TIMBER-FRAME WALLS CONSTRUCTION AS ALTERNATIVE TO MASONRY BRICK WALLS CONSTRUCTION FOR RECONSTRUCTION AND DEVELOPMENT PROGRAMME HOUSES; AN ANALYTIC EFFECTIVENESS OF TIMBER

By

Maneo Adelina Mabesa
2000018842

Supervisor: M.S. Ramabodu

A thesis submitted for fulfilling the requirements for the Master programme in Quantity Surveying
At University of the Free State

Faculty of Natural and Agricultural Sciences
Department of Quantity Surveying and Construction Management
Bloemfontein
November 2013

The thesis of Maneo Adelina Mabesa is approved by

Mr MS Ramabodu (supervisor)

ABSTRACT

The imbalance and diversities in the housing problem have to be addressed in South Africa. Attention should be given to investigating the basic needs and means of those who need shelter.

This document is a study on timber-frame wall construction as an alternative to masonry brick-wall construction for the Reconstruction and Development Programme (RDP) houses; an analytic effectiveness of timber.

A study was carried out comprising on-site and literature investigations in addition to interviews with key persons such as engineers, contractors and the general public. Although this study attempts to cover most of the factors influencing the use and advantages of timber-frames, the purpose is to investigate timber-frame walling as a possible replacement to traditional masonry brick walling on RDP houses. The objective is to speed up housing delivery and to save money, as well as to analyse the effectiveness of timber.

The investigation indicates that timber-frame material is as competitive as any other conventional building material. A house built with timber is not a cabin or a temporary building. It is a permanent structure which is as durable, effective and resilient as any other accepted construction material and comes with a number of benefits.

KEY WORDS
South Africa, timber-frame wall, masonry wall, RDP, houses.

ACKNOWLEDGEMENTS

I thank all the people who helped me with my research. I am specifically thankful to Messrs Baloyi and Thinyane for all the interest and support they gave me. They have taught me technical issues, shared experiences, and overall they have taught me values of construction industry. I also thank Professor J.J.P. Vester, for offering me opportunity to write this research

DECLARATION

I, Maneo Adelina Mabesa, do hereby declare that the work contained in this thesis is entirely my own work, except where otherwise stated and not been produced in any manner or form before.

Maneo Adelina Mabesa_ _Mabesa_ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Date November 2013

TABLE OF CONTENTS **Page No.**

LIST OF FIGURES / PICTURES

LIST OF TABLES

CHAPTER 1

1 THE PROBLEM AND SETTING

1.1 INTRODUCTION

It has been reported that a fifth of the world's houses are built from earth materials (Elizabeth & Adams, 2005:7). Nonetheless there have been two technologies widely used for residential architecture throughout the world. One is traditional masonry such as bricks, concrete blocks and stones, and the other one is lightweight construction, with predominantly timber-frames. Each of these building techniques has its own unique set of tradeoffs and to consider which method to use; their relative merits have to be analysed and compared (Brinkley, 2005).

In South Africa, bricks and concrete blocks remain the primary materials for construction of houses and are used extensively in buildings of all types, low income houses included. This is because masonry has a lot of advantageous properties like acoustics, durability, low maintenance, a strong structural frame, fire resistance and aesthetics (Pringle & Bruce, 2011). With the South African government failing to deliver quality low income houses in the specified time and budget, the Department of Human Settlements (RSA) will have to undertake investigations in respect of alternative building technologies which should have all the requisite standards for quality, norms and standards and while facilitating rapid housing delivery. Thus, the idea of using timber-frames as an alternative method of construction (unlike the usual brick and mortar) was triggered to promote a better quality of structures, faster construction solutions and to discover new economic developments.

A timber-frame house differs from a brick and mortar house only with regard to the walls, as both types of houses have the same foundations, windows, doors and roofs. Therefore emphasis will be placed on their respective walls to determine which type of walls is the most viable, easily obtained, cost effective and durable .The selected method of construction should be suitable for the construction of Reconstruction and Development Programme (RDP) houses by being the quickest and most economical method of erection.

"Timber-frame construction is a method of building that relies on a timber-frame as a basic means of structural support. The panels are engineered in a factory environment under strict quality control systems using computer aided design and manufacturing machines. In the factory the weight-bearing structure of a building is made of heavy wood panels instead of steel or concrete breeze blocks. Ironically, given its strength, timber-frame construction is often referred to as lightweight construction" (Lund, [n.d.]: 13).

Timber-frame homes were re-introduced in South Africa as an alternative to conventional brick homes in the early nineteen sixties (1963). One of the main reasons that timber-framed homes have taken so long to become a norm in South Africa is a lack of suitable indigenous timber, techniques and skills. However, milling and forestry techniques and skills have improved over the years (Osborn, 2010). Even the South African National Building Regulations accept it as a high standard of construction method (SANS1200 and NBR - SANS 10400 – F: 2010).

While timber-frame houses are not common in South Africa, they have become a norm in developed countries such as the United States of America and Canada. This alone shows that there may be advantages to be gained from this type of construction.

1.2 THE RESEARCH PROBLEM

The goal of this study is to determine whether timber-frame walls can replace traditional brick and mortar walls to improve quality, faster construction solutions, durability and cost effectiveness.

Will timber-frame wall construction be a better alternative to brick wall construction in South Africa? Can timber-frame wall construction be appropriate for RDP houses?

The housing problem in South Africa should be addressed. Government should find ways of decreasing the shortage and slow delivery of low income houses by using the most economic and efficient methods of construction.

1.2.1 SUB-PROBLEMS

Time and cost are two of the most important factors in the completion of any project. The longer it takes to finish a certain project, the more expensive it becomes. The different sub-problems are stated below:

1. What does the timber-frame construction method consist of and how can it be helpful in the construction of RDP houses?

2. Is the timber-frame wall method quicker and more cost effective than masonry?
3. Is the timber-frame wall method of construction cheaper than the masonry method of construction?
4. Is it easier to construct timber-frame wall constructions than masonry wall constructions?
5. Which of the construction materials are more sustainable between brick and timber-frame?
6. How does the construction of these methods differ? How do the timber-frame walls compare with brick and mortar walls when it comes to durability?

1.3 THE HYPOTHESIS

Timber-frame construction is a cost effective and economic method of construction. It is a better and quicker type of erection than brick and mortar. The use of timber-frame construction is a possible alternative for house wall construction for the low income groups of South Africans, as timber-frame erection is more energy efficient, cost effective, and may provide home owners with affordable and durable houses.

1.4 THE LIMITATIONS

The purpose of the literature review is to identify the advantages and benefits of building with timber to speed up the process of low income housing delivery. The study is limited to masonry and timber-frame construction. Combining the literature investigations with structured questionnaires and interviews makes the study more reliable and realistic.

