18.1 Walls (timber panelling)	m ²	12.08	0.0050
Ceilings (timber panelling)	m ²	13.15	0.0050
Doors	m ²	21.50	0.0050
Windows	m ²	21.50	0.0050
18.2 Walls (timber panelling)	m ²	11.79	0.0050
Ceilings (timber panelling)	m ²	12.86	0.0050
Doors	m ²	21.20	0.0050
Windows	m ²	21.20	0.0050
18.3 Walls (timber panelling)	m ²	7.25	0.0050
Ceilings (timber panelling)	m ²	7.29	0.0050
Doors	m ²	12.40	0.0050
Windows	m ²	12.40	0.0050
18.4 Walls (timber panelling)	m ²	7.77	0.0050
Ceilings (timber panelling)	m ²	8.32	0.0050
Doors	m ²	13.43	0.0050
Windows	m ²	13.43	0.0050
18.5 Walls	m ²	9.68	0.0050
Ceilings	m ²	10.05	0.0050
18.6 Walls	m ²	6.28	0.0050
Ceilings	m ²	6.82	0.0050
18.7 Walls	m ²	12.80	0.0050
Ceilings	m ²	13.88	0.0050
18.8 Wall	m ²	7.58	0.0050
Ceilings	m ²	8.40	0.0050
18.9 Walls	m ²	4.91	0.0050
Ceilings	m ²	5.44	0.0050
18.10 Walls	m ²	10.00	0.0050
Ceilings	m ²	11.08	0.0050
18.11 Walls (timber panelling)	m ²	6.72	0.0050
Ceilings (timber panelling)	m ²	7.27	0.0050
Doors	m ²	12.38	0.0050
Windows	m ²	12.38	0.0050
18.12 Walls (timber panelling)	m ²	9.33	0.0050
Ceilings (timber panelling)	m ²	10.13	0.0050
Doors	m ²	16.87	0.0050
Windows	m ²	16.87	0.0050

<i>Material/Dimension/Methods of Construction</i>		<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
18.13	Walls (timber panelling)	m ²	11.79	0.0050
	Ceilings (timber panelling)	m ²	12.86	0.0050
	Doors	m ²	21.20	0.0050
	Windows	m ²	21.20	0.0050
18.14	Walls (timber panelling)	m ²	7.77	0.0050
	Ceilings (timber panelling)	m ²	8.32	0.0050
	Doors	m ²	13.43	0.0050
	Windows	m ²	13.43	0.0050
18.15	Walls	m ²	5.67	0.0050
	Ceilings	m ²	6.21	0.0050
18.16	Walls	m ²	6.21	0.0050
	Ceilings	m ²	6.75	0.0050
18.17	Walls	m ²	15.13	0.0050
	Ceilings	m ²	16.18	0.0050
18.18	Walls	m ²	8.64	0.0050
	Ceilings	m ²	9.06	0.0050
18.19	Walls	m ²	4.43	0.0050
	Ceilings	m ²	4.96	0.0050
18.20	Walls	m ²	4.85	0.0050
	Ceilings	m ²	5.38	0.0050
18.21	General surfaces	m ²	10.28	0.0050
	Open balustrades/railings/fencing/grilles (per side)	m ²	38.33	0.0050
	Gutters/pipes/conduits/flashings	m	1.77	0.0050
18.22	General surfaces	m ²	7.79	0.0050
	Open balustrades/railings/fencing/grilles (per side)	m ²	28.47	0.0050
	Gutters/pipes/conduits/flashings	m	1.35	0.0050
19.1	15mm (12.70mm actual) diameter x 0.91mm pipe	m	12.44	0.1050
	15mm 90 degree elbow	no	9.35	0.0960
	15 x 15 x 15mm 90 degree tee	no	12.77	0.3210
	15mm straight connection	no	11.75	0.7710
	15mm end cap	no	12.01	0.0450
	18mm (15.88mm actual) diameter x 1.02mm pipe	m	11.07	0.1050
	18mm 90 degree elbow	no	10.32	0.0960
	18 x 18 x 18mm 90 degree tee	no	13.59	0.3210
	18 x 15mm concentric reducer	no	13.65	0.3060
	18mm straight connection	no	14.08	0.7710
	18mm end cap	no	13.26	0.0450
	20mm (19.05mm actual) diameter x 1.02mm pipe	m	11.70	0.1050
	20mm 90 degree elbow	no	10.87	0.0960
	20 x 20 x 20mm 90 degree tee	no	15.19	0.3210
	20 x 18mm concentric reducer	no	9.10	0.3060
	20mm straight connection	no	14.91	0.7710
	20mm end cap	no	13.26	0.0450
	25mm (25.40mm actual) diameter x 1.22mm pipe	m	18.19	0.1050
	25mm 90 degree elbow	no	15.08	0.0960
	25 x 25 x 25mm 90 degree tee	no	20.94	0.3210
	25 x 20mm concentric reducer	no	12.20	0.3060
	25mm straight connection	no	16.33	0.7710
	25mm end cap	no	15.99	0.0450
	32mm (31.75mm actual) diameter x 1.22mm pipe	m	23.12	0.1050
	32mm 90 degree elbow	no	14.89	0.0960

<i>Material/Dimension/Methods of Construction</i>		<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
	32 x 32 x 32mm 90 degree tee	no	22.96	0.3210
	32 x 25mm concentric reducer	no	13.90	0.3060
	32mm straight connection	no	16.80	0.7710
	32mm end cap	no	17.01	0.0450
	40mm (38.10mm actual) diameter x 1.22mm pipe	m	26.04	0.1050
	40mm 90 degree elbow	no	17.81	0.0960
	40 x 40 x 40mm 90 degree tee	no	29.10	0.3210
	40 x 32mm concentric reducer	no	16.35	0.3060
	40mm straight connection	no	19.50	0.7710
	40mm end cap	no	25.02	0.0450
	15mm (12.70mm actual) diameter x 0.91mm pipe	m	18.15	0.1050
	18mm (15.88mm actual) diameter x 1.02mm pipe	m	16.78	0.1050
	20mm (19.05mm actual) diameter x 1.02mm pipe	m	17.67	0.1050
	25mm (25.40mm actual) diameter x 1.22mm pipe	m	23.26	0.1050
	32mm (31.75mm actual) diameter x 1.22mm pipe	m	30.59	0.1050
	40mm (38.10mm actual) diameter x 1.22mm pipe	m	33.57	0.1050
	15mm (12.70mm actual) diameter x 0.91mm pipe	m	13.24	0.1050
	18mm (15.88mm actual) diameter x 1.02mm pipe	m	12.12	0.1050
	20mm (19.05mm actual) diameter x 1.02mm pipe	m	13.89	0.1050
	25mm (25.40mm actual) diameter x 1.22mm pipe	m	21.10	0.1050
	32mm (31.75mm actual) diameter x 1.22mm pipe	m	26.23	0.1050
	40mm (38.10mm actual) diameter x 1.22mm pipe	m	29.20	0.1050
19.2	20mm diameter pipe	m	13.46	0.0068
	25mm diameter pipe	m	15.58	0.0086
	32mm diameter pipe	m	13.37	0.0109
	32mm 90 degree elbow	no	14.85	0.0125
	32 x 32mm 90 degree tee	no	12.41	0.0417
	32 x 25mm concentric reducer	no	14.40	0.0397
	40mm diameter pipe	m	13.42	0.0137
	40mm 90 degree elbow	no	15.23	0.0125
	40 x 40mm 90 degree tee	no	16.87	0.0417
	40 x 32mm concentric reducer	no	16.70	0.0397
19.3	6mm (6.35mm actual) diameter x 0.91mm pipe	m	20.09	0.0431
	8mm (7.94mm actual) diameter x 0.91mm pipe	m	21.17	0.0586
	10mm (9.52mm actual) diameter x 1.22mm pipe	m	22.57	0.0977
	15mm (12.70mm actual) diameter x 1.02mm pipe	m	29.50	0.1261
	8mm (15.90mm actual) diameter x 1.22mm pipe	m	25.16	0.0769
	20mm (19.05mm actual) diameter x 1.42mm pipe	m	26.59	0.2337
	25mm (25.40mm actual) diameter x 1.63mm pipe	m	37.35	0.3364
	6mm (6.35mm actual) diameter x 0.91mm pipe	m	15.41	0.0431
	8mm (7.94mm actual) diameter x 0.91mm pipe	m	16.49	0.0586
	10mm (9.52mm actual) diameter x 1.22mm pipe	m	16.49	0.0977
	15mm (12.70mm actual) diameter x 1.02mm pipe	m	16.49	0.1261
	8mm (15.90mm actual) diameter x 1.22mm pipe	m	16.53	0.0769
	20mm (19.05mm actual) diameter x 1.42mm pipe	m	16.59	0.2337
	25mm (25.40mm actual) diameter x 1.63mm pipe	m	16.85	0.3364
19.4	32mm (31.75mm actual) diameter x 1.22mm pipe	m	30.47	0.3267
	32mm 85 degree bend	no	18.68	0.0960
	32mm 85 degree bend with inspection opening	no	30.72	0.0960
	32 x 32mm 85 degree junction	no	27.22	0.3210
	32 x 32mm 85 degree junction with inspection opening	no	39.49	0.3210

<i>Material/Dimension/Methods of Construction</i>			<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
	32mm expansion joint	no	41.26	0.7710	
	40mm (38.10mm actual) diameter x 1.22mm pipe	m	33.57	0.4100	
	40mm 85 degree bend	no	21.40	0.0960	
	40mm 85 degree bend with inspection opening	no	32.71	0.0960	
	40 x 40mm 85 degree junction	no	31.26	0.3210	
	40 x 40mm 85 degree junction with inspection opening	no	50.11	0.3210	
	40 x 32mm concentric reducer	no	42.75	0.7710	
	40mm expansion joint	no	16.35	0.7710	
	50mm (50.88mm actual) diameter x 1.22mm pipe	m	41.00	0.5141	
	50mm 85 degree bend	no	25.74	0.0960	
	50mm 85 degree bend with inspection opening	no	58.07	0.0960	
	50 x 50mm 85 degree junction	no	36.51	0.3210	
	50 x 50mm 85 degree junction with inspection opening	no	53.72	0.3210	
	50 x 40mm concentric reducer	no	20.02	0.7710	
	50mm expansion joint	no	46.51	0.7710	
	65mm (63.50mm actual) diameter x 1.22mm pipe	m	50.50	0.6703	
	65mm 85 degree bend	no	34.59	0.0960	
	65mm 85 degree bend with inspection opening	no	65.39	0.0960	
	65 x 65mm 85 degree junction	no	41.54	0.3210	
	65 x 65mm 85 degree junction with inspection opening	no	66.31	0.3210	
	65 x 50mm concentric reducer	no	24.23	0.7710	
	65mm expansion joint	no	50.96	0.7710	
	80mm (76.20mm actual) diameter x 1.63mm pipe	m	70.09	1.1013	
	80mm 85 degree bend	no	45.09	0.0960	
	80mm 85 degree bend with inspection opening	no	72.66	0.0960	
	80 x 80mm 85 degree junction	no	43.29	0.3210	
	80 x 80mm 85 degree junction with inspection opening	no	69.74	0.3210	
	80 x 65mm concentric reducer	no	30.45	0.7710	
	80mm expansion joint	no	57.82	0.7710	
	100mm (101.60mm actual) diameter x 1.63mm pipe	m	63.81	1.3794	
	100mm 85 degree bend	no	97.88	0.0960	
	100mm 85 degree bend with inspection opening	no	57.81	0.0960	
	100 x 100mm 85 degree junction	no	100.02	0.3210	
	100 x 100mm 85 degree junction with inspection opening	no	83.14	0.3210	
	100mm expansion joint	no	75.88	0.7710	
19.5	32mm	no	56.60	0.0159	
	40mm	no	57.87	0.0200	
	50mm	no	68.76	0.0251	
	32mm	no	52.24	0.0159	
	40mm	no	71.20	0.0200	
	50mm	no	84.47	0.0251	
19.6	80 x 65mm	no	96.15	0.0565	
	80 x 65mm chrome plated	no	121.08	0.0565	
19.7	65mm	no	33.04	0.0038	
	80mm	no	33.04	0.0058	
	100mm	no	35.40	0.0090	
19.8	50mm	no	18.01	0.0005	
	65mm	no	21.61	0.0009	
	80mm	no	21.66	0.0014	
	100mm	no	22.70	0.0021	

	<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
19.9	32mm	no	34.50	0.0449
	40mm	no	34.50	0.0449
	50mm	no	35.53	0.0449
19.10	32mm	no	28.55	0.0327
	40mm	no	17.07	0.0327
	50mm	no	20.80	0.0327
19.11	50mm	no	5.80	0.0467
19.12	Chinamans cap 75mm diameter throat	no	22.49	0.0323
	Chinamans cap 100mm diameter throat	no	22.93	0.0323
19.13	40mm	no	7.91	0.0487
	50mm	no	5.98	0.0487
	65mm	no	13.97	0.0487
	80mm	no	18.31	0.0487
	100mm	no	27.74	0.0487
19.14	Chrome plated brass - 13mm	no	29.50	0.0033
	Chrome plated brass - 20mm	no	68.83	0.0033
	Chrome plated brass - 25mm	no	109.63	0.0033
	Polished brass - 13mm	no	50.95	0.0033
	Polished brass - 20mm	no	52.54	0.0033
	Rough brass - 13mm	no	25.17	0.0033
	Rough brass - 20mm	no	41.34	0.0033
	Rough brass - 25mm	no	88.47	0.0033
	Rough brass - 32mm	no	150.09	0.0033
	Rough brass - 40mm	no	155.58	0.0033
19.15	Screw connection (1400 kPa) - 15mm	no	22.77	0.0195
	Screw connection (1400 kPa) - 20mm	no	28.48	0.0195
	Screw connection (1400 kPa) - 25mm	no	38.90	0.0195
	Screw connection (1400 kPa) - 32mm	no	57.09	0.0195
	Screw connection (1400 kPa) - 40mm	no	69.86	0.0195
	Screw connection (2100 kPa) - 15mm	no	31.44	0.0195
	Screw connection (2100 kPa) - 20mm	no	40.11	0.0195
	Screw connection (2100 kPa) - 25mm	no	53.70	0.0195
	Screw connection (2100 kPa) - 32mm	no	77.39	0.0195
	Screw connection (2100 kPa) - 40mm	no	95.84	0.0195
	Screw connection (3500 kPa) - 8mm	no	120.73	0.0195
	Screw connection (3500 kPa) - 10mm	no	121.69	0.0195
	Screw connection (3500 kPa) - 15mm	no	53.21	0.0195
	Screw connection (3500 kPa) - 20mm	no	63.04	0.0195
	Screw connection (3500 kPa) - 25mm	no	80.64	0.0195
	Screw connection (3500 kPa) - 32mm	no	107.65	0.0195
	Screw connection (3500 kPa) - 40mm	no	135.27	0.0195
	Compression connections (1700 kPa) - 15mm	no	58.18	0.0195
	Compression connections (1700 kPa) - 20mm	no	58.18	0.0195
19.16	Flange connection (14mm kPa) - 40mm	no	225.95	0.0195
19.17	Screw connection (2100 kPa) - 15mm	no	55.53	0.0221
	Screw connection (2100 kPa) - 20mm	no	67.45	0.0221
	Screw connection (2100 kPa) - 25mm	no	83.37	0.0221
	Screw connection (2100 kPa) - 32mm	no	133.21	0.0221
	Screw connection (2100 kPa) - 40mm	no	152.96	0.0221