1.5 SCOPE

The study will focus on timber-frame walls as an alternative to brick and mortar walls for RDP houses. Timber-frame construction is not only durable and strong but also lightweight, suited to all climate conditions, environmentally friendly and thermally efficient. The selection of appropriate building materials is important to the quality and sustainability of any structure.

Timber houses are as good as other conventional houses and they should be as prevalent in the Republic of South Africa as houses built from bricks, blocks and concrete. Timber-framed structures can be used for low income housing.

1.6 METHODOLOGY

Information gathered for this thesis comes from the following sources:

- A literature review regarding timber-frame construction by reviewing books, timber manuals, guides, reports and information gathered from the internet;
- Engineering designs and building regulations' reviews (SANS1200 and NBR - SANS 10400 – F: 2010) in order to assess compliance with standards;
- Interviews with contractors;
- A comparison of the cost of timber-frame wall and brick and mortar wall construction;
- Site visits to examine where brick and mortar walls and timber-frame walls are constructed in South Africa; and
- Distributing questionnaires to architects, contractors, quantity surveyors, engineers and to the general public.

1.7 THE AIM AND IMPORTANCE OF THE STUDY

The principal aim of this research is to determine the cost effectiveness of timber frames and outline the reasons why timber-frame houses should be as widely used in South Africa as brick and mortar houses.

1.8 THE ASSUMPTIONS

The timber-frame method of construction may be environmentally friendly, and ecologically and energy efficient. The overall aims of environmentally sustainable developments are to reduce the use of energy, and to minimise adverse environmental impacts.

1.9 ABBREVIATIONS

FSC	–	Forest Stewardship Council
ILO	–	International Labour Organisation
LCA	–	Life Cycle Assessment
NHFC	–	National Housing Finance Corporation
NTDC	–	National Timber Development Council
OSB	–	Oriented Strand Board

PER	–	Product Energy Requirement
RDP	–	Reconstruction and Development Programme
RSA	–	Republic of South Africa
SALMA	–	South African Lumber Millers Association
SANS	–	South African National Standards
SASFA	–	South African Light Steel Frame Building Association
SATFBA	–	South Africa Timber Frame Builder's Association
TBTN	–	Tributyltin Napthnate
TFBA	-	Timber Frame Builders Association
TRADA	–	Timber Research and Development Association
UK	–	United Kingdom
USA	–	United State of America

2 CHAPTERS OUTLINE

In order to address the research problem as outlined above, this research report will be divided into the following chapters:

CHAPTER 1 - THE PROBLEM AND SETTING

Chapter one introduces the reader to the research problem and gives a general idea of what the study aims to accomplish.

CHAPTER 2 - METHOD OF TIMBER-FRAME AND MASONRY WALLS CONSTRUCTION

Chapter two investigates the advantages and disadvantages of brick and timber-frame wall construction systems. Also to be discussed are different materials required for each type of wall erection and the time it takes to construct each wall.

CHAPTER 3 - TIMBER-FRAME BUILDINGS COMPARED TO CONVENTIONAL BUILDINGS

Chapter three compares timber-frame houses to conventional buildings such as brick houses. The aim of this chapter is to focus on the advantages of timber-frame houses.

CHAPTER 4 - THE ADVANTAGES OF WOOD-FRAME CONSTRUCTION

Chapter four investigates timber-frame properties and advantages.

CHAPTER 5 - LOW INCOME HOUSING IN SOUTH AFRICA

Chapter five discusses South Africa's approach to low income housing, present statistics of the housing backlog and building material for Reconstruction and Development Programme houses (RDP).

CHAPTER 6 - COMPARATIVE COST ANALYSIS OF TIMBER-FRAME AND BRICK WALLS CONSTRUCTION

In this chapter, the cost of constructing masonry brick walls and timber-frame walls is compared to prove which method of construction is more cost effective.

CHAPTER 7 - THE RESEARCH METHODOLOGY

Chapter seven introduces the methodology used in the research. To discover more about the problem and sub-problems, the literature study was supported by questionnaires, interviews and field observations.

CHAPTER 8 – FINDINGS

The findings of the study are discussed in great length.

CHAPTER 9 - CONCLUSIONS AND RECOMMENDATIONS

In the last chapter the findings of this research report are revisited and a suitable conclusion is drawn.

CHAPTER 2

2 METHOD OF TIMBER-FRAME AND MASONRY WALL CONSTRUCTION

2. 1 Introduction

There are typically two common wall systems being used in house construction, namely timber-frame and masonry brick or block work. These methods are commonly used in the building industry worldwide. While wood construction is not popular in South Africa, timber houses are more prevalent in the developed world, where 70% of the population is estimated to live in timber homes (Elizabeth & Adams, 2005: 10).

Walls and foundations play an important role in the stability of the structure, as well as in the percentage of the building's total cost and construction time. Emphasis will be placed on walls mainly because timber-frame and brickwork houses differ mainly with regards to their walls. Other elements of a house structure such as foundations, floors, doors, windows, ceilings and roofs are usually the same for the two construction methods.

In South Africa, masonry brickwork construction is the most preferable practice and common solution for low income houses. This is because masonry brickwork has many advantageous properties such as acoustics, durability, low maintenance and a strong structural frame. The important one is durability. Bricks have been successfully used as a building material for centuries. The numerous ancient structures and monuments built with bricks that still exist in many parts of world such as the Pyramids and the large Roman Aqueducts are a clear testament to its worthiness. Masonry brick walls are structurally sound and have great compressive strength. The brick walls can, to a large extent, hold up against the ravages of bad weather, and are generally resistant to fire, mold and pests. The mortar used to bond brick or masonry blocks prevents water and wind seepage into the building. These construction materials are incombustible and, once in place, their surfaces offer little opportunity for mold growth or pest incursions. Another advantage of a masonry building which is very important to the RDP houses is its cost-effectiveness. Apart from the money saved in later maintenance work, the initial construction costs are lower compared to other types of building (Rocky Mountain Masonry Institute, 2002). Construction workers and materials are usually available locally, and the construction can be carried out by a general contractor without too many work delays. The use of material such as bricks and blocks can increase the thermal mass of a building. The mass of a masonry brick walled building is also advantageous as it acts as a barrier and prevents easy sound transmission. It reduces noise pollution and helps in creating a quieter environment. This feature makes masonry construction ideal for homes as well as public buildings where large numbers of people congregate. Masonry brick walls also offer excellent thermal insulation. Their slow rate of heat discharge keeps interiors warm in winter, and their high rate of heat absorption makes for cool interiors in summer. Such energy-efficient buildings not only lower energy bills, but the manufacture of the masonry materials used in their construction also requires lower energy consumption (Davis, 2013). Another quality is aesthetics; houses built with brick are mostly attractive and beautiful.

To replace the brick and block wall construction used on RDP houses, timber–frame wall construction have to be more economical, cost effective and practical. This can be achieved by reducing waste, reducing the amount of required materials, simplifying assembly and increasing accuracy and the speed of construction. The materials and construction techniques may be based on traditions or on more industrialised methods using specialised skills, computerised manufacturing and design processes and sophisticated equipment.

Timber-frame and masonry brickwork are acceptable building methods and comply with the required building standards and regulations such as, the National Building Regulations (NBR — SANS 10400 – F: 2010) and South African National Standards (SANS 1200). These two methods of building wall systems will be compared and discussed. Certain parameters such as durability, thermal performance and acoustic performance will be taken into account.

2.2 Masonry Brick Wall Construction System

The most common use of bricks worldwide throughout time is in residential dwellings, as shown in Figure 1 (an example of an RDP brick wall house). The shape and size of bricks can vary considerably depending on the quality of the clay and the manufacturing tradition. Similarly the mortars used depend on its strength. The materials used in mortar mixes are sand, water, and one or more bonding agents such as mud, clay, or cement, depending on local availability. The proportion of bonding agents to sand determines the compressive and bonding strength of the mortar (D'Ayal, 2004).

Figure 1: RDP brick wall house in Bohlokong (own information).

Bricks are stacked on top of one another with mortar between them to bind them together and to hold them in place as shown in Figure 2. The bricks can be laid in different orientations such as stretcher (as shown in Figure 3), soldier, header, rowlock stretcher, and sailor. The brick orientations will not be discussed in detail in this paper. A damp-proof course is placed on top of foundation walls to prevent moisture from ascending into the building from the foundation. Openings for doors and windows are created by leaving openings in the walls. There are no channels for services left in walls and such channels must be created using a grinder or hammer and chisel (Davis, 2013).

Figure 2: A picture illustrates construction of concrete block walls and how the blocks were being stacked on top of one another, Maliele, Lesotho (own Information).

Figure 3: A picture illustrates orientation of the bricks called stretcher, Maliele, Lesotho (own Information).

Brick force can be placed between the layers of brick to increase the strength and load carrying capabilities. The more brick force used, the stronger the wall will be. Brick force is normally placed in every third to fourth layer, but more or less can be used, depending on the purpose of the wall and the required strength. For aesthetic and smooth finishes, the external and internal walls may be plastered and painted.

2.2.1 Wall construction duration

A study was conducted on a construction site in Bohlokong, Bethlehem, where an RDP house of 6.25m x 2.55m high double skinned brick wall was constructed. It took a skilled bricklayer and a labourer roughly nine and half hours to construct the brick wall that consisted of 1754 bricks.

2.2.2 Material used in a brick wall system

A house cannot be built without the fundamental knowledge of building materials and construction (Stulz & Mukerji, 1993). Therefore material that makes up the brick wall will be explained thoroughly. The properties or characteristics of different materials must match the purpose of the structure. Properties include: brittleness, ductility, hardness, plasticity, resistance to heat, resistance to water, compression and tensile strength (Stulz & Mukerji, 1993).

2.2.2.1 Brick

A brick is a block, or a single unit of a ceramic material used in masonry construction. Bricks are stacked together, or laid as brickwork using various kinds of mortar to hold the bricks together and make a permanent structure. They are typically produced in common or standard sizes in bulk quantities (Pandey, [n.d.]).They have been regarded as one of the longest lasting and strongest building materials used throughout history. Their sizes have varied over the centuries but have always been similar to present-day sizes (D'Ayal, 2004). Some sizes were developed to meet specific designs, production or construction needs. For example, larger bricks were developed to increase the bricklaying economy, while thinner bricks help to conserve resources.

2.2.2.2 Mortar

Mortar is a workable paste used to bind construction blocks together and fill the gaps between them. Mortar binds bricks and blocks together to give strength and stability to a wall. The blocks may be stone, brick or concrete blocks. Mortar becomes hard when it sets, resulting in a rigid aggregate structure. Modern mortars are typically made from a mixture of sand, a binder such as cement or lime and water (Stulz & Mukerji, 1993). Mortar joints to brickwork shall be not less than 5 mm or more than 10 mm thick and descriptions of brickwork, unless otherwise specified, shall be deemed to include for raking out joints whilst the mortar is soft to form an adequate key for plaster or mortar backing (Mishra, 2012).

2.2.2.3 Damp Proof Course

A damp proof course (DPC) is a barrier of impervious material built into a wall or pier to prevent moisture from moving to any part of the building. A damp-proof membrane (DPM) performs a similar function for a solid floor. The DPC is built into the base wall brickwork. It bridges brick skins and/or the brick and pier. DPC is used to stop dampness in buildings (Burchell & Sunter, 1987:27).

The DPC is laid into the brick wall approximately two courses (two bricks) below the lowest brick member, typically the bearer.

2.3 Timber-frame Wall Construction System

The use of timber-framed load-bearing walls and partitions is the most essential difference between timber-frame and brick or block construction. The timber-framed load-bearing walls are designed by the structural engineer to transmit the entire vertical and dead load safely through to the foundations. The walls should be designed as to resist racking and overturning loads which result from wind pressure and seismic shock. The load-bearing walls combined with internal lining, insulation and external claddings should be structurally sound, weatherproof and durable with thermal, acoustic and fire-resistant properties (Burchell & Sunter, 1987:17). Timber-frame construction may be an alternative wall construction method to brick and mortar. The timber-frame wall construction can be erected faster than brick and mortar.
Timber-frame house construction can be erected by different methods. The most common are:

- Platform-frame construction is the most common technique which is used mostly in Canada, the United States of America (USA) and the United Kingdom (UK). It can be explained as structural timber, with stud panels replacing the internal partitions and inner leaf of the external walls (Burchell, 1984: 3). In platform framing, each floor is built separately, one on top of another, and then the roof is added on the top. Platform-frame offers infinite flexibility to the designer and provides the builder and prefabricator with the opportunity to vary the size and degree of factory contents in components to suit their particular requirements. While there are some variations in material specifications, the main difference between competing platform-frame 'systems' is in the type of component and how far down the way towards a fully factory finished unit the manufacturer has gone (Burchell, 1984: 4).

- Balloon-frame construction is a form of construction where the external timber-frame extends from sole-plate level to eaves. The external panels having been erected, the roof trusses are placed in position and the floor joist inserted on a waist-band let into the studs of the external panels. Internal panels are put up after the roof is in position. Long lengths of timbers are required. This type of framing is not often used because it is difficult to transport large pieces of timber-frames (Bellaloggia, 2009).

- Post and beam construction is a form of construction where large-section timber beams are supported on large-section timber posts. Post and beam construction is essentially a structural grid of beams supported on posts usually on a regular spacing of between 2 and 5 meters which is an economical distance for spanning secondary roof and floor members of solid timber. The external infill panels and internal partition panels are usually identical to those used in platform-frame construction, in order to achieve the necessary standards of acoustic and thermal insulation and also to provide the necessary standards of wind and impact resistance (Burchell & Sunter, 1987: 4).