<i>Material/Dimension/Methods of Construction</i>		<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
19.18	Screw connection (2100 kPa) - 8mm	no	22.56	0.0339
	Screw connection (2100 kPa) - 10mm	no	22.56	0.0339
	Screw connection (2100 kPa) - 15mm	no	25.88	0.0339
	Screw connection (2100 kPa) - 20mm	no	30.29	0.0339
	Screw connection (2100 kPa) - 25mm	no	38.82	0.0339
	Screw connection (2100 kPa) - 32mm	no	54.30	0.0339
	Screw connection (2100 kPa) - 40mm	no	63.09	0.0339
19.19	Screw connection (1400 kPa) - 8mm	no	158.70	0.0177
	Screw connection (1400 kPa) - 15mm	no	123.84	0.0177
	Screw connection (1400 kPa) - 20mm	no	134.05	0.0177
	Screw connection (1400 kPa) - 32mm	no	263.01	0.0177
	Screw connection (1400 kPa) - 40mm	no	308.95	0.0177
19.20	15mm	no	39.45	0.0266
19.21	Basin set	no	173.72	0.0702
	Bath set	no	155.18	0.0868
	Shower set	no	173.88	0.1204
	Sink set	no	194.62	0.0905
	Bib tap	pair	175.51	0.0868
	Cistern tap	no	62.06	0.1521
	Pillar tap	pair	151.31	0.0868
	Washing machine tap	pair	118.31	0.0664
19.22	Basin set	no	168.22	0.0702
	Bath set	no	151.88	0.0868
	Shower set	no	172.78	0.1204
	Sink set	no	199.02	0.0905
	Bib tap	pair	162.31	0.0868
	Cistern tap	no	54.36	0.1521
	Pillar tap	pair	140.31	0.0868
	Washing machine tap	pair	118.31	0.0664
19.23	Basin set	no	361.82	0.0702
	Bath set	no	316.88	0.0868
	Shower set	no	415.88	0.1204
	Sink set	no	499.32	0.0905
	Bib tap	pair	309.71	0.0868
	Cistern tap	no	121.46	0.1521
	Pillar tap	pair	309.71	0.0868
	Washing machine tap	pair	226.11	0.0664
19.24	Sink mixer	no	268.32	0.0702
	Basin mixer	no	268.32	0.0702
	Bidette mixer	no	435.52	0.0702
19.25	Combination handles and spout mixer taps	no	244.12	0.0702
19.26	Hands free taps	no	560.92	0.1377
19.27	13mm	no	20.78	0.0868
	20mm	no	22.64	0.0868
	25mm	no	104.06	0.0868
19.28	Black chrome plated	no	52.12	0.1521
	Colour coated	no	45.28	0.1521
	Chrome plated	no	45.28	0.1521
	Gold plated	no	50.12	0.1521

	<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
19.29	400 litre	no	226.50	7.4912
	1000 litre	no	301.50	11.7922
	2250 litre	no	527.25	17.6433
	4500 litre	no	733.00	24.9141
19.30	400 litre	no	246.50	7.4912
	1000 litre	no	436.50	11.7922
	2250 litre	no	587.25	17.6433
	4500 litre	no	833.00	24.9141
19.31	2250 litre	no	637.25	0.9736
	4500 litre	no	933.00	1.2514
19.32	915 x 915 x 325mm white	no	327.90	17.1400
	1300 x 1300 x 450mm white	no	650.05	17.1400
	1470 x 1470 x 450mm white	no	696.50	17.1400
	1525 x 725 x 410mm white	no	292.90	17.1400
	1655 x 725 x 410mm white	no	308.90	17.1400
	1830 x 760 x 410mm white	no	427.05	17.1400
19.33	915 x 915 x 285mm white	no	573.90	1.3344
	1125 x 1125 x 340mm white	no	686.05	1.3344
	1295 x 760 x 330mm white	no	338.90	1.3344
	1525 x 760 x 330mm white	no	364.90	1.3344
	1675 x 760 x 330mm white	no	387.90	1.3344
19.34	1470 x 1470 x 450mm (4 plastic jets)	no	1818.18	15.4260
	1525 x 725 x 410mm (4 plastic jets)	no	969.68	15.4260
	1690 x 920 x 470mm (5 plastic jets)	no	998.68	15.4260
	1675mm diameter x 470mm (6 plastic jets)	no	2466.68	15.4260
19.35	1470 x 1470 x 450mm (16 chrome plated brass jets)	no	2000.00	18.8540
	1525 x 725 x 410mm (12 chrome plated brass jets)	no	1099.50	18.8540
	1690 x 920 x 470mm (12 chrome plated brass jets)	no	1128.50	18.8540
	1675mm diameter x 470mm (16 chrome plated brass jets)	no	2552.50	18.8540
19.36	1935 x 900 x 900mm (2 wall shower unit) white	no	771.00	17.1400
	1950 x 900 x 750mm (3 wall shower/bath unit) white	no	861.00	17.1400
	1945 x 1200 x 800mm (3 wall shower/bath unit) white	no	962.00	17.1400
	1945 x 1675 x 800mm (3 wall shower/bath unit) white	no	1684.00	17.1400
19.37	530 x 380 x 165mm white	no	133.18	0.7113
	550 x 430 x 200mm white	no	141.18	0.7113
	553 x 406 x 160mm	no	153.18	0.3896
	540 x 415mm; white	no	296.18	1.6932
	540 x 415mm; coloured	no	379.18	1.6932
19.38	510 x 305mm; white	no	393.48	1.6932
	510 x 305mm; coloured	no	449.48	1.6932
19.39	510 x 400mm; white	no	647.23	1.6932
	510 x 400mm; coloured	no	760.23	1.6932
19.40	Drop in' type; 900mm single bowl	no	312.50	0.2435
	Drop in' type; 1200mm single bowl	no	394.65	0.2435
	Drop in' type; 1350mm single bowl	no	407.80	0.2435
	Drop in' type; 1500mm single bowl	no	432.95	0.2435
	Drop in' type; 1200mm 1 1/2 bowl	no	415.40	0.2435
	Drop in' type; 1200mm 1 1/2 bowl (designer model)	no	530.55	0.2435
	Drop in' type; 1350mm 1 1/2 bowl	no	569.62	0.2435
	Drop in' type; 1500mm 1 1/2 bowl	no	583.70	0.2435

<i>Material/Dimension/Methods of Construction</i>		<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
	Drop in' type; 1350mm twin bowl	no	557.62	0.2435
	Drop in' type; 1500mm twin bowl	no	583.70	0.2435
	Drop in' type; 1800mm twin bowl	no	636.78	0.2435
	Fascia' type; 900mm single bowl	no	373.65	0.2435
	Fascia' type; 1200mm single bowl	no	398.80	0.2435
	Fascia' type; 1350mm single bowl	no	425.03	0.2435
	Fascia' type; 1500mm single bowl	no	452.10	0.2435
	Fascia' type; 1500mm twin bowl	no	621.70	0.2435
	Drop in' type; 380 x 380mm single bowl	no	372.35	0.2435
	Drop in' type; 500 x 450mm single bowl	no	392.50	0.2435
	Drop in' type; 450mm diameter single bowl	no	275.65	0.2435
	Drop in' type; 450mm diameter single drainer bowl	no	347.80	0.2435
	Drop in' type; 830 x 480mm single bowl with drainer bowl	no	685.25	0.2435
	Drop in' type; 960 x 500mm twin bowl	no	520.40	0.2435
19.41	45/46 litre single compartment	no	286.20	0.5755
	45/46 litre double compartment	no	624.50	0.5755
	70 litre single compartment	no	471.20	0.5755
	70 litre double compartment	no	802.50	0.5755
19.42	Close coupled S or P trap; white	no	653.50	5.5080
	Close coupled S or P trap; coloured	no	767.50	5.5080
	Close coupled concealed S or P trap; white	no	659.50	5.5080
	Close coupled concealed S or P trap; coloured	no	916.50	5.5080
	Wall face close coupled concealed trap; white	no	1316.50	5.5080
	Wall face close coupled concealed trap; coloured	no	1595.50	5.5080
19.43	910 x 910 x 115mm; white	no	302.34	1.2465
	910 x 910 x 115mm; coloured	no	323.34	1.2465
	910 x 910 x 115mm; white (corner unit)	no	347.34	1.2465
	910 x 910 x 115mm; coloured (corner unit)	no	374.34	1.2465
19.44	900 x 900 x 100mm	no	185.35	23.1000
	1500 x 900 x 100mm	no	218.34	23.1000
19.45	915 x 915 x 100mm	no	382.34	0.7084
19.46	50 litre	no	495.52	0.9401
	80 litre	no	599.08	1.1304
	125 litre	no	672.23	1.2719
	160 litre	no	784.53	1.4870
	250 litre	no	904.98	1.7013
	315 litre	no	1008.98	1.8881
19.47	90 litre	no	837.18	1.6107
	135 litre	no	889.48	1.7069
	170 litre	no	1041.63	1.9099
19.48	300 litre	no	2433.48	4.5026
20.1	100mm diameter pipe	m	57.00	0.0728
	100mm 85 degree bend	no	82.67	0.0071
	100 x 100mm 85 degree junction	no	109.86	0.0237
	100mm straight coupling	no	71.50	0.0058
	150mm diameter pipe	m	163.68	0.1094
	150mm 85 degree bend	no	147.60	0.0071
	150 x 100mm 85 degree junction	no	178.12	0.0237
	150mm straight coupling	no	102.23	0.0058

	<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
20.2	100mm diameter pipe	m	32.48	0.0728
	100mm 85 degree bend	no	26.10	0.0071
	100 x 100mm 45 degree junction	no	47.27	0.0049
	100mm inspection opening	no	37.70	0.0270
	100mm disconnecter trap	no	42.25	0.0237
	100mm boundary trap	no	42.25	0.0226
	150mm diameter pipe	m	48.61	0.1094
	150mm 85 degree bend	no	46.24	0.0071
	150 x 150mm 45 degree junction	no	63.68	0.0049
	150mm inspection opening	no	66.78	0.0270
	150mm disconnecter trap	no	80.99	0.0237
	150mm boundary trap	no	80.99	0.0226
20.3	100mm diameter pipe	m	15.33	0.0173
	100mm straight connector	no	11.01	0.0037
	100mm 85 degree bend	no	15.24	0.0032
	100 x 100mm 45 degree junction	no	14.67	0.0015
	100 x 100mm 85 degree junction	no	13.45	0.0032
	100mm inspection opening	no	17.63	0.0009
	100mm disconnecter trap	no	41.19	0.0009
	100mm boundary trap	no	71.33	0.0009
	100mm push on cap	no	12.31	0.0049
	100mm threaded cap	no	16.00	0.0049
	150mm diameter pipe	m	29.07	0.0260
	150mm straight connector	no	24.21	0.0037
	150mm 85 degree bend	no	37.93	0.0032
	150 x 150mm 45 degree junction	no	64.31	0.0015
	150mm inspection opening	no	56.05	0.0009
	150mm disconnecter trap	no	254.52	0.0009
	150mm push on cap	no	19.50	0.0049
	150mm threaded cap	no	30.03	0.0049
20.4	150mm diameter pipe	m	37.62	0.0001
	150mm 85 degree bend	no	155.78	0.0531
	150 x 100mm 45 degree junction	no	264.90	0.0365
20.5	100mm diameter pipe	m	32.48	0.0728
	100mm 85 degree bend	no	26.10	0.0071
	100 x 100mm 85 degree junction	no	30.80	0.0049
	150mm diameter pipe	m	48.61	0.1094
	150mm 85 degree bend	no	46.24	0.0071
	150 x 100mm 85 degree junction	no	47.90	0.0049
20.6	90mm diameter pipe	m	12.42	0.0156
	90mm 45 degree bend	no	9.78	0.0015
	90mm 90 degree bend	no	9.91	0.0032
	90 x 90mm 90 degree junction	no	12.08	0.0032
	90mm straight coupling	no	11.57	0.0037
	90mm push on cap	no	8.96	0.0049
	90 x 110 x 50mm rectangular down pipe adaptor	no	10.13	0.0021
	110mm diameter pipe	m	18.45	0.0190
	110mm 45 degree bend	no	23.27	0.0015
	110mm 90 degree bend	no	14.57	0.0032
	110 x 110mm 90 degree junction	no	17.33	0.0032
	110mm straight coupling	no	17.63	0.0037

	<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
	110mm push on cap	no	16.88	0.0049
	110 x 110 x 50mm rectangular down pipe adaptor	no	10.58	0.0021
	160mm diameter pipe	m	22.53	0.0277
	160mm 45 degree bend	no	24.83	0.0015
	160mm 90 degree bend	no	24.83	0.0032
	160 x 160mm 90 degree junction	no	41.84	0.0032
	160mm straight coupling	no	34.83	0.0037
	160mm push on cap	no	25.20	0.0049
	160 x 160 x 110mm rectangular down pipe adaptor	no	81.62	0.0021
20.7	200mm wide x 150mm deep overall (150mm wide grate)	m	41.89	0.0010
	275mm wide x 150mm deep overall (225mm wide grate)	m	49.28	0.0016
	350mm wide x 150mm deep overall (300mm wide grate)	m	56.62	0.0023
20.8	100mm wide x 100mm deep	m	57.00	0.0006
	100mm wide x 150mm deep	m	70.20	0.0008
	100mm wide x 225mm deep	m	86.83	0.0011
	100mm wide x 300mm deep	m	107.97	0.0014
	100mm wide x 500mm long x 470mm deep sump	no	125.22	0.0059
20.9	370 x 370 x 500mm	no	133.11	0.0648
	370 x 370 x 1000mm	no	258.11	0.1660
	490 x 490 x 500mm	no	382.29	0.1759
	490 x 490 x 1000mm	no	696.71	0.3433
	610 x 610 x 500mm	no	449.03	0.2208
	610 x 610 x 1000mm	no	817.87	0.4324
	970 x 970 x 500mm	no	665.57	0.3599
	970 x 970 x 1000mm	no	1187.35	0.6963
20.10	450 x 450 x 500mm	no	499.88	0.0451
	450 x 450 x 1000mm	no	948.92	0.0549
	600 x 600 x 500mm	no	629.38	0.0478
	600 x 600 x 1000mm	no	1193.92	0.0325
	900 x 900 x 500mm	no	904.74	0.0325
	900 x 900 x 1000mm	no	1684.68	0.0325
20.11	450 x 450 x 600mm	no	194.81	0.0265
	450 x 450 x 900mm	no	274.81	0.0361
	600 x 600 x 600mm	no	205.59	0.0385
	600 x 600 x 900mm	no	292.21	0.0513
	600 x 600 x 1200mm	no	382.21	0.0642
	900 x 900 x 600mm	no	324.15	0.0674
	900 x 900 x 900mm	no	370.78	0.0866
	900 x 900 x 1200mm	no	440.78	0.1059
	1000/1050/1100mm diameter x 700mm depth	no	365.89	0.0198
	1000/1050/1100mm diameter x 1050mm depth	no	409.47	0.0296
	1000/1050/1100mm diameter x 1400mm depth	no	470.43	0.0395
20.12	305 x 305 x 450mm deep	no	131.99	0.0325
	460 x 460 x 600mm deep	no	290.92	0.0678
20.13	1000 litre with 2 LPS submersible cutter 0.075 kW 240 volt automatic sewerage pump	no	3419.85	0.7084
20.14	18 litre	no	91.68	0.0187
20.15	18 litre	no	86.69	0.2862
20.16	300mm wide x 600mm deep	m	18.30	0.0084
	450mm wide x 600mm deep	m	26.80	0.0189
	600mm wide x 600mm deep	m	35.26	0.0336

<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
20.17 70 ltr/metre storage	m	29.02	0.0575
20.18 100mm diameter pipe	no	13.70	0.0410
150mm diameter pipe	no	15.35	0.0612
20.19 100mm diameter pipe	m	51.60	0.0410
150mm diameter pipe	m	59.24	0.0612
21.1 Single phase	m	27.80	0.0502
3 phase	m	31.90	0.0618
21.2 Overhead mains connection	no	557.00	0.7874
21.3 Houses	no	473.00	1.1232
Home units (6 x 2 bed units)	no	1093.00	1.1232
Add extra for home unit sub board	no	315.00	1.1232
21.4 Light duty 20mm diameter	m	5.20	0.0068
Light duty 25mm diameter	m	6.20	0.0086
Light duty 32mm diameter	m	10.30	0.0137
21.5 Single switch; concrete/ masonry	no	48.40	0.0907
Single switch; timber	no	38.10	0.0714
Double switch; concrete/masonry	no	42.20	0.0791
Double switch; timber	no	38.10	0.0714
Single switch; concrete/ masonry	no	47.40	0.0888
Single switch; timber	no	37.10	0.0695
Double switch; concrete/masonry	no	52.50	0.0984
Double switch; timber	no	42.20	0.0791
Single switch; concrete/ masonry	no	206.00	0.3860
Single switch; timber	no	201.90	0.3783
21.6 Batten fitting; 20 watt single	no	42.20	0.2482
Batten fitting; 20 watt double	no	51.50	0.2482
Batten fitting; 40 watt single	no	44.30	0.2482
Batten fitting; 40 watt double	no	61.80	0.2482
Batten fitting with diffuser; 20 watt single	no	61.80	0.2482
Batten fitting with diffuser; 20 watt double	no	72.10	0.2482
Batten fitting with diffuser; 40 watt single	no	62.80	0.2482
Batten fitting with diffuser; 40 watt double	no	88.60	0.2482
Tougher fitting with diffuser; 20 watt double	no	82.40	0.2482
Tougher fitting with diffuser; 40 watt double	no	95.80	0.2482
21.7 Emergency lighting 8 watt fluorescent	no	231.00	0.4323
Illuminated exit sign; single sided	no	242.00	0.4536
Illuminated exit sign; double sided	no	242.00	0.4536
21.8 Fixed to concrete/masonry	no	115.00	0.2162
Fixed to timber	no	63.00	0.1177
21.9 Thermal detection system	m ²	14.30	0.0275
21.10 Passive infra-red detection system	no	4860.00	9.1057
Ultrasonic detection system	no	5045.00	9.4493
21.11 Closed circuit television surveillance system	no	16200.00	28.5601
Video telephone call system	no	1100.00	3.8388
21.12 Range/stove	no	115.00	0.2162
Oven	no	115.00	0.2162
Cooktop	no	115.00	0.2162
Hot water system; 50 litre	no	84.00	0.1583
Hot water system; 250 litre	no	126.00	0.2355
21.13 Fixed to concrete/masonry	no	90.00	0.1949
Fixed to timber	no	104.00	0.1679