- A volumetric housing unit is a form of a construction that is manufactured off site, in the factory. The completed box is then transported to the prepared site (Lund, [n.d.]: 14).

2.3.1 Members of a frame wall system

Many building materials are required to make up a timber-frame wall. The panels of solid timbers are sheathed in or cladded with OSB (Oriented Strand Board) and gypsum boards on the inside while on the outside are nutec panels and aerolite. All these materials give the panel strength and durability.

2.3.1.1 Oriented Strand Board

OSB boards are made up of strands of wood which are layered and mixed with wax in a specific orientation (Arnold, 1986: 6). The mixture of splinters, wax and waterproofing are formed into large continuous mats. These mats are pressed under extreme pressure and under high temperature into layers. The OSB boards are very versatile and reliable. The boards are impact resistant, and have very good thermal and acoustic properties and performance. They are moisture resistant and environmentally appropriate (Domone, 2001: 12).

2.3.1.2 Nutec panels

Nutec panels work as external cladding and are suitable for a wide range of internal and external wall applications throughout the market. Nutec building planks are light-weight and can be supported by light-weight metal galvanised steel frames or light timber structures.They are offered in different sheets (Nutec, 2012).

2.3.1.3 Gypsum board

Gypsum board, also known as dry wall as shown in Figure 4, is made from a paper liner that is wrapped around an inner core made of gypsum plaster. The gypsum used in the inside is mixed with a few additives to increase the fire resistance and lower the water absorption. The most commonly used additives include fibreglass, plasticiser, foaming agent and potash. The wet gypsum is placed between two layers of heavy paper and then dried in a drying chamber. When it comes out of the chamber it is strong enough to be used as a building material. The 1200mm x 2400mm gypsum board is the most common size. There are also other sizes which are seldom used. The thickness used for walling is 12.5mm (Gypsum Association, 2012).

Two edge treatments are used most frequently: tapered edge where the end is a bit smaller than the middle of the board to ensure that joining materials be flush with the board, and straight edge, where the inside and the middle of the board are the same size. Because the gypsum contains water of crystallisation it has very good fire resistance. As the board receives heat the water is vaporized and retards heat transfer. As a result, the room will not exceed boiling point. If the wall has more than one paper at a side it is even more fire resistance. The board is not waterproof and therefore it should be used only internally. The product is a high-grade material with mineral wool as the main raw material. It has undergone the processes of burdening, forming, drying, cutting, tendon-making and surface finishing (Gypsum Association, 2012).

Figure 4: The picture shows Gypsum board on the inside walls, Bokong, Lesotho (own Information).

There are also two most used edge treatments: tapered edge where the end is a bit smaller than the middle of the board to ensure that joining materials may be flush with the board and straight edge where the inside and the middle of the board are the same size. Because the gypsum contains water of crystallisation it has very good fire resistance. As the board receives heat the water is vaporized and retards the heat transfer. As a result, the room will not exceed boiling point. If the wall has more than one paper at a side it is even more fire resistance. The board is not waterproof and therefore it should be used only internally. The product is a high-grade material with mineral wool as the main raw material. It has undergone the processes of burdening, forming, drying, cutting, tendon-making and surface finishing (Gypsum Association, 2012).

2.3.1.4 Aerolite

Aerolite is a thick pink, high quality glass wool thermal and acoustic insulation that is bonded with an inert, thermosetting resin. The strong, resilient, flexible blanket is supplied in compression packed rolls as illustrated in Figure 5 below that are easy to cut and install. It is made out of 50% recycled products such as broken glass and window panels. It forms an efficient thermo barrier that reduces heat up to 5°C in the summer, and reduces heat loss up to 87%. Aerolite can easily be installed even in hard to reach places. Because it is made of glass, it is fire resistant and cannot burn (Aeropink, 2012). Aerolite insulation is manufactured from pure spun glass bonded with an inert thermo-setting resin to form a strong, easy-to-handle blanket.

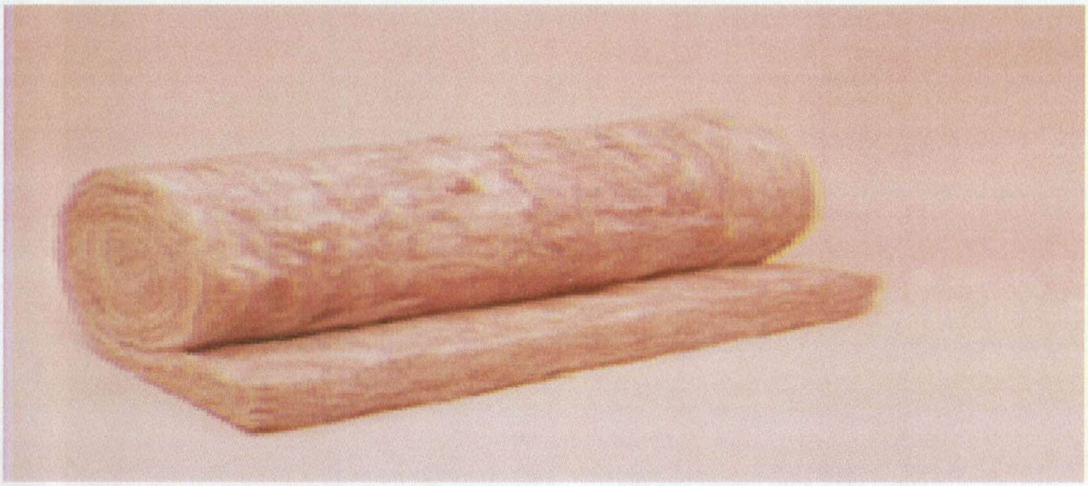


Figure 5: Think pink aerolite with class 1 fire index rating. It is manufactured according to ISO 9001:2000 and is SABS tested and approved.

2.4 Timber-frame wall construction method and construction duration

The construction of a timber- frame wall is a rapid, clean, dry operation. The timbers can be cut and assembled with simple hand or power operated tools and once the wall is raised into position and fixed, it can be ready to receive wall finishes. A timber-frame wall has adequate stability and strength to support the floors and roofs of small buildings, such as houses. Covered with wall finishes it has sufficient resistance to damage by fire, good thermal insulating properties and reasonable durability, providing it is sensibly constructed and protected from decay (Barry, 1988: 105).

A standard method is used for wall frames. This is used for:

- External walls;
- Separating walls formed of double frames, one for each dwelling;
- Ground floor partitions that carry floor joists in a two storey dwelling; and
- Internal wind bracing partitions (NBA, 1989: 17).

In contrast with a brick and mortar house, a timber-frame house is built by carpenters. With the exception of the foundations, all the structural elements above ground level are built using timber.

2.4.1 Foundation

According to Burchell (1984: 11), the first step in the construction of any house is for the architect to prepare detailed building plans. Once these plans have been drafted and passed, the foundations can be laid. Whichever method of building is used, attention needs to be paid to the foundations and groundwork. There are four main kinds of foundations to consider: strip foundation, raft foundation, pad foundation and pile foundation. Strip and pad foundations are the most common types, while raft and piled foundations are reinforced foundations usually used for more difficult sites.

A typical modern wood-frame house consists of a reinforced concrete strip-footing foundation, just like the masonry brick and mortar RDP house. The floor is constructed in such a way that it resists the passage of moisture from the ground to the interior of the building. In a timber-frame house floor, above the sole plate level all connections are timber to timber and no joist are supported on masonry. This should be in place prior to the erection of the walls (Barry, 1988: 10).

2.4.2 Floors

The design and construction of the ground floor will mostly be determined by the ground conditions. There are three main types of ground floor construction: traditional ground supported concrete floors, suspended timber floors as illustrated in Figure 6, and pre-cast concrete beam and block floors. In the case of difficult ground conditions, such as slopes and clay soil, a suspended floor will be required. Timber is used here, as wood is very versatile and allows for some ground movement. Suspended timber floor construction is also the preferred choice for first floors. Flooring on both ground and first floors may be part of the first fix carpentry, or one may prefer to screed the ground floor. If walls are dry-lined, it is important to let the screed dry out first. Screed provides a smooth surface on to which carpets, tiles and timber floor covering is laid. Screed is also the best covering for under-floor heating, which should be planned well in advance of floor construction. Tongued and grooved boarding, clipboard or plywood may be used and these materials are applied as in other housing (NBA, 1989: 6).

Figure 6: Suspended timber floor construction on a second floor of the house in Bokong, Lesotho (own Information).

2.4.3 Structure

The National Building Agency (NBA) method of building uses floor joists and trussed rafters which are carried on wall frames. These are floor to ceiling level panels, not more than 3.6m long so that they can be handled by man. They are made up of uniformly spaced vertical members, known as studs. The standard spacing of the studs is usually at 600mm, 400mm and 300mm centre. This is to ensure that the joints will occur at the centre. Unless specified otherwise all the joints are made with nails set out at 600mm centres.

The same type of frame should be used for external walls, for internal partitions carrying floor joists and for separating walls between dwellings. The latter are made of double frames with, one for each house (NBA, 1989: 18). Wall panels may be assembled with a single top rail or alternatively a top plate may be incorporated as a binder. This acts as a beam between the studs and allows joints and rafters to be located (Burchell & Sunter, 1987:17).

External walls should be sheathed outside throughout, with OSB boards or other suitable sheeting. This stiffens the structure against wind loads. In some cases, sheathing is used to stiffen certain internal partitions. Openings which are formed with lintels are usually made up of double joist material. With large openings or with heavy loads from the upper floors and roofs, hardwood lintels are needed. Lintels are carried on extra studs, known as cripple studs (Burchell & Sunter, 1987:17).

Table 1: The table below shows the elements of timber-frame wall and sizes

Top & Bottom Plate	- 140 x 38mm treated
Studs	- 140 x 38mm treated at 600mm centres
Lintels	- 220 x 45mm treated or as required by design
Sheathing	- 9.5mm OSB (factory fitted)
Breather Membrane	- Glidevale Protect tf200 thermo (factory fitted)
Head plate	- 140 x 38mm treated
Packer Head plate	- 140 x 14mm treated as required by design
Insulation	- 140mm glass fibre (between studs)
Plasterboard	- 12.7mm Plain plasterboard (taper edged) on
	vapour barrier
U Value	- 0.23 W/m²K (standard - options available)

(NBA, 1989: 5).

All framing should be designed so that simple butt joists and nails are used for assembly. Accuracy in the work is fundamental. Lintels are carried on extra studs, known as cripple studs and nailing schedules should be followed but no special skill in carpentry is required (NBA, 1982: 5).

2.4.5 Openings in timber-frame wall

Openings can be of any width up to a maximum of 2.1m. The heads of all main openings should be 2.1m above floor level. In all frames, any opening must be at least 300mm away from the ends of the frame, and from any other opening.

Small openings, which can be fitted between studs, are simply framed up, using the standard section. Large openings require lintels. This includes openings in internal partitions carrying upper floor joists. Lintels are always fitted between studs, directly under the head plate of the wall frame. They are carried on extra studs, known as cripple studs (Allen & Iano, 2004:16).

Figure 7: The timber-frame external wall openings were fitted with windows at Bokong in Lesotho (own Information).

2.4.6 Construction of walls in the Republic of South Africa

Any wall used as a structural external or internal wall, non-structural internal wall, external wall panel, parapet wall, balustrade wall, free standing wall or retaining wall shall comply with rules KK3 to KK17, noted under Section K of SANS 10400: 2010 as the case may be. Where such a wall is non-structural and a timber-frame, it shall be constructed in accordance with SANS 082. The height and unsupported length of such wall shall not exceed the limits given in Table 2 below (SANS 082: 16).

Table 2: Permissible dimensions for timber-frame wall

Wall type	Stud size mm	Stud spacing mm	Supported both ends	Supported one end	Maximum height m	Maximum height, m
Structural	114 x 38	400	4.8	2.4	6.0	**4.0**
	114 x 38	600	4.0	2.0	6.0	**3.0**
	76 x 38	450	3.6	1.8	6.0	**3.0**
Non Structural	**114 x 38**	**600**	**4.8**	**3.0**	**-**	**4.0**
	76 x 38	**600**	**4.2**	**2.4**	**-**	**3.0**

Maximum height means height to wall plate of highest floor or height to top of a gable, if there is a gable (Freeman, 1985: 151).

Where any wall is of timber-frame construction, the height and unsupported length shall not exceed the values given in Table 2.

2.4.7 Cladding

The OSB (Oriented Strand Board) boards can then be fixed onto the wood-frame as cladding for interior walls. Cladding is usually used for exterior finishes, waterproofing the walls and providing the necessary fire resistance. Exterior finishes are not structural as they do not support the floors and the roofs. In some cases, the nutec panels (flat sheets), gypsum boards and stones as illustrated in Figure 8 are used as cladding for exterior walls (Smit, 2003: 16). While gypsum boards can work both as external and internal cladding, it can also provide decorative finishes for the walls and strong surfaces capable of withstanding normal wear and tear. The gypsum board is used as internal lining to walls and ceilings. It also requires being fire resistant and preventing the transmission of sound.

Figure 8: The concrete block wall house in Matsoku, Lesotho was cladded with masonry stone (own information).