	<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
21.14	3 blade (plain); 1200mm diameter	no	211.72	0.2925
	4 blade (rattan insert); 1200mm diameter	no	228.24	0.2925
22.1	Self contained type; 2hp; 4.7 kW (40m ² area)	no	1466.47	2.7175
	Self contained type; 2hp; 6.2 kW (50m ² area)	no	1778.47	3.3196
	Split system type; 1hp; 2.46 kW cooling/3.28 kW heating (30m ² area)	no	1990.04	3.7018
	Split system type; 1.5hp; 3.75 kW cooling/4.2 kW heating (40m ² area)	no	2223.04	4.1514
	Split system type; 2hp; 5.2 kW cooling/6.07 kW heating (55m ² area)	no	2562.04	4.8057
	Split system type; 2.5hp; 6.15 kW cooling/7.16 kW heating (65m ² area)	no	2785.04	5.2361
22.2	Portable electric heaters; 800w/1600w (radiant type)	no	127.00	0.2364
	Portable electric heaters; 1000w/1400w (fan convection type)	no	197.00	0.3715
	In-built electric heaters; 2400w (fan assisted type)	no	308.35	0.5651
	In-built electric heaters; 3500w (fan assisted type)	no	334.35	0.6153
22.3	50m ² area (portable flueless type)	no	573.00	1.0972
	70m ² area (in-built flued type)	no	1401.39	2.6181
	120m ² area (in-built flued type)	no	1669.39	3.1354
	120m ² area (in-built log fire type)	no	1669.39	3.1354
22.4	Radiant type (free standing); 10/15 kW (140m ² area)	no	1311.50	2.4226
	Radiant type (free standing); 16/20 kW (190m ² area)	no	1489.50	2.7662
	Convection type (free standing); 10/15 kW (140m ² area)	no	1578.50	2.9379
	Convection type (free standing); 16/20 kW (190m ² area)	no	1936.50	3.6289
	Convection type (free standing); 25+ kW (280m ² area)	no	2293.50	4.3179
	Convection type (in-built); 15/20 kW (190m ² area)	no	308.50	3.6289
	Convection type (in-built); 25+ kW (230m ² area)	no	107.24	4.3179
23.1	Aluminium fixed awning; 900mm deep	m	265.00	0.3456
	Aluminium fixed awning; 1500mm deep	m	350.00	0.4968
	Aluminium louver awning; fixed louver; 1200mm high	m	330.00	0.5028
	Aluminium louver awning; fixed louver; 2000mm high	m	600.00	0.7428
	Aluminium louver awning; fixed louver; 2400mm high	m	685.00	0.7968
	Aluminium louver awning; adjustable louver (hand crank operation); 1200mm high	m	435.00	0.5316
	Aluminium louver awning; adjustable louver (hand crank operation); 2000mm high	m	720.00	0.7572
	Aluminium louver awning; adjustable louver (hand crank operation); 2400mm high	m	650.00	0.8640
	Aluminium interlocking slat roller awning; fixed guides; 1200mm high	m	330.00	0.3192
	Aluminium interlocking slat roller awning; fixed guides; 2000mm high	m	415.00	0.4032
	Aluminium interlocking slat roller awning; fixed guides; 2400mm high	m	445.00	0.4704
	Aluminium interlocking slat roller awning; pivoting frame; 1200mm high	m	385.00	0.3540
	Aluminium interlocking slat roller awning; pivoting frame; 2000mm high	m	465.00	0.4440
	Aluminium interlocking slat roller awning; pivoting frame; 2400mm high	m	430.00	0.5160

	<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
23.2	Canvas fabric roller awning; fixed guides; 1200mm high	m	285.00	0.2712
	Canvas fabric roller awning; fixed guides; 2000mm high	m	310.00	0.3096
	Canvas fabric roller awning; fixed guides; 2400mm high	m	325.00	0.3504
	Canvas fabric roller awning; pivoting frame; 1200mm high	m	360.00	0.2160
	Canvas fabric roller awning; pivoting frame; 2000mm high	m	400.00	0.2832
	Canvas fabric roller awning; pivoting frame; 2400mm high	m	430.00	0.3108
	Canvas fabric awning; 1750mm deep	m	620.00	0.7428
	Canvas fabric awning; 2100mm deep	m	655.00	0.7836
	Canvas fabric awning; 2600mm deep	m	690.00	0.8256
	Canvas fabric awning; 3100mm deep	m	745.00	0.8928
	Canvas fabric awning; barrel walkway; 900mm wide	m	375.00	0.4500
	Canvas fabric awning; barrel walkway; 1200mm wide	m	510.00	0.6120
	Canvas fabric awning; cupola; 900mm wide x 600mm deep	no	705.00	0.8040
	Canvas fabric awning; cupola; 900mm wide x 900mm deep	no	825.00	1.1292
	Canvas fabric awning; cupola; 1200mm wide x 600mm deep	no	745.00	0.9264
	Canvas fabric awning; cupola; 1200mm wide x 900mm deep	no	875.00	1.1568
23.3	Semi translucent fabric; 600mm high	m	85.00	0.0780
	Semi translucent fabric; 1200mm high	m	100.00	0.0876
	Semi translucent fabric; 2000mm high	m	115.00	0.1320
	Semi translucent fabric; 2400mm high	m	125.00	0.1392
	Opaque fabric with reflective lining; 600mm high	m	90.00	0.0852
	Opaque fabric with reflective lining; 1200mm high	m	105.00	0.0960
	Opaque fabric with reflective lining; 2000mm high	m	130.00	0.1464
	Opaque fabric with reflective lining; 2400mm high	m	135.00	0.1536
	Reflective tinted film; 600mm high	m	150.00	0.1464
	Reflective tinted film; 1200mm high	m	180.00	0.1632
	Reflective tinted film; 2000mm high	m	230.00	0.1932
	Reflective tinted film; 2400mm high	m	250.00	0.2148
23.4	600mm high	m	235.00	0.2220
	1200mm high	m	305.00	0.2832
	2000mm high	m	405.00	0.3648
	2400mm high	m	440.00	0.4044
23.5	Aluminium Slats - 15mm wide; 600mm high	m	80.00	0.1656
	Aluminium Slats - 15mm wide; 1200mm high	m	105.00	0.1920
	Aluminium Slats - 15mm wide; 2000mm high	m	140.00	0.2292
	Aluminium Slats - 15mm wide; 2400mm high	m	150.00	0.2460
	Aluminium Slats - 25mm wide; 600mm high	m	70.00	0.1500
	Aluminium Slats - 25mm wide; 1200mm high	m	85.00	0.1584
	Aluminium Slats - 25mm wide; 2000mm high	m	105.00	0.1800
	Aluminium Slats - 25mm wide; 2400mm high	m	115.00	0.1908
23.6	Semi translucent fabric; 600mm high	m	95.00	0.1920
	Semi translucent fabric; 1200mm high	m	105.00	0.2112
	Semi translucent fabric; 2000mm high	m	120.00	0.2592
	Semi translucent fabric; 2400mm high	m	125.00	0.2832
	Opaque fabric; 600mm high	m	100.00	0.1872
	Opaque fabric; 1200mm high	m	105.00	0.2040
	Opaque fabric; 2000mm high	m	130.00	0.2508
	Opaque fabric; 2400mm high	m	135.00	0.2748
	Reflective tinted film; 600mm high	m	160.00	0.1920
	Reflective tinted film; 1200mm high	m	175.00	0.2112
	Reflective tinted film; 2000mm high	m	215.00	0.2592
	Reflective tinted film; 2400mm high	m	235.00	0.2832

	<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
23.7	600mm high	m	152.00	0.1916
	1200mm high	m	201.00	0.2525
	2000mm high	m	266.00	0.3367
	2400mm high	m	303.00	0.3834
23.8	600mm high	m	156.00	0.1963
	1200mm high	m	208.00	0.2620
	2000mm high	m	278.00	0.3526
	2400mm high	m	317.00	0.4024
23.9	600mm high	m	165.00	0.2082
	1200mm high	m	226.00	0.2857
	2000mm high	m	308.00	0.3922
	2400mm high	m	353.00	0.4499
23.10	600mm high	m	45.00	0.0573
	1200mm high	m	57.00	0.0764
	2000mm high	m	75.00	0.1013
	2400mm high	m	85.00	0.1147
23.11	600mm high	m	49.00	0.0608
	1200mm high	m	65.00	0.0835
	2000mm high	m	87.00	0.1132
	2400mm high	m	99.00	0.1289
23.12	600mm high	m	52.00	0.0656
	1200mm high	m	72.00	0.0930
	2000mm high	m	99.00	0.1290
	2400mm high	m	114.00	0.1479
23.13	Aluminium; hand traversed	m	31.00	0.0388
	Aluminium; cord traversed - single	m	37.00	0.0465
	Aluminium; cord traversed - double	m	58.00	0.0674
	Aluminium; motorised	no	845.00	0.7880
	Plastic; hand traversed	m	22.00	0.0263
	Steel rob (painted finish)	m	24.00	0.0271
	Timber rob including rings and decorative rod ends	m	43.00	0.0616
24.1	Thermal detection system	m ²	14.30	0.0275
24.2	Mains operated with battery back up	no	117.82	0.2083
	Battery operated	no	28.59	0.0603
24.3	Water sprinkler system	m ²	36.00	0.0695
24.4	100mm	no	7870.00	15.1917
	150mm	no	10120.00	19.5324
24.5	Diesel	no	20200.00	39.0669
	Electric	no	13500.00	26.0446
24.6	Hydrant point	no	226.44	0.4092
24.7	36 metre	no	200.60	0.5407
24.8	1000 x 1000mm	no	24.45	0.0848
	1200 x 1800mm	no	30.45	0.1659
	1800 x 1800mm	no	37.45	0.2141
24.9	Carbon dioxide; 2.0 kg	no	198.91	0.0548
	Carbon dioxide; 3.5 kg	no	166.99	0.4987
	Carbon dioxide; 5.0 kg	no	196.99	0.5083
	Dry chemical (foam compatible); 2.25 kg	no	91.99	0.2285
	Dry chemical (foam compatible); 4.5 kg	no	106.99	0.2574
	Dry chemical (foam compatible); 9.0 kg	no	116.99	0.3057
	Foam - 9.1 litre	no	131.99	0.2960
	Water - 9.1 litre	no	116.99	0.2767

	<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
24.10	Medium risk; 100 litres	no	2248.00	4.1109
	Medium risk; 200 litres	no	2438.00	4.3039
	High risk; 200 litres	no	4228.00	7.9709
	High risk; 400 litres	no	5238.00	9.9009
25.1	Electric standard oven (540mm wide) with mechanical timer	no	782.00	1.3558
	Electric forced air oven (540mm wide) with electronic timer	no	982.00	1.7032
	Electric forced air oven (600mm wide) with electronic timer	no	1620.00	0.2847
	Gas standard oven (540mm wide) with mechanical timer	no	857.75	1.4480
	Gas forced air oven (540mm wide) with electronic timer	no	1023.90	1.8063
	Gas forced air oven (600mm wide) with electronic timer	no	1460.90	2.8871
	Electric standard oven (1070mm wide) with mechanical timer	no	1103.00	2.0545
	Electric forced air oven (1070mm wide) with electronic timer	no	1754.00	3.2607
	Gas standard oven (1070mm wide) with mechanical timer	no	1301.75	2.1949
	Gas forced air oven (1070mm wide) with electronic timer	no	1570.90	2.6478
25.2	Electric standard oven (540mm wide) with mechanical timer	no	584.40	1.0889
	Electric forced air oven (540mm wide) with electronic timer	no	627.40	1.1700
	Electric forced air oven (600mm wide) with electronic timer	no	769.40	1.3765
	Gas standard oven (540mm wide) with mechanical timer	no	793.90	1.4396
	Gas forced air oven (540mm wide) with electronic timer	no	927.90	1.6770
	Gas forced air oven (600mm wide) with electronic timer	no	1257.90	2.3930
	Electric forced air oven (600mm wide) with electronic timer	no	747.00	1.4485
	Gas forced air oven (600mm wide) with electronic timer	no	1427.90	2.7115
25.3	Electric enamel hob (rectangular)	no	396.60	0.7427
	Electric enamel hob (square)	no	363.60	0.7890
	Electric ceramic hob (rectangular)	no	768.60	1.4896
	Electric ceramic hob (square)	no	747.60	1.4413
	Gas enamel hob (rectangular)	no	499.11	0.0973
	Gas enamel hob (square)	no	455.11	1.0411
	Gas ceramic hob (rectangular)	no	654.11	1.1183
	Gas ceramic hob (square)	no	703.11	1.3248
25.4	Microwave oven	no	216.35	0.4713
25.5	Standard	no	863.50	1.5951
	Programmable	no	871.50	1.5469
25.6	Ceiling mounted (plasterboard); 200mm diameter	no	101.60	0.1733
	Ceiling mounted (plasterboard); 250mm diameter	no	101.60	0.1733
	Wall mounted (brick veneer); 200mm diameter	no	234.32	0.4598
	Window mounted (glass); 200mm diameter	no	222.16	0.3757
	Window mounted (glass); 250mm diameter	no	256.58	0.3757
25.7	Standard type 600mm wide	no	208.00	0.3397
	Standard type 900mm wide	no	302.00	0.4034
25.8	Waste disposal unit	no	405.50	0.8193
26.1	150mm depth (overall excluding topping)	m ²	82.00	1.1255
	200mm depth (overall excluding topping)	m ²	88.00	1.5006
	250mm depth (overall excluding topping)	m ²	93.00	1.8758
26.2	100mm thick	m ²	96.35	0.7503
	125mm thick	m ²	105.99	0.9379
	150mm thick	m ²	112.29	1.1255
	175mm thick	m ²	120.91	1.3130
	200mm thick	m ²	127.00	1.5006

	<i>Material/Dimension/Methods of Construction</i>	<i>Unit</i>	<i>Cost (\$/unit)</i>	<i>Embodied energy (GJ/unit)</i>
27.1	52mm frame	m	200.00	4.0799
	64mm frame	m	205.00	4.0799
	75mm frame	m	210.00	4.0799
	94mm frame	m	215.00	5.5012
27.2	75 x 50mm	m	203.21	0.7662
27.3	18mm thick	no	1200.00	1.4438
25.1	11 - 12 person; 1.0 m/s speed	no	148000.00	387.9300
	14 - 17 person; 1.0 m/s speed	no	166000.00	419.7750
	Add/deduct for additional floors	no	8100.00	16.7910
25.2	16 person; 1.75 m/s speed	no	215000.00	526.8900
	20 person; 1.75 m/s speed	no	230000.00	540.4000
	23 person; 1.75 m/s speed	no	9600.00	569.3500
	16 person; 2.5 m/s speed	no	410000.00	791.3000
	16 person; 3.5 m/s speed	no	425000.00	820.2500
	20 person; 2.5 m/s speed	no	433000.00	835.6900
	20 person; 3.5 m/s speed	no	448000.00	864.6400
	20 person; 5.0 m/s speed	no	488000.00	941.8400
	20 person; 6.0 m/s speed	no	516000.00	995.8800
	20 person; 7.0 m/s speed	no	554000.00	1069.2200
	20 person; 8.0 m/s speed	no	576000.00	1111.6800
	23 person; 2.5 m/s speed	no	445000.00	858.8500
	23 person; 3.5 m/s speed	no	457000.00	882.0100
	23 person; 5.0 m/s speed	no	505000.00	974.6500
	23 person; 6.0 m/s speed	no	528000.00	1019.0400
	23 person; 7.0 m/s speed	no	590000.00	559.7000
	23 person; 8.0 m/s speed	no	625000.00	1206.2500
	Add/deduct for additional floors	no	11000.00	21.2300

APPENDIX B

CODING OF SOFTWARE TOOL -

APPENDIX B

CODING OF SOFTWARE TOOL –

This appendix presents the coding of software tool, *BEE* – “*Bill of Embodied Energy*” developed mainly using PHP language as discussed in Section 4.1.2. Bill of Embodied Energy is programmed to record user’s input, interactively, in to a plain text file. PHP eliminates the need for numerous small cgi programs to place simple scripts directly in to HTML language to be displayed online. Apart from PHP, software program *BEE* also makes use of Javascript, a client-side scripting language particularly for menu creation. After coded, the program is uploaded to the web server via AceFTP program.

Appendix B.1 Introduction Coding

```
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.0 Transitional//EN">
<HTML>
<HEAD>
<TITLE>Bill of Embodied Energy (BEE)</TITLE>
<META NAME="Generator" CONTENT="EditPlus">
<META NAME="Author" CONTENT="">
<META NAME="Keywords" CONTENT="">
<META NAME="Description" CONTENT="">
<style type="text/css">
<!--

p, li {font-family:verdana; color:black; font-size:9pt}

-->
</style>
</HEAD>

<BODY style="font-family:verdana">
<table align=center width=600 height=600 border=1 cellpadding=15><tr><td valign=top>

<p>The Bill of Embodied Energy (BEE) is a tool to assist engineering an optimum energy embodied configuration for domestic construction.
```

```

<p>The main capabilities of the tool are:
<ol>
<li>to provide sufficient and easy-to-use data to evaluate quantities of embodied energy for standard activities such as external walls, floor
system, etc., listed in cost guides;
<li>to provide a "Bill of Embodied Energy" which has a complementing "Bill of Quantities (BOQ)", and
<li>to provide capability to optimise both cost and embodied energy at the same time.
</ol>
<p>Domestic buildings are broadly categorised in to three sectors in the Bill of Embodied Energy. They are single dwelling, medium density
construction (15 to 35 units per block) and high density construction (40 to 80 units per block). The domestic building comprises structures,
finishes and services.

<br><br>
<center><form action="select.php">Key in the Project Name: <input type="text" name="file_to_use" value=".txt"> <input type="submit
name="submit" value="Start Using BEE Now"></form></center>
</td></tr>
</table>
</BODY>
</HTML>

```

Appendix B.2 Select Type of Domestic Construction Sector Coding

```

<?
    session_start();
    if(!session_is_registered("filename"))
    {
        session_register("filename");
        $filename = "report/".$file_to_use;
    }
?>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.0 Transitional//EN">
<HTML>
<HEAD>
<TITLE>Bill of Embodied Energy (BEE)</TITLE>
<META NAME="Generator" CONTENT="EditPlus">
<META NAME="Author" CONTENT="">
<META NAME="Keywords" CONTENT="">
<META NAME="Description" CONTENT="">
<style type="text/css">
<!--

p, li {font-family:verdana; color:black; font-size:9pt; text-align:center}
b {font-family:verdana; font-size:9pt}

-->
</style>
</HEAD>

<BODY style="font-family:verdana">
<table align=center width=600 height=600 border=1 cellpadding=15><tr><td valign=top>
 <b>Project Name: <? echo substr($filename, 7);?></b>
<p>Select Type of Domestic Construction Sector:
<p><a href="start1.php">Single Dwelling Housing</a>
<p><a href="start2.php">Medium Density Housing</a>
<p><a href="start2.php">High Density Housing</a>
<p>&nbsp;</p><p>&nbsp;</p>
</td></tr>
<tr><td valign=bottom><div style="text-align:center">    </div></td></tr>
</table>
</BODY>
</HTML>

```


Appendix B.3 Single Dwelling Coding

```

<?
    session_start();
    if(!session_is_registered("num_item"))
    {
        session_register("num_item");
        $num_item = 0;
    }
    if(!session_is_registered("item"))
    {
        session_register("item");
        $item = array();
    }
?>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.0 Transitional//EN">
<HTML>
<HEAD>
<TITLE>Bill of Embodied Energy (BEE)</TITLE>
<META NAME="Generator" CONTENT="EditPlus">
<META NAME="Author" CONTENT="">
<META NAME="Keywords" CONTENT="">
<META NAME="Description" CONTENT="">
<style type="text/css">
<!--

p, li {font-family:verdana; color:black}
span {border:groove 2px; padding:3; font-family:arial; font-size:12; width:120; height:30;
    background-color:#a0a1a2; text-align:center; margin-left:5px}
span a {text-decoration:none; color:black}
span a:visited {color:black}
span a:hover {color:blue}
fieldset {display:none}
b {font-size:8pt}

-->
</style>
<script type="text/javascript">
// End hiding script from old browsers -->
function change(i){
    tempCol=document.all.tags("span");
    tempColl=document.all.tags("fieldset");
    tempColl(3).style.display="none";
    for(var j=0; j<3; j++){
        tempColl(j).style.display="none";
        tempCol(j).style.backgroundColor="#a0a1a2";
    }
    tempCol(i).style.backgroundColor="#efefef";
    tempColl(i).style.display="block";
}
function clear(){
    tempol=document.all.tags("span");
    for(var j=0; j<3; j++)
        tempol(j).style.backgroundColor="#a0a1a2";
}
</script>

</HEAD>

<BODY style="font-family:verdana">
<table align=center width=600 height=600 border=1 cellspacing=0 cellpadding=15><tr><td valign=top>
 <b>Project Name: <? echo substr($filename, 7);?></b>
<p>There are three groups of building elements that you can choose from, put your cursor on  to view the
list before you proceed:
<br><br>
<center>
<span onMouseOver="change(0)" onMouseOut="clear()">Structures</span>
<span onMouseOver="change(1)" onMouseOut="clear()">Finishes</span>
<span onMouseOver="change(2)" onMouseOut="clear()">Services</span>
</center>
<fieldset>
<legend>&nbsp;  Structures </legend>
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<ul>
<li>Piering & Piling

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<ul>
<li>Cast In-Situ Piling <a href="calc.php?class=Cast In-Situ Piling&title=Piering %26 Piling"></a>
<li>Prefabricated Driven Piling <a href="calc.php?class=Prefabricated Driven Piling&title=Piering %26 Piling"></a>
<li>Sheet Piling <a href="calc.php?class=Sheet Piling&title=Piering %26 Piling"></a>
</ul>
<li>Concrete In-Situ
<ul>
<li>Structural Concrete <a href="calc.php?class=Structural Concrete&title=Concrete In-Situ"></a>
<li>Slab Bases <a href="calc.php?class=Slab Bases&title=Concrete In-Situ"></a>
<li>Membranes <a href="calc.php?class=Membranes&title=Concrete In-Situ"></a>
</ul>
<li>Concrete Composite
<ul>
<li>Footings <a href="calc.php?class=Footings&title=Concrete Composite"></a>
<li>Slabs <a href="calc.php?class=Slabs&title=Concrete Composite"></a>
<li>Beams <a href="calc.php?class=Beams&title=Concrete Composite"></a>
<li>Walls <a href="calc.php?class=Walls&title=Concrete Composite"></a>
<li>Columns <a href="calc.php?class=Columns&title=Concrete Composite"></a>
</ul>
<li>Mansory - Brickwork
<ul>
<li>Brickwork <a href="calc.php?class=Brickwork&title=Mansory - Brickwork"></a>
<li>Lintels <a href="calc.php?class=Lintels&title=Mansory - Brickwork"></a>
<li>Damp Proof Courses <a href="calc.php?class=Damp Proof Courses&title=Mansory - Brickwork"></a>
</ul>
<li>Structural Steel
<ul>
<li>Columns (Steel) <a href="calc.php?class=Columns (Steel)&title=Structural Steel"></a>
<li>Beams (Steel) <a href="calc.php?class=Beams (Steel)&title=Structural Steel"></a>
</ul>
<li>Carpentry
<ul>
<li>Ground Floor Framing <a href="calc.php?class=Ground Floor Framing&title=Carpentry"></a>
<li>Upper Floor Framing <a href="calc.php?class=Upper Floor Framing&title=Carpentry"></a>
<li>Wall Framing <a href="calc.php?class=Wall Framing&title=Carpentry"></a>
<li>Conventional Roof Framing <a href="calc.php?class=Conventional Roof Framing&title=Carpentry"></a>
<li>Roof Trusses <a href="calc.php?class=Roof Trusses&title=Carpentry"></a>
<li>Posts <a href="calc.php?class=Posts&title=Carpentry"></a>
<li>Timber Beams <a href="calc.php?class=Timber Beams&title=Carpentry"></a>
</ul>
<li>Roofing
<ul>
<li>Membrane Roofing <a href="calc.php?class=Membrane Roofing&title=Roofing"></a>
<li>Sheet Roofing <a href="calc.php?class=Sheet Roofing&title=Roofing"></a>
<li>Tile Roofing <a href="calc.php?class=Tile Roofing&title=Roofing"></a>
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<fieldset>
<legend>&nbsp;Finishes </legend>
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<ul>
<li>Metalwork
<ul>
<li>Metal Furniture <a href="calc.php?class=Metal Furniture&title=Metal Furniture"></a>
</ul>
<li>Carpentry
<ul>
<li>Ceiling Framing <a href="calc.php?class=Ceiling Framing&title=Carpentry"></a>
<li>Battens <a href="calc.php?class=Battens&title=Carpentry"></a>
<li>Flooring <a href="calc.php?class=Flooring&title=Carpentry"></a>
<li>Wall Linings <a href="calc.php?class=Wall Linings&title=Carpentry"></a>
</ul>
<li>Insulation
<ul>
<li>Aluminium Insulation <a href="calc.php?class=Aluminium Insulation&title=Insulation"></a>
<li>Fibreglass Insulation <a href="calc.php?class=Fibreglass Insulation&title=Insulation"></a>
</ul>
<li>Joinery
<ul>
<li>Architrave & Skirting <a href="calc.php?class=Architrave %26 Skirting&title=Joinery"></a>
<li>External Staircase <a href="calc.php?class=External Staircase&title=Joinery"></a>

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<li>Internal Staircase <a href="calc.php?class=Internal Staircase&title=Joinery"></a>
<li>Cupboards <a href="calc.php?class=Cupboards&title=Joinery"></a>
<li>Kitchen Cupboards <a href="calc.php?class=Kitchen Cupboards&title=Joinery"></a>
<li>Vanity Units <a href="calc.php?class=Vanity Units&title=Joinery"></a>
<li>Wardrobes <a href="calc.php?class=Wardrobes&title=Joinery"></a>
</ul>
<li>Glazing
<ul>
<li>Float Glass <a href="calc.php?class=Float Glass&title=Glazing"></a>
<li>Toughened Glass <a href="calc.php?class=Toughened Glass&title=Glazing"></a>
<li>Shower Screens <a href="calc.php?class=Shower Screens&title=Glazing"></a>
</ul>
<li>Roofing
<ul>
<li>Skylights <a href="calc.php?class=Skylights&title=Roofing"></a>
</ul>
<li>Windows
<ul>
<li>Aluminium Windows <a href="calc.php?class=Aluminium Windows&title=Windows"></a>
<li>Meranti Timber Windows <a href="calc.php?class=Meranti Timber Windows&title=Windows"></a>
<li>Steel Windows <a href="calc.php?class=Steel Windows&title=Windows"></a>
</ul>
<li>Doors
<ul>
<li>External <a href="calc.php?class=External&title=Doors"></a>
<li>Internal <a href="calc.php?class=Internal&title=Doors"></a>
<li>Bi-Fold & Multi-Fold Doors <a href="calc.php?class=Bi-Fold %26 Multi-Fold Doors&title=Doors"></a>
<li>Disabled Person Doors <a href="calc.php?class=Disabled Person Doors&title=Doors"></a>
<li>Fire Doors <a href="calc.php?class=Fire Doors&title=Doors"></a>
<li>Louver Doors & Shutters <a href="calc.php?class=Louver Doors %26 Shutters&title=Doors"></a>
<li>Security Doors <a href="calc.php?class=Security Doors&title=Doors"></a>
<li>Roller Doors & Shutters <a href="calc.php?class=Roller Doors %26 Shutters&title=Doors"></a>
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<ul>
<li>Plastering
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</ul>
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<ul>
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<li>Floor Tiling <a href="calc.php?class=Floor Tiling&title=Tiling"></a>
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<li>Floorcoverings
<ul>
<li>Floorcoverings <a href="calc.php?class=Floorcoverings&title=Floorcoverings"></a>
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<li>Painting
<ul>
<li>Woodwork Painting (Internal) <a href="calc.php?class=Woodwork Painting (Internal)&title=Painting"></a>
<li>Brickwork & Blockwork & Concrete & Render Painting (Internal) <a href="calc.php?class=Brickwork %26 Blockwork %26 Concrete
%26 Render Painting (Internal)&title=Painting"></a>
<li>Fibre Cement & Plaster & Plasterboard Painting (Internal) <a href="calc.php?class=Fibre Cement %26 Plaster %26 Plasterboard
Painting (Internal)&title=Painting"></a>
<li>Woodwork Painting (External) <a href="calc.php?class=Woodwork Painting (External)&title=Painting"></a>
<li>Brickwork & Blockwork & Concrete & Render Painting (External) <a href="calc.php?class=Brickwork %26 Blockwork %26
Concrete %26 Render Painting (External)&title=Painting"></a>
<li>Fibre Cement & Plaster & Plasterboard Painting (External) <a href="calc.php?class=Fibre Cement %26 Plaster %26 Plasterboard
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<li>Metalwork Painting (External) <a href="calc.php?class=Metalwork Painting (External)&title=Painting"></a>
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<ul>
<li>Fixture Traps <a href="calc.php?class=Fixture Traps&title=Plumbing"></a>
<li>Floor Traps <a href="calc.php?class=Floor Traps&title=Plumbing"></a>
<li>Floor Waste <a href="calc.php?class=Floor Waste&title=Plumbing"></a>
<li>Waste Outlet <a href="calc.php?class=Waste Outlet&title=Plumbing"></a>
<li>Flap Valves <a href="calc.php?class=Flap Valves&title=Plumbing"></a>
<li>Vent Cows <a href="calc.php?class=Vent Cows&title=Plumbing"></a>
<li>Valves <a href="calc.php?class=Valves&title=Plumbing"></a>
<li>Taps Spouts & Roses <a href="calc.php?class=Taps Spouts %26 Roses&title=Plumbing"></a>

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<li>Water Tanks <a href="calc.php?class=Water Tanks&title=Plumbing"></a>
<li>Baths <a href="calc.php?class=Baths&title=Plumbing"></a>
<li>Spa Baths <a href="calc.php?class=Spa Baths&title=Plumbing"></a>
<li>Shower Cabinets <a href="calc.php?class=Shower Cabinets&title=Plumbing"></a>
<li>Basins <a href="calc.php?class=Basins&title=Plumbing"></a>
<li>Sinks <a href="calc.php?class=Sinks&title=Plumbing"></a>
<li>Laundry Tub <a href="calc.php?class=Laundry Tub&title=Plumbing"></a>
<li>Toilet Suites <a href="calc.php?class=Toilet Suites&title=Plumbing"></a>
<li>Shower Bases <a href="calc.php?class=Shower Bases&title=Plumbing"></a>
<li>Hot Water Units <a href="calc.php?class=Hot Water Units&title=Plumbing"></a>
</ul>
<li>Blinds & Curtains
<ul>
<li>Awnings <a href="calc.php?class=Awnings&title=Blinds %26 Curtains"></a>
<li>Blinds <a href="calc.php?class=Blinds&title=Blinds %26 Curtains"></a>
<li>Curtains <a href="calc.php?class=Curtains&title=Blinds %26 Curtains"></a>
</ul>
<li>Sundry Appliances
<ul>
<li>Domestic Appliances <a href="calc.php?class=Domestic Appliances&title=Sundry Appliances"></a>
</ul>
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<fieldset>
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<ul>
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<li>Gas Supply Pipework <a href="calc.php?class=Gas Supply Pipework&title=Plumbing"></a>
<li>Sanitary Pipework <a href="calc.php?class=Sanitary Pipework&title=Plumbing"></a>
</ul>
<li>Drainage
<ul>
<li>Sewer Drains <a href="calc.php?class=Sewer Drains&title=Drainage"></a>
<li>Stormwater Drains <a href="calc.php?class=Stormwater Drains&title=Drainage"></a>
<li>Surface Drains <a href="calc.php?class=Surface Drains&title=Drainage"></a>
<li>Mainholes, Sumps & Pits <a href="calc.php?class=Mainholes, Sumps %26 Pits&title=Drainage"></a>
<li>Sewer Pumping Station <a href="calc.php?class=Sewer Pumping Station&title=Drainage"></a>
<li>Grease Traps <a href="calc.php?class=Grease Traps&title=Drainage"></a>
<li>Stormwater Pits <a href="calc.php?class=Stormwater Pits&title=Drainage"></a>
<li>Pipe Connections <a href="calc.php?class=Pipe Connections&title=Drainage"></a>
<li>Pipe Encasement <a href="calc.php?class=Pipe Encasement&title=Drainage"></a>
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<ul>
<li>Roof Plumbing
<ul>
<li>Gutters <a href="calc.php?class=Gutters&title=Roof Plumbing"></a>
<li>Valley Gutters <a href="calc.php?class=Valley Gutters&title=Roof Plumbing"></a>
<li>Sumps <a href="calc.php?class=Sumps&title=Roof Plumbing"></a>
<li>Rain Heads <a href="calc.php?class=Rain Heads&title=Roof Plumbing"></a>
<li>Downpipes <a href="calc.php?class=Downpipes&title=Roof Plumbing"></a>
<li>Flashings <a href="calc.php?class=Flashings&title=Roof Plumbing"></a>
</ul>
<li>Electrical Services
<ul>
<li>Mains Connection <a href="calc.php?class=Mains Connection&title=Electrical Services"></a>
</ul>
<li>Mechanical - Air Conditioning
<ul>
<li>Cooling Equipment <a href="calc.php?class=Cooling Equipment&title=Mechanical - Air Conditioning"></a>
<li>Heating Equipment <a href="calc.php?class=Heating Equipment&title=Mechanical - Air Conditioning"></a>
</ul>
<li>Fire Protection
<ul>
<li>Fire Detection <a href="calc.php?class=Fire Detection&title=Fire Protection"></a>
<li>Active Fire Protection <a href="calc.php?class=Active Fire Protection&title=Fire Protection"></a>
<li>Cabinets Safes & Strong Room Doors <a href="calc.php?class=Cabinets Safes %26 Strong Room Doors&title=Fire Protection"></a>

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<?
    session_start();
    if(!session_is_registered("num_item"))
    {
        session_register("num_item");
        $num_item = 0;
    }
    if(!session_is_registered("item"))
    {
        session_register("item");
        $item = array();
    }
?>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.0 Transitional//EN">
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<TITLE>Bill of Embodied Energy (BEE)</TITLE>
<META NAME="Generator" CONTENT="EditPlus">
<META NAME="Author" CONTENT="">
<META NAME="Keywords" CONTENT="">
<META NAME="Description" CONTENT="">
<style type="text/css">
<!--

p, li {font-family:verdana; color:black}
span {border:groove 2px; padding:3; font-family:arial; font-size:12; width:120; height:30;
    background-color:#a0a1a2; text-align:center; margin-left:5px}
span a {text-decoration:none; color:black}
span a:visited {color:black}
span a:hover {color:blue}
fieldset {display:none}
b {font-size:8pt}

-->
</style>
<script type="text/javascript">
// End hiding script from old browsers -->
function change(i){
    tempCol=document.all.tags("span");
    tempColl=document.all.tags("fieldset");
    tempColl(3).style.display="none";
    for(var j=0; j<3; j++){
        tempColl(j).style.display="none";
        tempCol(j).style.backgroundColor="#a0a1a2";
    }
    tempCol(i).style.backgroundColor="#efefef";
    tempColl(i).style.display="block";
}