2.4.8 Insulation

Thermal insulation as required by the building regulations is easily achieved in timber-frame construction by placing the insulation in the walls or ceilings cavities as shown in Figure 9. The spaces between the studs are covered with aerolite insulation (as mentioned on page 17) which is face-fixed into the face of the studs (Arnold, 1995: 22).Thermal insulation is used to prevent heat loss, thus conserving energy to provide heat within the house. The ceiling insulation construction for timber-frame construction is exactly the same as for masonry construction.

Figure 9: The diagram illustrates placing of aerolite in the ceiling of a house in Mohlanapeng, Lesotho (own information).

2.4.9 Keeping external wall frames dry

Two steps are taken to keep external wall frames dry.

First, a polyethylene sheet is fixed to the inside face, or aluminium foil-backed plasterboard is used to prevent condensation within the walling. Second, special building paper known as breather paper, is fixed to the outside face of the plywood sheathing. This prevents any rainwater that may get behind the cladding from wetting the wall panels, but it is not impervious to water vapour, and as a result, it will not trap vapour and cause condensation. Both the vapour barrier on the inside and the breather paper on the outside have an important function and they must therefore be carefully fixed on site to give complete protection, and any damage must be repaired (Roy, 2004).

2.4.10 Avoiding roof condensation

With good insulation of ceilings, roof spaces get cold in winter. This increases the risk of condensation on the sharking felt. Because of this, good ventilation of the roof space is needed with cross ventilation usually being used. The total free area is not to be less than 1/300th of the ceiling area. Part of this area should be provided in the form of ridge ventilators in the cases of shelter sites and narrow fronted houses. To ensure that roof insulation continues right up to the eaves but does not obstruct the airflow from any eaves ventilators is crucial (NBA, 1982: 5).

2.4.11 Heating, plumbing and electrics

Accurate dimensions must be given on the drawings to locate service entry positions like electrical, plumbing and heating. Plumbers and electricians should not be allowed to cut notches or drill as they please. The rules that are set out in manuals should be followed. These services are easily installed within the walls, in the open space above ceilings, within the floor structure, and in the space between the ground floor and the first floor. As with other types of housing, no wiring or pipe work should go into separating walls between dwellings. The holes made would be liable to let noise through (NBA, 1982: 6).

2.4.12 Roofing

Finally the trussed rafters as illustrated in Figure 10 are erected and fixed, together with their bracing and verge ladders. Felt and battens are then laid over the trussed rafters. This should be laid as soon as practicable in order to protect the timber, following which the upper floor decking can be laid, if not already fixed. Temporary bracing can then be removed. The roof structure typically consists of prefabricated trusses, which are covered with sheathing and roof tiles (Osborn, 2010: 10).

Figure 10: The photo demonstrates timber roof trusses and rafters, Matsoku, Lesotho (own Information).

The following measures increase the longevity of wood-frame wall structures:

- Use a roof overhang;
- Use properly installed flashing;
- Avoid exposing large beams and columns to the elements;
- Protect band boards and underlying sheathing and siding;
- Provide adequate gaps between deck board and between ledgers and walls;
- Provide drainage and avoid creating spaces where water can collect;
- Provide ventilation where appropriate; and
- Select wood that will last (Thallon, 2000:4).

2.5 Wall construction duration

According to Ochshom (2010) an average timber-frame building can be erected and completed in a third of the time it takes to build the same structure in brick and mortar. It can be weather-proofed in five days or less. This means that tradesmen such as plumbers and electricians can get to work on the inside of the house from virtually the outset. The house may be occupied within six to eight weeks. That is an incredible saving in time, which can mean big savings in labour costs, rental and storage costs as well as a faster return on investment.

While a brick and mortar house is built by bricklayers, who are easy to come by, a timber-frame house is built by carpenters. With the exception of the chimney, all the structural elements above ground level are built using timber. The timber panels can be prepared off site, at a factory. This greatly reduces the work done on site and it usually takes fewer weeks as opposed to several weeks needed to build a masonry superstructure (Scot, 2007: 46). The erection time for a big timber-frame house was also witnessed on the television program "Extreme Makeover: Home edition" in which a house was built in seven days.

2.6 The advantages and disadvantages of brick and timber-frame wall building systems

Certain parameters need to be considered when constructing walls and these include:

- Structural strength: resistance to all likely loading, e.g. compression, tension, flexion and impact (Hodges & Simitses, 2005: 5).
- Structural stability: the ability of a structural assembly to carry loads and forces and determine how stable it will be over time (Hodges & Simitses, 2005: 5).
- Special requirements or in-service performance: resistance to seismic design, vibration or cyclical loads, accidental loads, door slamming forces, attachment of fitting, condensation and fire (Arnold, 1995: 16).
- Thermal performance: the result of the process through which the design, layout, orientation and construction materials of the building modify the prevailing outdoor climate to create an indoor climate (Becker & Wang, 2011).
- Acoustic performance: good sound insulation by walls and floors whereby the noise transmitted from both outside and inside the building can be controlled (Smit, 2003: 22).
- Water resistance and damp-proofing: the state when no dampness is allowed to penetrate on the inside of the external walls of a building for human habitation under normal weather conditions, while the damp proofing elements should comply with standards (Scot, 2007: 46).
- Durability: a period for which the specific material or structure fulfils its intended function satisfactory when subjected to normal use, assuming reasonable maintenance at regular intervals (Smith, 2008).

A comparison of advantages and disadvantages among the two systems is shown in Table 3.

Table 3: Advantages and disadvantages of timber-frame and brick wall building systems

	Advantages	Disadvantages
Timber-frame system	• Medium resistance to natural hazards • High construction speed • Medium innovative design and construction techniques	• Increased variety of components, equipment and skills • Intermediate level of accessibility of information for design, construction and maintenance • Compulsory use of wall finishing • Possibilities of Insects and fungi attacks
Brick and block wall system	o Reduced number of materials and components o Materials could be manufactured in situ o High thermal capacities (common in hot arid climates o Medium to high resistance to dampness o Medium construction speed o Accessible Information for design, construction and maintenance	o High quantities of the same material needed o It needs wall finishing to perform well o Needs support and centring during construction (verticality problems may cause the failure of structure)

(Ballerino, 2002).

2.7 Timber-frame wall

Timber-frame is probably one of the most commonly used materials for houses in the developed world. The timber frame panels are manufactured off-site, usually in a factory in a quality controlled environment, then loaded onto a truck, delivered to site and built within a matter of days. The structural members of the panels are solid timber and the outside of the frame is sheathed in OSB (Orientated Strand Board). This gives the panel enormous strength and durability. Timber-frame construction is a very fast way of building, which also makes it safer, less wasteful and very cost-effective (Arnold, 1986: 6). Timber-frame wall construction is erected by carpenters. Some negative aspects with timber construction remain, however, including:

- Maintenance and treatment are required.
- Deforestation on a large scale causes environmental problems.
- Storage needs to be covered.
- Sensitivity to fires and biological agents such as fungus and insects (Bellaloggia, 2009).