```

```

function clear(){
    tempol=document.all.tags("span");
    for(var j=0; j<3; j++)
        tempol(j).style.backgroundColor='#a0a1a2';
}
</script>

</HEAD>

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 <b>Project Name: <? echo substr($filename, 7);?></b>
<p>There are three groups of building elements that you can choose from, put your cursor on to view the
list before you proceed:
</ol>
<p>Notes: Please multiplying factor of 1.5 in the medium density sector and factor of 1.7 in the high density sector by manually. It is
because the on-site vertical transportation of labour and material over twelve levels in construction requires more energy intensity than on
ground or for a four level construction. This multiplication factor is only applied to structures.
<br><br>
<center>
<span onMouseOver="change(0)" onMouseOut="clear()">Structures</span>
<span onMouseOver="change(1)" onMouseOut="clear()">Finishes</span>
<span onMouseOver="change(2)" onMouseOut="clear()">Services</span>
</center>
<fieldset>
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<table height=250 cellpadding=10><tr><td valign=top align=left>
<ul>
<li>Piering & Piling
<ul>
<li>Cast In-Situ Piling <a href="calc.php?class=Cast In-Situ Piling&struc=2&title=Piering %26 Piling"></a>
<li>Prefabricated Driven Piling <a href="calc.php?class=Prefabricated Driven Piling&struc=2&title=Piering %26 Piling"></a>
<li>Sheet Piling <a href="calc.php?class=Sheet Piling&struc=2&title=Piering %26 Piling"></a>
</ul>
<li>Concrete In-Situ
<ul>
<li>Structural Concrete <a href="calc.php?class=Structural Concrete&struc=2&title=Concrete In-Situ"></a>
<li>Slab Bases <a href="calc.php?class=Slab Bases&struc=2&title=Concrete In-Situ"></a>
<li>Membranes <a href="calc.php?class=Membranes&struc=2&title=Concrete In-Situ"></a>
</ul>
<li>Concrete Composite
<ul>
<li>Footings <a href="calc.php?class=_Footings&struc=2&title=Concrete Composite"></a>
<li>Slabs <a href="calc.php?class=_Slabs&struc=2&title=Concrete Composite"></a>
<li>Beams <a href="calc.php?class=Beams&struc=2&title=Concrete Composite"></a>
<li>Walls <a href="calc.php?class=Walls&struc=2&title=Concrete Composite"></a>
<li>Columns <a href="calc.php?class=Columns&struc=2&title=Concrete Composite"></a>
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<li>Concrete Precast
<ul>
<li>Precast Concrete (Composite Floor System) <a href="calc.php?class=Precast Concrete (Composite Floor
System)&struc=2&title=Concrete Precast"></a>
<li>Tilt Up Concrete Wall Panels <a href="calc.php?class=Tilt Up Concrete Wall Panels&struc=2&title=Concrete Precast"></a>
</ul>
<li>Mansory - Brickwork
<ul>
<li>Brickwork <a href="calc.php?class=_Brickwork&struc=2&title=Mansory - Brickwork"></a>
<li>Lintels <a href="calc.php?class=Lintels&struc=2&title=Mansory - Brickwork"></a>
<li>Damp Proof Courses <a href="calc.php?class=Damp Proof Courses&struc=2&title=Mansory - Brickwork"></a>
</ul>
<li>Structural Steel
<ul>
<li>Columns (Steel) <a href="calc.php?class=Columns (Steel)&struc=2&title=Structural Steel"></a>
<li>Beams (Steel) <a href="calc.php?class=Beams (Steel)&struc=2&title=Structural Steel"></a>
<li>Portal Frames <a href="calc.php?class=Portal Frames&struc=2&title=Structural Steel"></a>
<li>Trusses (Steel) <a href="calc.php?class=Trusses (Steel)&struc=2&title=Structural Steel"></a>
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<ul>
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<li>Upper Floor Framing <a href="calc.php?class=Upper Floor Framing&struc=2&title=Carpentry"></a>

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<li>Wall Framing <a href="calc.php?class=Wall Framing&struc=2&title=Carpentry"></a>
<li>Conventional Roof Framing <a href="calc.php?class=Conventional Roof Framing&struc=2&title=Carpentry"></a>
<li>Roof Trusses <a href="calc.php?class=Roof Trusses&struc=2&title=Carpentry"></a>
<li>Posts <a href="calc.php?class=Posts&struc=2&title=Carpentry"></a>
<li>Timber Beams <a href="calc.php?class=Timber Beams&struc=2&title=Carpentry"></a>
</ul>
<li>Partitions
<ul>
<li>Fixed Partitions <a href="calc.php?class=Fixed Partitions&struc=2&title=Partitions"></a>
<li>Toilet Partitions <a href="calc.php?class=Toilet Partitions&struc=2&title=Partitions"></a>
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<li>Roofing
<ul>
<li>Membrane Roofing <a href="calc.php?class=Membrane Roofing&struc=2&title=Roofing"></a>
<li>Sheet Roofing <a href="calc.php?class=Sheet Roofing&struc=2&title=Roofing"></a>
<li>Tile Roofing <a href="calc.php?class=Tile Roofing&struc=2&title=Roofing"></a>
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<fieldset>
<legend>&nbsp;Finishes </legend>
<table height=250 cellpadding=10><tr><td valign=top>
<ul>
<li>Metalwork
<ul>
<li>Metal Furniture <a href="calc.php?class=Metal Furniture&struc=2&title=Metalwork"></a>
</ul>
<li>Carpentry
<ul>
<li>Ceiling Framing <a href="calc.php?class=Ceiling Framing&struc=2&title=Carpentry"></a>
<li>Battens <a href="calc.php?class=Battens&struc=2&title=Carpentry"></a>
<li>Flooring <a href="calc.php?class=Flooring&struc=2&title=Carpentry"></a>
<li>Wall Linings <a href="calc.php?class=Wall Linings&struc=2&title=Carpentry"></a>
</ul>
<li>Insulation
<ul>
<li>Aluminium Insulation <a href="calc.php?class=Aluminium Insulation&struc=2&title=Insulation"></a>
<li>Fibreglass Insulation <a href="calc.php?class=Fibreglass Insulation&struc=2&title=Insulation"></a>
</ul>
<li>Joinery
<ul>
<li>Architrave & Skirting <a href="calc.php?class=Architrave %26 Skirting&struc=2&title=Joinery"></a>
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<li>Internal Staircase <a href="calc.php?class=Internal Staircase&struc=2&title=Joinery"></a>
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<li>Kitchen Cupboards <a href="calc.php?class=Kitchen Cupboards&struc=2&title=Joinery"></a>
<li>Vanity Units <a href="calc.php?class=Vanity Units&struc=2&title=Joinery"></a>
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<li>Glazing
<ul>
<li>Float Glass <a href="calc.php?class=Float Glass&struc=2&title=Glazing"></a>
<li>Toughened Glass <a href="calc.php?class=Toughened Glass&struc=2&title=Glazing"></a>
<li>Shower Screens <a href="calc.php?class=Shower Screens&struc=2&title=Glazing"></a>
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<li>Roofing
<ul>
<li>Skylights <a href="calc.php?class=Skylights&struc=2&title=Roofing"></a>
</ul>
<li>Windows
<ul>
<li>Aluminium Windows <a href="calc.php?class=Aluminium Windows&struc=2&title=Windows"></a>
<li>Meranti Timber Windows <a href="calc.php?class=Meranti Timber Windows&struc=2&title=Windows"></a>
<li>Steel Windows <a href="calc.php?class=Steel Windows&struc=2&title=Windows"></a>
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<li>Doors
<ul>
<li>External <a href="calc.php?class=External&struc=2&title=Doors"></a>
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<li>Fire Doors <a href="calc.php?class=Fire Doors&struc=2&title=Doors"></a>
<li>Louver Doors & Shutters <a href="calc.php?class=Louver Doors %26 Shutters&struc=2&title=Doors"></a>
<li>Security Doors <a href="calc.php?class=Security Doors&struc=2&title=Doors"></a>
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<ul>
<li>Plasterboard <a href="calc.php?class=Plasterboard&struc=2&title=Plastering"></a>
</ul>
<li>Tiling
<ul>
<li>Wall Tiling <a href="calc.php?class=Wall Tiling&struc=2&title=Tiling"></a>
<li>Floor Tiling <a href="calc.php?class=Floor Tiling&struc=2&title=Tiling"></a>
</ul>
<li>Floorcoverings
<ul>
<li>Floorcoverings <a href="calc.php?class=Floorcoverings&struc=2&title=Floorcoverings"></a>
</ul>
<li>Painting
<ul>
<li>Woodwork Painting (Internal) <a href="calc.php?class=Woodwork Painting (Internal)&struc=2&title=Painting"></a>
<li>Brickwork & Blockwork & Concrete & Render Painting (Internal) <a href="calc.php?class=Brickwork %26 Blockwork %26 Concrete
%26 Render Painting (Internal)&struc=2&title=Painting"></a>
<li>Fibre Cement & Plaster & Plasterboard Painting (Internal) <a href="calc.php?class=Fibre Cement %26 Plaster %26 Plasterboard
Painting (Internal)&struc=2&title=Painting"></a>
<li>Woodwork Painting (External) <a href="calc.php?class=Woodwork Painting (External)&struc=2&title=Painting"></a>
<li>Brickwork & Blockwork & Concrete & Render Painting (External) <a href="calc.php?class=Brickwork %26 Blockwork %26
Concrete %26 Render Painting (External)&struc=2&title=Painting"></a>
<li>Fibre Cement & Plaster & Plasterboard Painting (External) <a href="calc.php?class=Fibre Cement %26 Plaster %26 Plasterboard
Painting (External)&struc=2&title=Painting"></a>
<li>Metalwork Painting (External) <a href="calc.php?class=Metalwork Painting (External)&struc=2&title=Painting"></a>
</ul>
<li>Plumbing
<ul>
<li>Fixture Traps <a href="calc.php?class=Fixture Traps&struc=2&title=Plumbing"></a>
<li>Floor Traps <a href="calc.php?class=Floor Traps&struc=2&title=Plumbing"></a>
<li>Floor Waste <a href="calc.php?class=Floor Waste&struc=2&title=Plumbing"></a>
<li>Waste Outlet <a href="calc.php?class=Waste Outlet&struc=2&title=Plumbing"></a>
<li>Flap Valves <a href="calc.php?class=Flap Valves&struc=2&title=Plumbing"></a>
<li>Vent Cowl <a href="calc.php?class=Vent Cowl&struc=2&title=Plumbing"></a>
<li>Valves <a href="calc.php?class=Valves&struc=2&title=Plumbing"></a>
<li>Taps Spouts & Roses <a href="calc.php?class=Taps Spouts %26 Roses&struc=2&title=Plumbing"></a>
<li>Water Tanks <a href="calc.php?class=Water Tanks&struc=2&title=Plumbing"></a>
<li>Baths <a href="calc.php?class=Baths&struc=2&title=Plumbing"></a>
<li>Spa Baths <a href="calc.php?class=Spa Baths&struc=2&title=Plumbing"></a>
<li>Shower Cabinets <a href="calc.php?class=Shower Cabinets&struc=2&title=Plumbing"></a>
<li>Basins <a href="calc.php?class=Basins&struc=2&title=Plumbing"></a>
<li>Sinks <a href="calc.php?class=Sinks&struc=2&title=Plumbing"></a>
<li>Laundry Tub <a href="calc.php?class=Laundry Tub&struc=2&title=Plumbing"></a>
<li>Toilet Suites <a href="calc.php?class=Toilet Suites&struc=2&title=Plumbing"></a>
<li>Shower Bases <a href="calc.php?class=Shower Bases&struc=2&title=Plumbing"></a>
<li>Hot Water Units <a href="calc.php?class=Hot Water Units&struc=2&title=Plumbing"></a>
</ul>
<li>Blinds & Curtains
<ul>
<li>Awnings <a href="calc.php?class=Awnings&struc=2&title=Blinds %26 Curtains"></a>
<li>Blinds <a href="calc.php?class=Blinds&struc=2&title=Blinds %26 Curtains"></a>
<li>Curtains <a href="calc.php?class=Curtains&struc=2&title=Blinds %26 Curtains"></a>
</ul>
<li>Sundry Appliances
<ul>
<li>Domestic Appliances <a href="calc.php?class=Domestic Appliances&struc=2&title=Sundry Appliances"></a>
</ul>
</td></tr>

```



```

</table>
</fieldset>

<fieldset>
<legend>&nbsp;Services </legend>
<table height=250 cellpadding=10><tr><td valign=top>
<ul>
<li>Plumbing
<ul>
<li>Water Supply Pipework <a href="calc.php?class=Water Supply Pipework&struc=2&title=Plumbing"></a>
<li>Gas Supply Pipework <a href="calc.php?class=Gas Supply Pipework&struc=2&title=Plumbing"></a>
<li>Sanitary Pipework <a href="calc.php?class=Sanitary Pipework&struc=2&title=Plumbing"></a>
</ul>
<li>Drainage
<ul>
<li>Sewer Drains <a href="calc.php?class=Sewer Drains&struc=2&title=Drainage"></a>
<li>Stormwater Drains <a href="calc.php?class=Stormwater Drains&struc=2&title=Drainage"></a>
<li>Surface Drains <a href="calc.php?class=Surface Drains&struc=2&title=Drainage"></a>
<li>Mainholes, Sumps & Pits <a href="calc.php?class=Mainholes, Sumps %26 Pits&struc=2&title=Drainage"></a>
<li>Sewer Pumping Station <a href="calc.php?class=Sewer Pumping Station&struc=2&title=Drainage"></a>
<li>Grease Traps <a href="calc.php?class=Grease Traps&struc=2&title=Drainage"></a>
<li>Stormwater Pits <a href="calc.php?class=Stormwater Pits&struc=2&title=Drainage"></a>
<li>Pipe Connections <a href="calc.php?class=Pipe Connections&struc=2&title=Drainage"></a>
<li>Pipe Encasement <a href="calc.php?class=Pipe Encasement&struc=2&title=Drainage"></a>
</ul>
</ul>
</td><td valign=top>
<ul>
<li>Roof Plumbing
<ul>
<li>Gutters <a href="calc.php?class=Gutters&struc=2&title=Roof Plumbing"></a>
<li>Valley Gutters <a href="calc.php?class=Valley Gutters&struc=2&title=Roof Plumbing"></a>
<li>Sumps <a href="calc.php?class=Sumps&struc=2&title=Roof Plumbing"></a>
<li>Rain Heads <a href="calc.php?class=Rain Heads&struc=2&title=Roof Plumbing"></a>
<li>Downpipes <a href="calc.php?class=Downpipes&struc=2&title=Roof Plumbing"></a>
<li>Flashings <a href="calc.php?class=Flashings&struc=2&title=Roof Plumbing"></a>
</ul>
<li>Electrical Services
<ul>
<li>Mains Connection <a href="calc.php?class=Mains Connection&struc=2&title=Electrical Services"></a>
</ul>
<li>Mechanical - Air Conditioning
<ul>
<li>Cooling Equipment <a href="calc.php?class=Cooling Equipment&struc=2&title=Mechanical - Air Conditioning"></a>
<li>Heating Equipment <a href="calc.php?class=Heating Equipment&struc=2&title=Mechanical - Air Conditioning"></a>
</ul>
<li>Mechanical - Lifts & Escalators
<ul>
<li>Passenger Lifts <a href="calc.php?class=Passenger Lifts&struc=2&title=Mechanical - Lifts %26 Escalators"></a>
</ul>
<li>Fire Protection
<ul>
<li>Fire Detection <a href="calc.php?class=Fire Detection&struc=2&title=Fire Protection"></a>
<li>Active Fire Protection <a href="calc.php?class=Active Fire Protection&struc=2&title=Fire Protection"></a>
<li>Cabinets Safes & Strong Room Doors <a href="calc.php?class=Cabinets Safes %26 Strong Room Doors&struc=2&title=Fire
Protection"></a>
</ul>
</ul>
</td></tr>
</table>
</fieldset>

<fieldset style="display:block">
<legend>&nbsp;Current View </legend>
<p>&nbsp;
<p>&nbsp;
<p>&nbsp;
<center>Browse by pointing your cursor on above.</center>
<p>&nbsp;

```

```
<?
    session_start();
    if(!session_is_registered("num_item"))
    {
        session_register("num_item");
        $num_item = 0;
    }
    if($num_item<=0) $num_item = 0;
    if(!session_is_registered("total_cost"))
    {
        session_register("total_cost");
        $total_cost = 0;
    }
    if(!session_is_registered("total_energy"))
    {
        session_register("total_energy");
        $total_energy = 0;
    }
    if(!session_is_registered("filename"))
    {
        session_register("filename");
        $filename = $file;
    }
    if(!isset($struc))
        $struc = 1;

?>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.0 Transitional//EN">
<HTML>
<HEAD>
<TITLE>Bill of Embodied Energy (BEE)</TITLE>
<META NAME="Generator" CONTENT="EditPlus">
<META NAME="Author" CONTENT="">
<META NAME="Keywords" CONTENT="">
<META NAME="Description" CONTENT="">
<style type="text/css">
<!--

p, li, td {font-family:verdana; color:black; font-size:8pt}
b {font-size:8pt}

-->
</style>
<script type="text/javascript">
function goback(i)
{
    location="http://bee.ins-studio.com/start"+i+".php?struc=<?echo $struc;?>";
}
</script>
</HEAD>

<BODY style="font-family:verdana; font-size:8pt">
<table align=center width=600 height=600 border=1 cellspacing=0 cellpadding=15><tr><td valign=top colspan=2 height=310>
 <b>Project Name: <? echo substr($filename, 7);?></b>
<p><b>Current Element/Item:</b><b style="color:darkred"> <? echo $class;?></b>

<form action="calc.php" method="get"><b>Component: &nbsp;</b>
<select name="sub" onchange="proceedsub()">
    <option>-Select Component-
```

```

<?

$file_name = $class."_txt";
if(!file_exists($file_name))
    $file_name = $class.".txt";
if(file_exists($file_name))
{
    $read = file($file_name); //read the tree structure
    for($i=0; $i<count($read); $i++)
    {
        $check = str_replace("&", "%26", $read[$i]);
        echo "<option value=\"\" $check.\"\"";
        if(trim($sub)==trim($check) || trim($sub)==trim($read[$i]))
            echo " selected";
        echo ">". $read[$i];
    }
    echo "</select>";
    $class = str_replace("&", "%26", $class);
?>
<script type="text/javascript">
function proceedsub()
{
    var go1 = document.forms[0].sub.value
    location="http://bee.ins-studio.com/calc.php?struc=<?echo $struc;?>&file=<? echo $filename;?>&title=<?echo $title;?>&class=<?echo $class;?>&sub=" + go1
}

function proceed_sel()
{
    var go1 = document.forms[0].sub.value
    var go2 = document.forms[0].material.value
    location="http://bee.ins-studio.com/calc.php?struc=<?echo $struc;?>&file=<? echo $filename;?>&title=<?echo $title;?>&class=<?echo $class;?>&sub=" + go1 + "&sel_id=" + go2
}
</script>
<?
    if(isset($sub))
    {
        if($struc==1){
            $check = str_replace("/", "_", $sub); //avoid "/" in the file name
            $footing_file = $check.".txt";
        }
        else {
            $footing_file = "_" . $sub . ".txt";
            if(!file_exists($footing_file))
                $footing_file = $sub.".txt";
        }

        if(file_exists($footing_file)){
            $row = file($footing_file);
            echo "<p><b>Material/Dimension/Methods of Construction: </b>";
            echo "<select id=\"material\" name=\"materials\" onchange=proceed_sel()>\n";
            echo "<option value=\"\">Select Component-\n";
            for($i=0; $i<count($row); $i++)
            {
                $item[$i] = explode("|", $row[$i]);
                //if($i==0) $starting_unit = $item[[1];
                if(trim($sel_id)==trim($i))
                    echo "<option value=\"$i\" selected>". $item[$i][0]."\n";
                else echo "<option value=\"$i\">". $item[$i][0]."\n";
                echo "<option value=\"\". $item[2].\"|. $item[3].\"|. $item[0].\"|. $item[1].\">". $item[0];
            }
            echo "</select><br><br>";
            if(isset($sel_id)){
?>
<script language="javascript">
function print_total()
{
    var detail = <? echo "\"\". $item[$sel_id][0].\"\"\">
    var price = <? echo $item[$sel_id][2].\"\"\">
    var energy = <? echo $item[$sel_id][3].\"\"\">
    var q = document.forms[0].qty.value
    total = Math.round(price*q*100)/100
    total_energy = Math.round(energy*q*10000)/10000
    document.getElementById('price').innerHTML= total
    document.getElementById('energy').innerHTML= total_energy

```

```

}

function save()
{
    var detail = <? echo "\"" . $item[$sel_id][0] . "\"\n";?>
    var price = <? echo $item[$sel_id][2] . "\n";?>
    var energy = <? echo $item[$sel_id][3] . "\n";?>
    var q = document.forms[0].qty.value
    total = Math.round(price*q*100)/100
    total_energy = Math.round(energy*q*10000)/10000
    var go1 = document.forms[0].sub.value
    var go3 = document.forms[0].qty.value
    var unit = document.forms[0].units.value
    location="http://bee.ins-studio.com/report.php?action=add&title=<?echo $title;?>&sub=" + go1 + "&detail=" + detail + "&unit="
+ unit + "&qty=" + q + "&cost=" + total + "&energy=" + total_energy + "&struc=<?echo $struc;?>"
}

</script>

<?
    }
    }
    else
    echo "<p><big>Under Construction</big><br><br>";
    echo "<b>QTY:</b> <input type=text name=qty onkeyup=print_total() value=0 size=3> <span
id=units>". $item[$sel_id][1]. "</span><br>";
    }
    else
    {
        echo "<p><b>Material/Dimension/Methods of Construction: </b>\n<select>\n";
        echo "<option>-Select Material/Dimension/Methods-";
        echo "</select><br><br>";
    }
    }
    else
        echo "</select><p><big>Under Construction</big><br>\n";
?>
<br><span id=description><? echo $item[$sel_id][4];?></span>
</td></tr>
<tr><td align=right height=30>
    <b>Cost: </b></td><td width=100 bgcolor=#bbbbbb><b>$ <span id=price>0.00</span></b></td></tr>
<tr><td align=right height=30>
    <b>Embodied Energy: </b></td><td width=100 bgcolor=#bbbbbb><b><span id=energy>0.0000</span> GJ</b></td></tr>
<tr><td align=center colspan=2>
    <input type="button" value=" SAVE " onclick=save()> <input type="button" value=" BACK " onclick=goback(<? echo $struc;?>)>
    <input type=hidden name=class value=<?echo $class;?>>
    <input type=hidden name=struc value=<?echo $struc;?>>
    <input type=hidden name=units value=<?echo $item[$sel_id][1];?>>
</form>
<p></p>
<fieldset style="background-color: cfcfcf">
<legend> <b>Selection Summary</b> </legend>
<blockquote>
Total of Component: <? echo $num_item;?>&nbsp;&nbsp;&nbsp;<br>
Total Cost: $ <? echo $total_cost;?>&nbsp;&nbsp;&nbsp;<br>
Total Embodied Energy: <? echo $total_energy;?> GJ
<center><a href="report.php?struc=<? echo $struc;?>">View Full Report</a></center>
</blockquote>
</fieldset>
</td></tr>
</table>
</BODY>
</HTML>

```

Appendix B.6 Report Coding

```

<?
    session_start();
    if(!session_is_registered("num_item"))
    {
        session_register("num_item");
        $num_item = 0;
    }
    if(!session_is_registered("total_cost"))
    {
        session_register("total_cost");
        $total_cost = 0;
    }
    if(!session_is_registered("total_energy"))
    {
        session_register("total_energy");
        $total_energy = 0;
    }
?>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.0 Transitional//EN">
<HTML>
<HEAD>
<TITLE>Bill of Embodied Energy (BEE)</TITLE>
<META NAME="Generator" CONTENT="EditPlus">
<META NAME="Author" CONTENT="">
<META NAME="Keywords" CONTENT="">
<META NAME="Description" CONTENT="">
<style type="text/css">
<!--

p, li {font-family:verdana; color:black}
span {border:groove 2px; padding:3; font-family:arial; font-size:12; width:120; height:30;
    background-color:#a0a1a2; text-align:center; margin-left:5px}
span a {text-decoration:none; color:black}
span a:visited {color:black}
span a:hover {color:blue}
fieldset {display:none}
td, th {font-family:verdana; font-size:8pt}
b {font-family:8pt}

-->
</style>
<script type="text/javascript">
function deleteAll()
{
    location="http://bee.ins-studio.com/report.php?action=empty";
}
function goback(i)
{
    location="http://bee.ins-studio.com/start"+i+".php";
}
</script>

</HEAD>

<BODY style="font-family:verdana">
<table align=center width=600 height=600 border=1 cellpadding=15><tr><td valign=top align=center>
 <b>Project Name: <? echo substr($filename, 7);?></b>
<br><br>
<table cellpadding=4 border=1 width=590>
<tr><th>No</th><th>Component</th><th>Material/Dimension/Methods of Construction</th><th>Unit</th><th>Qty</th><th>Cost
($)</th><th>Embodied Energy (GJ)</th><th>Remove</th></tr>
<?
    if($action=="empty"){
        $num_item=0;
        $total_cost=0;
        $total_energy=0;
        $fp = fopen($filename, "w");
        fwrite($fp, "");
        fclose($fp);
    }
    elseif($action=="delete")
    {

```

```

$record = file($filename);
$num_item--;
$fp = fopen($filename, "w"); //clear the content of the file first
fwrite($fp, "");
fclose($fp);
//now write in to it
$fp = fopen($filename, "a");
for($i=0; $i<count($record); $i++){
    if($i!=$id)
        fwrite($fp, $record[$i]);
}
fclose($fp);
}
elseif($action=="add")
{
    if(!file_exists($filename)){
        touch($filename);
        chmod($filename, 0777);
    }
    $fp = fopen($filename, "a+");
    $new_record = "Title:$sub:$detail:$unit:$qty:$cost:$energy\n";
    fwrite($fp, $new_record);
    fclose($fp);
    $message = "The component has been added to your report.";
    $num_item++;
    $total_energy += $energy;
    $total_cost += $cost;
}
if(file_exists($filename)){
    $record = file($filename);
    if(count($record)>=0)
    {
        $tot_cost = 0;
        $tot_energy = 0;
        for($i=0; $i<count($record); $i++)
        {
            $item[$i] = explode(":", $record[$i]);
            if(isset($item[$i][1])){
                $num = $i+1;
                echo
                "<tr><td>$num</td><td>". $item[$i][0]. "</td><td>". $item[$i][1]. "</td><td>". $item[$i][2]. "</td><td>".
                $item[$i][3]. "</td><td>". $item[$i][4]. "</td><td>". $item[$i][5]. "</td><td>". $item[$i][6]. "</td>";
                echo "<td><a href='\"report.php?action=delete&id=$i\"'>Remove</a></td></tr>\n";
                $tot_cost += $item[$i][5];
                $tot_energy += $item[$i][6];
            }
        }
    }
    else
        echo "<tr><td colspan=8 align=center>Currently Empty</td></tr>";
}
else
    echo "<tr><td colspan=8 align=center>Currently Empty</td></tr>";

if(!$struc) $struc = 1;
?>
<tr><th colspan=7 align=right bgcolor=#bfbfbf>TOTAL COST</th><th><u>$ <? echo $tot_cost;?></u></th></tr>
<tr><th colspan=7 align=right bgcolor=#bfbfbf>TOTAL EMBODIED ENERGY</th><th><u><? echo $tot_energy;?> GJ</u></th></tr>
</table>
<p><? echo $message;?></p>

<form action="report.php" method="get">
<input type=hidden name=struc value=<? echo $struc;?>>

<input type=button value=" Go Back " onclick=goback(<? echo $struc;?>)> &nbsp; <input type=button value=" Clear All "
onclick=deleteAll()>
</form>
</td></tr>
</table>
</BODY>
</HTML>

```

APPENDIX C

PRODUCT QUANTITIES FOR DEMONSTRATION DWELLING

APPENDIX C

PRODUCT QUANTITIES FOR DEMONSTRATION DWELLING

The purpose of this appendix is to present the quantities of the typical domestic building reported by Treloar (1998) is situated in Essendon, Victoria, Australia studied in Section 4.2.1. The dwelling is one of six in a block - a semi-detached, two-storey, two-bedroom brick-veneer unit. The total floor area of the control building is 123m², including the single-car garage. Assumptions are taken for the detail of the materials quantities. Cost and embodied energy per unit are given in Appendix A, Table A.3.