Figure 11: Timber-frame house (TFBA, 2011).

2.8 Concrete brick wall

Concrete brick wall can be hollow or massive with mortar or interlocked as a dry-stack masonry system. The masonry could be a non-reinforced or reinforced load-bearing wall, depending on local conditions and standards. Construction could achieve efficiency if well supervised and performed. The mortar can be traditional Portland cement or cement mixed with lime and/or rice husk ash. The preferred mix is that one which complies with SANS 50413-1. It must be soft and plastic so that it spreads easily and makes good contact without becoming too strong (D'Ayal, 2004). Masonry brick walls are constructed by bricklayers, and their negative elements include:

- Long term shrinkage of units placing wall under tension thereby increasing cracking.
- Mixing of mortar must be done under control to obtain good results or cracks may appear.
- Necessary to plaster and paint with waterproof painting.
- Requires on-site supervision.
- Methods of jointing must be controlled (Stulz & Mukerji, 1993).

2.9 Conclusion

The methods and materials used for the construction of this alternative wall construction system obviously differ from the brick and mortar wall system. The materials used to make up a brick wall are bricks, mortar and damp-proofing whereas the materials needed for timber-frame walls are oriented strand board, nutec panels, gypsum board and aerolite. This shows that timber-frame walls require more materials than masonry, which needs only four items. The timber-frame panels can be manufactured off site which can be quick and save erection time. With masonry brick and block wall construction, all the hard work is done on site. The primary elements that are essential for a house to stand, such as the foundation, floors, superstructure and roof are briefly discussed and the requirements by the South African National Building Association are emphasised. This shows that timber-frame and masonry brick construction differs only with regards to the construction of walls.

Research has shown that it takes a shorter time to build timber-frame walls than masonry brick or block walls. Timber-frame walls can be erected quicker and easier than the traditional brick and mortar method, and this clearly proves the hypothesis that timber-frame walls are constructed quicker and more easily than the traditional brick and mortar method. For this reason, timber-frame walls are appropriate for RDP houses.

Timber-frame is also a lighter form of construction which may be of great benefit to the foundations, especially where soil conditions are poor. The timber-frame wall technique can be used in RDP houses because it can speed up the housing delivery processes.

CHAPTER 3

3 TIMBER-FRAME BUILDINGS COMPARED TO CONVENTIONAL BUILDINGS

3.1 Introduction

Timber-frame construction is now becoming acceptable as a conventional method of building. Timber is both a trustworthy, traditional building material and one which is suitable for the application of advanced engineering and production techniques aimed at greater economy in the field of industrialised house building. In this chapter a timber-frame house is compared to a conventional building such as a brick house to prove the worthiness of the timber-frame house, to show that it can be durable, sustainable and as good as a brick and mortar houses, if not more.

According to (Brinkley, 2011), the key difference between masonry-built and timber-frame homes is the material used to build the load-bearing walls. In fact, a masonry house is constructed by bricklayers, building up both internal and external walls. The insulation inside the cavity between the two leaves of the external walls is fixed as the construction continues. The doors and windows can also be installed as the process continues. The construction of the external walls may stop at the first level to allow the carpenters to place the floor joist, though sometimes the floor is pre-cast concrete, craned into site. The bricklayers return to build up to roof level whilst the carpenters return to build the roof. If the design includes gable walls, the bricklayers return for a third time to complete the wall-building process.

In contrast, a timber-frame house is built by carpenters. With the exception of the chimney, all the structural elements above ground level are built using timber. The timber panels can be prepared off site, at a factory. This greatly reduces the work done on site and it usually takes only a few weeks as opposed to several weeks needed to build a masonry superstructure. The panels often have the windows and doors already in place. Some methods supply fully finished walls and roofs, but the typical timber-frame house has open panels; a semi-finished state that has to be insulated and cabled on site before the plasterers cover the inner walls with a wall-lining board (Scot, 2007: 48).

3.2 What are the differences?

In South Africa, almost all new houses have a foundation built out of concrete and a roof of timber. Thus, homes are, to some extent, both masonry and timber-frame. Nevertheless, there are obvious differences between conventional construction and timber-frame construction. These are the following:

- The main difference between the two types of construction is how the loads of the house are held. With timber-frame, the frame itself supports the weight of the house, while with brick and block; both the outer brick and the inner block take the weight. The external walls of a conventional house are normally 230 mm thick resting on concrete foundations. The external footings are 600mm x 200mm. The internal walls are at least 115mm thick and their footings are 400mm x 200mm high. The internal walls and floors also vary in construction. With timber-frame, dividing walls are plasterboard stud partitions, and floors are typically of timber (although ground floors can be concrete). With brick and block, dividing walls are usually solid block, and the floors are typically of solid beam and block construction (Wagner, 2005: 23).

- In timber-frame houses, light weight timber frames form the skeleton for the external and internal walls. This skeleton is erected on the substructure; that is, the foundations for the external walls, and either a cement slab or timber suspended floor for internal walls. The roof is supported on and anchored to the external wall framing (NTDC, 2001).

- Window and door frames are mounted in the external frame before cladding with a single leaf of non-load bearing brickwork or other acceptable cladding materials. Cladding materials can also be stone, cement render, tiled hanging, wood cladding, and composition board and plastic. Internal walls are cladded with gypsum board, timber or any other approved and acceptable cladding material (Lubber, 1986: 23). Windows in timber-frame houses are fixed on the inner timber-frame, rather than to the brick outer skin, which results in a deeper external sill. This feature helps to distinguish between the two types of construction from the outside.

- According to Thallon (2000: 25), with timber-frame, only dry-lined plasterboard may be used for the walls and the ceilings, while with brick and block, wet plaster may also be used. With dry-lined plasterboard, wallpaper may be put up immediately, whereas with wet plaster the waiting period is six months. Dry-lined plasterboard walls may sound hollow when tapped, while wet plaster on masonry walls makes for an all-round heavier, more solid structure.

- The weight is important to good sound insulation; sound waves are vibrations, and it is hard to vibrate a heavy wall. Solidly built walls offer an obvious advantage, while lightweight plasterboard-finished walls require more care. Sound insulation can be improved by suspending only mineral fibre between the stud partitions, which will absorb some of the sound (Domone, 2001: 6). Although solid walls give good resilience against airborne sound, such as music and voices, they offer little in resistance to impact sound, such as footsteps. Concrete floors are particularly prone to impact sounds, but laying a resilient layer, such as a carpet, onto the floor will guard against this.