Table C.1 Product Quantities for Demonstration Dwelling

Components	Material/Dimension/Methods of Construction	Unit	Qty	Cost (\$)	Embodied Energy (GJ)
Pad Footings - Square pad	500 x 500 x 200mm depth (overall depth 400mm)	no	224	3,053.12	1.971
Sand	50mm thick	m2	78	237.12	1.014
Membranes	200um	m2	132	356.40	0.383
Stiffened Raft Slabs	500mm deep x 300mm wide @ 4.5 meter spacing; 5 x Y12 bars and F72 mesh	m2	132	12,298.44	39.257
Clay Brickwork	Walls - 110mm thick	m2	254	18,229.58	276.428
Galvanised Steel Lintels	Galvanised steel flat bar; 85 x 8mm ribbed	m	13	240.24	3.380
Aluminium Core Bitumen Coated (0.45mm)	110mm wide	m	200	334.00	5.040
Upper Floor Framing - Hardwood F8	200 x 50mm @ 450mm centres	m2	47	1,292.97	5.283
Hardwood F8 - sawn	200 x 50mm	m	71	1,953.21	7.980
Wall Framing - Hardwood F8	75 x 38mm @ 450mm centres	m	254	6,987.54	28.550
Heads or Lintels - Hardwood F8	150 x 50mm	m	50	2,279.50	8.085
Pitched Roof Framing - Hardwood F8	100 x 38mm rafters @ 450mm centres	m2	62	1,953.62	3.249
Roof Truss	3600mm span @ 450mm centres	m2	40	2,347.60	9.764
Aluminium Sheet Roofing	Square ribbed (10 ribs per sheet); 0.7mm thick	m2	62	1,646.72	36.704
Ceiling Framing - Hardwood F8	100 x 38mm ceiling joist @ 450mm centres	m2	87	1,931.40	3.715
Hardwood F8 Battens	38 x 25mm with 450mm span @ 450mm centres	m2	87	280.14	0.931
Particleboard Flooring	19mm thick	m2	47	855.40	3.967
10mm Standard Plasterboard	Wall; fixed to timber (glued and nailed)	m2	849	12,471.81	73.863
Ceiling & Roof Insulation	R2.5 (125 - 145mm thick)	m2	43	390.87	6.923
Wall Insulation	R2.5 (125 - 145mm thick)	m2	182	1,858.22	29.302
Light Weight (290 g per m2)	Plain	m2	225	382.50	51.525
Architrave & Skirting - Pine	42 x 19mm bullnose/splay	m	255	1,450.95	5.610

Components	Material/Dimension/Methods of Construction	Unit	Qty	Cost (\$)	Embodied Energy (GJ)
Wall Framing - Hardwood F8	75 x 38mm @ 450mm centres	m	254	11,579.86	41.072
Staircase	Closed tread design (per metre rise)	m	2.4	1,084.80	7.581
Balustrade	Meranti/ Pacific maple	m	4	194.28	0.024
Cupboards	2400mm high x 900mm wide x 600mm deep	no	2	846.22	2.139
Benchtops - Square Edge	16mm thick and 450mm wide	m	1	114.57	0.057
Modular Floor Design Cupboards	Standard cabinets with one shelf 450mm deep	m	3	1,291.77	2.045
Modular Floor Design Cupboards	Four drawer cabinet; 450mm wide x 450mm deep	no	1	459.93	0.628
Modular Wall Design Cupboards	700mm high	m	2	800.08	0.969
Modular Pantry Design Cupboards	2100mm high x 450mm wide x 450mm deep	no	1	481.63	0.812
Wardrobes	2400mm high x 900mm wide x 600mm deep	no	2	1,672.62	3.094
Framed Shower Screens	Pivot door and full return panel	no	1	473.00	17.735
Vanity Units	750mm high x 750mm wide x 350mm deep; single basin	no	1	230.90	0.446
Square Shape	500 x 500mm	no	1	261.65	1.181
Sliding Windows	2000 x 2400mm wide	no	2	2,113.02	18.125
Sliding Windows	2000 x 1800mm wide	no	1	997.81	6.805
Sliding Windows	600 x 2400mm wide	no	1	558.78	2.758
Sliding Windows	600 x 1200mm wide	no	1	194.87	1.384
Timber (Feature) Doors	4 panel design	no	1	207.20	0.339
Timber (Flush) Doors	Solid construction	no	1	106.75	1.616
Timber (Flush) Doors	Hollow core construction	no	6	172.20	1.762
Ceramic Wall Tiling	25 x 25mm	m2	8	707.28	10.400
Ceramic Floor Tiling	25 x 25mm	m2	5	374.75	6.500
Acrylic (Flat or Semi Gloss or Gloss)	Wall	m2	1016	12,273.28	5.080
Acrylic (Flat or Semi Gloss or Gloss)	Ceilings	m2	87	1,144.05	0.435
Carpet	Polypropylene	m2	62	2,184.88	22.568
Vinyl Sheet	1.5mm thick	m2	21	446.25	1.884
Colour Coated Brass Taps	Basin set	no	5	868.60	0.351
Galvanised Steel Water Tanks	2250 litre	no	1	527.25	17.643
Kitchen Sinks	Drop in' type; 900mm single bowl	no	1	312.50	0.244

Components	Material/Dimension/Methods of Construction	Unit	Qty	Cost (\$)	Embodied Energy (GJ)
Laundry Tub	45/46 litre single compartment	no	1	286.20	0.576
Toilet Suites	Close coupled S or P trap; white	no	1	653.50	5.508
Acrylic Shower Bases	910 x 910 x 115mm; white	no	1	302.34	1.247
Electric Hot Water Unit	125 litre	no	1	672.23	1.272
Ranges & Stoves	Electric standard oven (540mm wide) with mechanical timer	no	1	782.00	1.356
Microwave Oven	Microwave oven	no	1	216.35	0.471
Dishwashers	Standard	no	1	863.50	1.595
Range Hood	Standard type 600mm wide	no	1	208.00	0.340
Letter Box	Galvanised steel	no	1	66.99	1.071
Switchboards	Houses	no	1	473.00	1.123
Conduits	Light duty 32mm diameter	m	100	1,030.00	1.370
Light Fittings	Batten fitting; 20 watt single	no	15	633.00	3.723
Electric Heating	Portable electric heaters; 800w/1600w (radiant type)	no	1	127.00	0.236
Aluminium Gutter	190 x 140mm fascia gutter	m	25	643.25	0.708
Aluminium Downpipe	100 x 50mm rectangular downpipe	m	20	405.00	0.422
Copper Pipework	32mm (31.75mm actual) diameter x 1.22mm pipe	m	100	2,312.00	10.500
TOTAL COST				<u>\$125,186.49</u>	
TOTAL EMBODIED ENERGY				<u>810.113 GJ</u>	

APPENDIX D

PRODUCT QUANTITIES FOR DOMESTIC BUILDING CASE STUDIES

APPENDIX D

PRODUCT QUANTITIES FOR DOMESTIC BUILDING CASE STUDIES

The purpose of this appendix is to present the quantities of domestic building case studies discussed in Section 5.1. The three cases presented here represent single dwelling, medium density (15 to 35 units per block) and high density (40 to 80 units per block). Three domestic buildings are existing real buildings in Victoria and the specific detail information is regarded as commercially sensitive and confidential. Assumptions are taken for the detail of the materials quantities. Cost and embodied energy per unit are given in Appendix A, Table A.3.

Table D.1 Product Quantities for Single Dwelling

Components	Material/Dimension/Methods of Construction	Unit	Qty	Cost (\$)	Embodied Energy(GJ)
Sand	50mm thick	m ²	180	547.2	2.34
Membranes	200um	m ²	180	486	0.522
Stiffened Raft Slabs	300mm deep x 300mm wide @ 7.0 meter spacing; F11TM3 and F72 mesh	m ²	180	13114.8	41.472
Clay Brickwork	Walls - 110mm thick	m ²	344	24668.78	374.07
Galvanised Steel Lintels	Galvanised steel flat bar; 75 x 10mm	m	39	707.2	11.153
Aluminium Core Bitumen Coated (0.45mm)	110mm wide	m	72	119.44	1.802
Upper Floor Framing - Hardwood F8	200 x 50mm @ 450mm centres	m ²	180	4951.8	20.232
Particleboard Flooring	22mm thick	m ²	180	3952.8	17.586
Wall Framing - F5 Pine	100 x 50mm @ 450mm centres	m	185	13187.81	46.718
Particleboard Wall Linings	18mm thick	m ²	618	17686.47	49.359
Pitched Roof Framing - F5 Pine	90 x 35mm rafters @ 600mm centres	m ²	223	5618.76	7.82
Roof Truss	12000mm span @ 600mm centres	m ²	223	7592.68	40.793
Concrete Tile Roofing	Square edge pattern	m ²	223	8020.44	53.47
Ceiling Framing - F5 Pine	90 x 35mm ceiling joist @ 600mm centres	m ²	336	2544	8.938
Ceiling & Roof Insulation	R2.5 (125 - 145mm thick)	m ²	336	3054.24	54.096
Wall Insulation	R1.5 (75 - 80mm thick)	m ²	113	876.41	18.183
Architrave & Skirting - Pine	42 x 19mm bullnose/splay	m	250	1422.5	5.5
Architrave & Skirting - Pine	70 x 19mm colonial	m	185	1279.52	6.796
Staircase	Closed tread design (per metre rise)	m	2	1084.8	7.581
Staircase	Landing	m ²	2	204	9.688
Handrail	Meranti/ Pacific maple	m	2	72.86	0.009
Modular Floor Design Cupboards	Standard cabinets with one shelf 600mm deep	m	6	2700.72	4.834
Modular Floor Design Cupboards	Four drawer cabinet; 450mm wide x 600mm deep	no	1	199.27	0.899
Modular Wall Design Cupboards	700mm high	m	4	1600.16	1.938

Components	Material/Dimension/Methods of Construction	Unit	Qty	Cost (\$)	Embodied Energy(GJ)
Modular Wall Oven Design Cupboards	800mm wide x 600mm deep	no	1	624.31	1.94
Modular Pantry Design Cupboards	2100mm high x 900mm wide x 600mm deep	no	1	836.31	1.547
Vanity Units	750mm high x 1500mm wide x 450mm deep; double basin	no	1	1122.5	2.166
Wardrobes	2400mm high x 900mm wide x 600mm deep	no	1	332.65	1.009
Wardrobes	2400mm high x 1800mm wide x 600mm deep	no	3	1555.71	4.623
Framed Shower Screens	Pivot door and full return panel	no	2	946	35.469
Sliding Windows	600 x 600mm wide	no	2	246.52	1.395
Sliding Windows	600 x 1200mm wide	no	1	156.13	1.383
Sliding Windows	1200 x 1200mm wide	no	4	784.16	10.966
Sliding Windows	1200 x 1800mm wide	no	7	1627.01	28.701
Sliding Windows	2000 x 600mm wide	no	4	1314.76	9.186
Sliding Windows	2000 x 1200mm wide	no	4	1375.8	18.212
Sliding Windows	2000 x 1800mm wide	no	3	1285.41	20.427
Aluminium Doors	2100 x 900mm wide	no	1	1206.44	5.534
Aluminium Doors	2100 x 1800mm wide (1 x 900mm sliding panel)	no	1	599	5.871
Timber Doors	4 panel design	no	2	378	3.232
Timber (Feature) Doors	4 panel design	no	19	3936.8	6.433
Colour Coated Steel	2400 x 2490mm wide	no	2	1616	2.378
10mm Standard Plasterboard	Ceilings; fixed to timber (glued and nailed)	m2	336	2499	29.232
Ceramic Wall Tiling	200 x 100mm	m2	50	3515	65.26
Ceramic Floor Tiling	200 x 100mm	m2	43	2981.66	56.225
Carpet	Polypropylene	m2	245	8624.99	89.089
Acrylic (Semi Gloss or Gloss)	Walls (timber panelling)	m2	618	7462.54	3.089
Acrylic (Semi Gloss or Gloss)	Ceilings (timber panelling)	m2	336	4418.4	1.68
Acrylic (Semi Gloss or Gloss)	Doors	m2	79	1706.67	0.397
Acrylic (Flat or Semi Gloss or Gloss)	Wall	m2	286	2765.54	1.428
Copper Fixture Traps	32mm	no	5	283	0.08
Copper Floor Traps	80 x 65mm	no	5	480.75	0.283
Colour Coated Brass Taps	Basin set	no	4	694.88	0.281
Colour Coated Brass Taps	Bath set	no	2	310.36	0.174

Components	Material/Dimension/Methods of Construction	Unit	Qty	Cost (\$)	Embodied Energy(GJ)
Colour Coated Brass Taps	Shower set	no	2	347.76	0.241
Colour Coated Brass Taps	Sink set	no	1	194.62	0.091
Colour Coated Brass Taps	Washing machine tap	pair	1	118.31	0.066
Acrylic Baths	1525 x 725 x 410mm white	no	1	292.9	17.14
Water Jet Spa Baths	1470 x 1470 x 450mm (4 plastic jets)	no	1	415.4	0.244
Kitchen Sinks	Drop in' type; 1200mm 1 1/2 bowl	no	1	415.4	0.244
Laundry Tub	45/46 litre single compartment	no	1	286.2	0.576
Toilet Suites	Close coupled S or P trap; white	no	3	1960.5	16.524
Electric Hot Water Unit	80 litre	no	1	599.08	1.13
Opaque Fabric	2400mm high	m	29	10237	13.047
Ranges & Stoves	Electric standard oven (540mm wide) with mechanical timer	no	1	782	1.356
Wall Ovens	Electric standard oven (540mm wide) with mechanical timer	no	1	584.4	1.089
Dishwashers	Standard	no	1	863.5	1.595
Aluminium Gutter	190 x 140mm fascia gutter	m	88	2264.24	2.49
Aluminium	0.8mm thick	no	7	152.67	0.085
Aluminium Downpipe	100 x 50mm rectangular downpipe	m	29	587.25	0.612
Copper Pipework	15mm (12.70mm actual) diameter x 0.91mm pipe	m	100	2950	12.61
Copper Pipework	15mm 90 degree elbow	no	20	187	1.92
Copper Pipework	15 x 15 x 15mm 90 degree tee	no	13	166.01	4.173
Copper Pipework	8mm (7.94mm actual) diameter x 0.91mm pipe	m	14	296.38	0.82
Copper Pipework	32mm (31.75mm actual) diameter x 1.22mm pipe	m	64	1950.08	20.909
Copper Pipework	32mm 85 degree bend	no	14	261.52	1.344
Overhead Mains Connection	Overhead mains connection	no	1	557	0.787
Switchboards	Houses	no	1	473	1.123
Conduits	Light duty 20mm diameter	m	150	780	1.02
Outlets & Switches	Double switch; concrete/masonry	no	2	84.4	0.158
Light Fittings	Batten fitting; 20 watt single	no	22	928.4	5.46
Outlets & Switches	Single switch; concrete/masonry	no	20	1800	3.898
Electric Heating	In-built electric heaters; 2400w (fan assisted type)	no	1	308.35	0.565
Smoke Detection System	Battery operated	no	3	85.78	0.18
TOTAL COST				\$205,517.91	
TOTAL EMBODIED ENERGY				1,312.255 GJ	

Table D.2 Product Quantities for Medium Density

Components	Material/Dimension/Methods of Construction	Unit	Qty	Cost (\$)	Embodied Energy(GJ)
Pad Footings - Square Pad	500 x 500 x 200mm depth (overall depth 400mm)	no	86	1172.18	0.757
Sand	50mm thick	m ²	720	2188.80	9.360
Membranes	200um	m ²	720	1944.00	2.088
Raft Slabs	300mm deep x 300mm wide; F8TM3 and F72 mesh	m ²	768	53007.36	140.698
Suspended Slabs	300mm thick	m ²	3180	758811.60	10621.359
Walls	200mm thick	m ²	48	12436.32	72.240
Attached Beams	600 x 300mm wide	m	138	31535.76	185.831
Attached Columns	450 x 450mm wide	m	120	28330.80	181.788
Walls	200mm thick	m ²	48	12436.32	72.240
Clay Brickwork	Walls - 230mm thick	m ²	3348	479634.48	10930.885
Clay Brickwork	Walls - 110mm thick	m ²	2565	184090.05	4187.234
Galvanised Steel Lintels	Galvanised steel flat bar; 75 x 10mm	m	620	11271.60	177.754
Aluminium Core Bitumen Coated (0.45mm)	110mm wide	m	156	260.52	3.931
Wall Framing - Hardwood F8	75 x 38mm @ 450mm centres	m	300	13677.00	72.765
Particleboard Wall Linings	12mm thick	m ²	1800	43848.00	143.910
Flat Roof Framing - Hardwood F8	140 x 45mm rafters @ 450mm centres	m ²	1040	29265.60	447.564
Steel Sheet Roofing	Corrugated; 0.42mm BMT; zinc aluminium coated	m ²	1040	16702.40	923.520
Stair Concrete	1000mm wide (per metre rise)	m	9	1350.00	26.100
Stair Concrete	Landing	m ²	12	600.00	18.007
Letter Box	31 bank	no	1	1925.71	22.142
Ceiling Framing - F5 Pine	90 x 35mm ceiling joist @ 600mm centres	m ²	1040	17638.40	27.664
10mm Standard Plasterboard	Ceilings; fixed to timber (glued and nailed)	m ²	1040	17326.40	90.480
Ceiling/Roof Insulation	R2.5 (125 - 145mm thick)	m ²	1040	9453.60	167.440
Architrave & Skirting - Pine	42 x 19mm bullnose/splay	m	2171	12352.99	47.762
Architrave & Skirting - Pine	70 x 19mm colonial	m	1971	13619.61	72.336

Components	Material/Dimension/Methods of Construction	Unit	Qty	Cost (\$)	Embodied Energy(GJ)
Cupboards	2400mm high x 900mm wide x 600mm deep	no	30	12693.30	32.085
Benchtops - Square Edge	16mm thick and 450mm wide	m	135	15466.95	7.709
Modular Floor Design Cupboards	Standard cabinets with one shelf 450mm deep	m	121.5	52316.69	82.839
Modular Floor Design Cupboards	Four drawer cabinet; 450mm wide x 450mm deep	no	30	13797.90	18.825
Modular Wall Design Cupboards	700mm high	m	135	54005.40	65.408
Vanity Units	750mm high x 750mm wide x 350mm deep; single basin	no	30	6927.00	13.368
Wardrobes	2400mm high x 900mm wide x 600mm deep	no	60	19959.00	60.558
Framed Shower Screens	Shower rod and half return panel	no	6	1188.00	9.636
Sliding Windows	1200 x 1200mm wide	no	16	3136.64	43.864
Sliding Windows	1200 x 2400mm wide	no	110	31507.30	600.479
Sliding Windows	600 x 1200mm wide	no	66	10304.58	91.278
Sliding Windows	600 x 2400mm wide	no	30	6303.90	82.620
Timber (Feature) Doors	Single light design with clear glazing	no	30	9757.50	16.464
Timber (Flush) Doors	Hollow core construction	no	30	1575.00	8.808
Timber (Flush) Doors	Hollow core construction	no	160	8400.00	46.976
Security Doors	Standard	no	30	18970.50	38.358
Ceramic Wall Tiling	200 x 100mm	m ²	1800	126036.00	2340.000
Ceramic Floor Tiling	25 x 25mm	m ²	660	58350.60	858.000
Carpet	Polypropylene	m ²	2940	103605.60	1070.160
Acrylic (Semi Gloss or Gloss)	Doors	m ²	7938	106607.34	39.690
Acrylic (Flat or Semi Gloss or Gloss)	Walls	m ²	7713	74661.84	38.565
Acrylic (Flat or Semi Gloss or Gloss)	Ceilings	m ²	3180	31959.00	15.900
Copper Fixture Traps	32mm	no	30	1698.00	0.477
Copper Floor Traps	80 x 65mm	no	30	2884.50	1.695
Colour Coated Brass Taps	Basin set	no	30	5211.60	2.106
Colour Coated Brass Taps	Bath set	no	30	4655.40	2.604

Components	Material/Dimension/Methods of Construction	Unit	Qty	Cost (\$)	Embodied Energy(GJ)
Colour Coated Brass Taps	Shower set	no	30	5216.40	3.612
Colour Coated Brass Taps	Sink set	no	30	5838.60	2.715
Colour Coated Brass Taps	Washing machine tap	pair	30	3549.30	1.992
Acrylic Baths	915 x 915 x 325mm white	no	30	9837.00	514.200
Shower Cabinets	1935 x 900 x 900mm (2 wall shower unit) white	no	30	23130.00	514.200
Kitchen Sinks	Drop in' type; 900mm single bowl	no	30	9375.00	7.305
Laundry Tub	45/46 litre single compartment	no	30	8586.00	17.265
Toilet Suites	Close coupled S or P trap; white	no	30	19605.00	165.240
Electric Hot Water Unit	50 litre	no	30	19605.00	28.203
Ranges & Stoves	Electric standard oven (540mm wide) with mechanical timer	no	30	23460.00	40.674
Microwave Oven	Microwave oven	no	30	6490.50	14.139
Dishwashers	Standard	no	30	25905.00	47.853
Copper Pipework	15mm (12.70mm actual) diameter x 0.91mm pipe	m	248	7316.00	31.273
Copper Pipework	15mm 90 degree elbow	no	550	5142.50	52.800
Copper Pipework	15 x 15 x 15mm 90 degree tee	no	150	1915.50	48.150
Copper Pipework	32mm (31.75mm actual) diameter x 1.22mm pipe	m	248	7556.56	81.022
Copper Pipework	32mm 85 degree bend	no	150	2802.00	14.400
Aluminium Gutter	190 x 140mm fascia gutter	m	50	1286.50	1.415
Aluminium Downpipe	100 x 50mm rectangular downpipe	m	65	1316.25	1.372
Overhead Mains Connection	Overhead mains connection	no	1	557.00	0.787
Switchboards	Home units (6 x 2 bed units)	no	6	6558.00	6.739
Switchboards	Add extra for home unit sub board	no	2	630.00	2.246
Conduits	Light duty 20mm diameter	m	250	1300.00	1.700
Outlets & Switches	Single switch; concrete/ masonry	no	512	24780.80	46.438
Light Fittings	Batten fitting; 20 watt single	no	320	13504.00	79.424
Electric Heating	In-built electric heaters; 2400w (fan assisted type)	no	30	9250.50	16.953
TOTAL COST				<u>\$2,781,372.45</u>	
TOTAL EMBODIED ENERGY				<u>35,976.443 GJ</u>	

Table D.3 Product Quantities for High Density

Components	Material/Dimension/Methods of Construction	Unit	Qty	Cost (\$)	Embodied Energy(GJ)
Bored Concrete Piers	600mm diameter	m	240	14,323.20	13.440
Sand	50mm thick	m ²	754	2,290.94	9.797
Membranes	200um	m ²	754	2,034.72	2.185
Raft Slabs	400mm deep x 300mm wide; F8TM3 and F72 mesh	m ²	754	52,013.47	138.060
Suspended Slabs	300mm thick	m ²	8323	1,986,081.98	32433.222
Attached Columns	450 x 450mm wide	m	960	226,646.40	1454.304
Tilt Up Concrete Wall Panels	200mm thick	m ²	22702	2,883,190.07	59617.333
Walls	200mm thick	m ²	10	2,487.26	14.448
Wall Framing - Hardwood F8	100 x 38mm @ 450mm centres	m	1454	89,605.58	513.367
Particleboard Wall Linings	12mm thick	m ²	6981	170,060.08	651.164
Flat Roof Framing - Hardwood F8	150 x 38mm rafters @ 600mm centres	m ²	694	11,735.71	420.096
Steel Sheet Roofing	Corrugated; 0.42mm BMT; zinc aluminium coated	m ²	694	11,139.22	718.570
Stair Concrete	1000mm wide (per metre rise)	m	31	4,680.00	158.340
Stair Concrete	Landing	m ²	78	3,900.00	204.832
Letter Box	31 bank	no	2	3,851.42	44.285
Letter Box	5 bank	no	2	993.26	7.143
Ceiling Framing - Hardwood F8	100 x 38mm ceiling joist @ 450mm centres	m ²	9077	186,107.04	387.579
10mm Standard Plasterboard	Ceilings; fixed to timber (glued and nailed)	m ²	9077	139,664.11	789.682
Ceiling/Roof Insulation	R2.5 (125 - 145mm thick)	m ²	694	6,304.82	111.670
Architrave & Skirting - Pine	42 x 19mm bullnose/splay	m	12368	70,374.40	272.098
Architrave & Skirting - Pine	70 x 19mm colonial	m	12368	85,463.47	453.909
Benchtops - Square Edge	16mm thick and 450mm wide	m	72	8,249.04	4.111
Modular Floor Design Cupboards	Standard cabinets with one shelf 450mm deep	m	72	31,002.48	49.090
Modular Floor Design Cupboards	Four drawer cabinet; 450mm wide x 450mm deep	no	72	33,114.96	45.180

Components	Material/Dimension/Methods of Construction	Unit	Qty	Cost (\$)	Embodied Energy(GJ)
Modular Wall Design Cupboards	700mm high	m	144	57,605.76	69.768
Vanity Units	750mm high x 750mm wide x 350mm deep; single basin	no	72	16,624.80	32.083
Wardrobes	2400mm high x 900mm wide x 600mm deep	no	144	47,901.60	145.339
Framed Shower Screens	Shower rod and half return panel	no	72	14,256.00	115.632
Sliding Windows	600 x 2400mm wide	no	216	45,388.08	594.864
Sliding Windows	2000 x 2400mm wide	no	72	44,120.16	652.709
Aluminium Doors	2100 x 1800mm wide (1 x 900mm sliding panel)	no	216	129,384.00	1268.179
Timber (Flush) Doors	Solid construction	no	82	8,753.50	132.504
Timber (Feature) Doors	4 panel design	no	292	55,188.00	471.843
2 Hour Fire Rating	2040 x 820 x 45mm paint ply	no	15	11,034.00	54.989
Ceramic Wall Tiling	200 x 100mm	m ²	7085	496,077.70	9210.240
Ceramic Floor Tiling	25 x 25mm	m ²	1524	134,736.84	1981.200
Carpet	Polypropylene	m ²	5162	181,922.98	1879.114
Acrylic (Semi Gloss or Gloss)	Doors	m ²	374	5,022.82	1.870
Acrylic (Flat or Semi Gloss or Gloss)	Walls	m ²	52386	507,093.46	261.928
Acrylic (Flat or Semi Gloss or Gloss)	Ceilings	m ²	8383	84,251.16	41.916
Copper Fixture Traps	32mm	no	72	4,075.20	1.145
Copper Floor Traps	80 x 65mm	no	72	6,922.80	4.068
Colour Coated Brass Taps	Basin set	no	72	12,507.84	5.054
Colour Coated Brass Taps	Bath set	no	72	11,172.96	6.250
Colour Coated Brass Taps	Shower set	no	72	12,519.36	8.669
Colour Coated Brass Taps	Sink set	no	72	14,012.64	6.516
Colour Coated Brass Taps	Washing machine tap	pair	72	8,518.32	4.781
Galvanised Steel Water Tanks	1000 litre	no	72	31,428.00	849.038

Components	Material/Dimension/Methods of Construction	Unit	Qty	Cost (\$)	Embodied Energy(GJ)
Shower Cabinets	1935 x 900 x 900mm (2 wall shower unit) white	no	72	55,512.00	1234.080
Kitchen Sinks	Drop in' type; 900mm single bowl	no	72	22,500.00	17.532
Laundry Tub	45/46 litre single compartment	no	72	20,606.40	41.436
Toilet Suites	Close coupled S or P trap; white	no	72	47,052.00	396.576
Electric Hot Water Unit	50 litre	no	72	35,677.44	67.687
Ranges & Stoves	Electric standard oven (540mm wide) with mechanical timer	no	72	56,304.00	97.618
Microwave Oven	Microwave oven	no	72	15,577.20	33.934
Dishwashers	Standard	no	72	62,172.00	114.847
Waste Disposal Unit	Waste disposal unit	no	12	4,866.00	9.832
Copper Pipework	18mm (15.88mm actual) diameter x 1.02mm pipe	m	775	8,579.25	81.375
Copper Pipework	18mm 90 degree elbow	no	150	1,548.00	14.400
Copper Pipework	18 x 18 x 18mm 90 degree tee	no	150	2,038.50	48.150
Copper Pipework	40mm (38.10mm actual) diameter x 1.22mm pipe	m	775	20,181.00	81.375
Copper Pipework	40mm 90 degree elbow	no	150	2,671.50	14.400
Copper Pipework	40 x 40 x 40mm 90 degree tee	no	150	4,365.00	48.150
Aluminium Gutter	190 x 140mm fascia gutter	m	200	5,146.00	5.660
Aluminium Downpipe	100 x 75mm rectangular downpipe	m	230	4,839.20	4.853
Overhead Mains Connection	Overhead mains connection	no	1	557.00	0.787
Switchboards	Home units (6 x 2 bed units)	no	12	13,116.00	13.478
Conduits	Light duty 20mm diameter	m	360	1,872.00	2.448
Outlets & Switches	Single switch; concrete/ masonry	no	720	34,848.00	65.304
Light Fittings	Batten fitting; 20 watt single	no	1200	50,640.00	297.840
Cooling Equipment	Split system type; 2.5hp;6.15 kW cooling/7.16 kW heating (65m2 area)	no	13	36,205.52	68.069
Thermal detection system	Thermal detection system	m ²	4641	66,366.30	127.628
Office and Hotel (High Rise) Passenger Lifts	16 person; 2.5 m/s speed	no	2	820,000.00	1582.600
TOTAL COST				\$9,359,071.94	
TOTAL EMBODIED ENERGY				120,783.659 GJ	

APPENDIX E

PRODUCT QUANTITIES FOR ALTERNATIVE BUILDING ENVELOPES

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PRODUCT QUANTITIES FOR ALTERNATIVE BUILDING ENVELOPES

The purpose of this appendix is to present the quantities and compare the initial embodied energy estimates of alternative building envelopes appropriate for single dwelling construction as a demonstration case. The single dwelling used in the comparison is the same 123m² two storey townhouse discussed in Section 4.2.1. In this comparison the structural components such as the ground floor, external walls, internal load bearing walls, first floor and the roof are considered as the building envelope. Eight alternatives cases have been investigated with alternative materials for these components in Section 5.3.

Table E.1 Standard House Construction (H1)

Component	Construction Material	Cost (\$)	Embodied Energy (GJ)
Ground Floor	Concrete slab	2090.87	2.01
Upper Floor	Timber frame with particleboard	1848.04	7.93
Internal Walls	Timber frame with plasterboard	9331.13	42.76
External Walls	Timber frame clay brick façade	18229.58	167.97
Roofing	Concrete tiles	2232.00	80.60
TOTAL COST (\$/m ²)			421.65
TOTAL EMBODIED ENERGY (GJ/m ²)			3.77

Table E.2 Standard House with Timber Framed Ground Floor (H2)

Component	Construction Material	Cost (\$)	Embodied Energy (GJ)
Ground Floor	Timber frame with particleboard	2762.60	12.29
Upper Floor	Timber frame with particleboard	1848.04	7.93
Internal Walls	Timber frame with plasterboard	9331.13	42.76
External Walls	Timber frame clay brick façade	18229.58	167.97
Roofing	Concrete tiles	2232.00	80.60
TOTAL COST (\$/m ²)			\$430.04
TOTAL EMBODIED ENERGY (GJ/m ²)			3.89

Table E.3 Standard House with Steel Framed Ground Floor (H3)

Component	Construction Material	Cost (\$)	Embodied Energy (GJ)
Ground Floor	Steel frame with particleboard	4943.80	150.35
Upper Floor	Timber frame with particleboard	1848.04	7.93
Internal Walls	Timber frame with plasterboard	9331.13	42.76
External Walls	Timber frame clay brick façade	18229.58	167.97
Roofing	Concrete tiles	2232.00	80.60
TOTAL COST (\$/m ²)			457.31
TOTAL EMBODIED ENERGY (GJ/m ²)			5.62

Table E.4 Standard House with Steel Framed Upper Floor (H4)

Component	Construction Material	Cost (\$)	Embodied Energy (GJ)
Ground Floor	Concrete slab	2090.87	2.01
Upper Floor	Steel frame with particleboard	2008.31	4.56
Internal Walls	Timber frame with plasterboard	9331.13	42.76
External Walls	Timber frame clay brick façade	18229.58	167.97
Roofing	Concrete tiles	2232.00	80.60
TOTAL COST (\$/m ²)			423.65
TOTAL EMBODIED ENERGY (GJ/m ²)			3.72

Table E.5 Standard House with Timber Framed External Wall (H5)

Component	Construction Material	Cost (\$)	Embodied Energy (GJ)
Ground Floor	Concrete slab	2090.87	2.01
Upper Floor	Timber frame with particleboard	1848.04	7.93
Internal Walls	Timber frame with plasterboard	9331.13	42.76
External Walls	Timber frame with weatherboard	10344.21	27.27
Roofing	Concrete tiles	2232.00	80.60
TOTAL COST (\$/m ²)			323.08
TOTAL EMBODIED ENERGY (GJ/m ²)			2.01

Table E.6 Standard House with Steel Framed External Wall (H6)

Component	Construction Material	Cost (\$)	Embodied Energy (GJ)
Ground Floor	Concrete slab	2090.87	2.01
Upper Floor	Timber frame with particleboard	1848.04	7.93
Internal Walls	Timber frame with plasterboard	9331.13	42.76
External Walls	Steel frame with weatherboard	24282.40	620.27
Roofing	Concrete tiles	2232.00	80.60
TOTAL COST (\$/m ²)			497.31
TOTAL EMBODIED ENERGY (GJ/m ²)			9.42

Table E.7 Standard House with Pre-Cast Concrete Wall (H7)

Component	Construction Material	Cost (\$)	Embodied Energy (GJ)
Ground Floor	Concrete slab	2090.87	2.01
Upper Floor	Timber frame with particleboard	1848.04	7.93
Internal Walls	Timber frame with plasterboard	9331.13	42.76
External Walls	Concrete pre-cast walls	24472.90	190.58
Roofing	Concrete tiles	2232.00	80.60
TOTAL COST (\$/m ²)			499.69
TOTAL EMBODIED ENERGY (GJ/m ²)			2.63

Table E.8 *Standard House with Steel Roofing (H8)*

Component	Construction Material	Cost (\$)	Embodied Energy (GJ)
Ground Floor	Concrete slab	1963.19	2.01
Upper Floor	Timber frame with particleboard	1848.04	7.93
Internal Walls	Timber frame with plasterboard	9331.13	42.76
External Walls	Timber frame clay brick façade	18229.58	167.97
Roofing	Colorbond	1646.72	36.70
TOTAL COST (\$/m²)			412.73
TOTAL EMBODIED ENERGY (GJ/m²)			3.22