- Isolating two structures is also important for good sound insulation, as it breaks the sound path. Cavity walls in both house types perform this function. Floor constructions can also be isolated with the use of a floating floor system. The two parts are separated by mineral wool, which gives resistance to both impact and airborne sound. A timber floor construction is lighter than a concrete floor; therefore to achieve the same levels of sound insulation, additional layers of board can be fitted to increase the total weight. An airtight structure is also important for good sound insulation. It is pointless spending money on sound insulation in either a timber-frame or brick and block house, if the sound can pass around a partition through a poorly sealed window, door or service duct (Domone, 2001: 6).

- According to Lancashire (2008) both timber-frame and brick and block houses have to comply with energy efficiency targets set out by the Building Regulations. The minimum U-value (insulation level for each component of the building) required for exposed walls is 0.45W/m^{2}K. A standard brick and block house offers a U-value of 0.43 W/m^{2}K; whereas a standard timber-frame outperforms the mandatory ratings, achieving a U-value of 0.41 W/m^{2}K. The latter can be improved to 0.29 W/m^{2}K by increasing the frame size from 90mm (standard) to 140mm (enhanced), which increases the space for insulation. This gain is at comparatively little extra cost.

- For conventional houses, plans are computerised. Builders can hand out quotations on a large number of different house plans within minutes. For timber-framed houses no such facilities exist. House builders work from quotations for brick houses as a basis, and add onto those prices for timber-frame houses (Scot, 2007: 22).

- From a builder's point of view, whether it is a future house owner or a speculation house building company, the time it takes to complete a house is quite important. A private house owner can save on alternative dwelling costs, and interim interest, whilst a civil servant can do so on his/her subsidy. Similarly, building companies can save the interest and possess a more favourable cash flow if time can be saved on the building of a house (Lubber, 1986: 25). Builders indicate that it takes about sixteen weeks to complete a conventional house. A timber-frame house can be completed in seven days. For a building company, it was calculated that after nine weeks, provided that the first houses are sold, no further loans are needed to finance a building project of twenty timber-framed houses, which can be completed in ten weeks. For the same company, a building project of twenty conventional houses will take twenty weeks to complete. Provided all the houses are sold when completed, the cash flow situation will be positive for the company after twenty weeks (Lubber, 1986: 25).

- A timber-frame house is usually wind and watertight by week five of the build; thus, while the bricklayers work on the outside, work can begin on the internals. By contrast, a brick and block house is not normally wind and watertight until around week nine or ten, so work on the inside starts later in the building process (Time Frame Builders Association, 2011).

- A timber-frame house gladded with bricks on the outside, will be as fire resistant as any other conventional house. The literature on tests done in the United States of America and Great Britain show that once a fire is out of control in one room of the house, the fire will spread from there after about half an hour. This time lapse is about the same for a brick house. All materials used for the construction of a timber-frame house have to meet specific requirements and specifications. If used correctly, all materials will last a lifetime (Lubber, 1986: 25).

- Because of the light-weight construction of a timber-frame house, especially when no bricks are used, this building method is quite attractive for areas in which the soil is unstable. Internal walls rest on the floor and not on a foundation as in a conventional brick house, and walls can be moved or taken out with much less effort than those for a conventional house. An additional door can be fitted in an internal wall by sawing the opening with any handy man's saw (Lubber, 1986: 26).

- Owing to the inherent unit strength, timber-frame houses are not affected by shifting ground, which causes cracks in masonry walls. Shrinkage cracks caused by drying out of conventionally constructed walls are also avoided. Face brick finish and plastic rainwater drainage systems further reduce maintenance. Timber has a better strength-to-weight ratio to most building materials and this includes concrete and steel. Timber-framed homes can therefore be built in areas where soil movement occurs because of the varying water content. The light-weight nature of a timber-frame structure, in relation to its strength, and combined with its resilience, makes it able to withstand shock and stress, which would severely damage a conventional structure (McRae, 2010).

- With a growing concern for the environment and global warming, it is in every one's interests to keep energy demands as low as possible. Building energy efficient, well-insulated homes to reduce fuel consumption and running costs is essential. However, what many home builders do not realise is that even before a house is built, the materials used in its construction have a Product Energy Requirement (or PER), which refers to all the energy (expressed in kilowatt-hours) that goes into producing and transporting a product (United States of America. Department of Energy, 2000). Timber has the advantage of being produced by natural means, such as sun, water and air; thus its energy requirements are all in the extraction and transportation of the logs from the forest. A timber-frame wall in a typical three-bedroom detached family house has a PER of around 7,450kWh, while a concrete block wall in the same property requires 1.7 times more energy, with a PER of around 12,816 kWh (Scot, 2007: 22). Timber is also the only renewable structural building material available, and the majority of timber-frame package companies invest heavily in well-managed replanting programmes.

- All major insurance companies in South Africa are insuring timber homes. More importantly, there is no additional premium for insuring a timber home as opposed to insuring a similar brick and mortar home. Country Timber Homes is a certified member of the Time Frame Builders Association (TFBA), which also extends insurance to timber frame home owners (TFBA, 2011).

3.3 Conclusion

From the above-mentioned discussion, there are many differences between timber-frame and brickwork buildings. Timber-frame buildings are as good as conventional buildings, if not more so. The world of today is taking stringent measures to keep the cost of living down and there is worldwide interest in maintaining energy demands as low as possible. Therefore, building energy efficient, well insulated homes to reduce fuel consumption and running costs would be of great benefit. A timber-frame home uses less energy as it is usually warm in winter and cool in summer. Timber-frame construction honours the environment; being made from a natural plan, it is a green building method. During its production it does not cause hazards to the environment like its counterparts.

Timber-frame houses are functional like conventional houses. They perform the same mandatory functions. The main difference is that a timber-frame house uses timber on its walls while a conventional house uses stone or brick on its superstructure. They can both use the same foundations and the same type of roofing. Timber-frame walls perform well where the soil is unstable and cannot easily be affected by the shifting ground like a masonry brick wall which usually forms cracks.

Timber-frame does not rely on the weather as much as more traditional techniques; that said, in fair weather, a framed house can be completed anywhere between 5-10 days.

CHAPTER 4

4 THE ADVANTAGES OF WOOD-FRAME CONSTRUCTION

4.1 Introduction

Today, buildings are not constructed to protect men from natural elements and wild animals only, but in such way that they are intended to create a healthy living environment and a degree of comfort for all occupants. In addition, there are many factors that can influence a homeowner's decision on the kind of end product he/she needs. These factors include price, quality, durability and image.

It is perhaps not surprising that certain materials such as bricks and concrete blocks are favoured when choosing a suitable building material for a house. This is because the properties and characteristics of these materials are known. It is therefore necessary to elaborate on the advantages and benefits of using timber-frame for houses. The disadvantages of using timber will not be discussed in this chapter. Building materials are preferred in terms of the sustainability of a building material. This needs to be considered in terms of its energy use, its impact on the carbon cycle and its environmental impact. Timber building is part of future energy-efficient building. Wood is sustainable, carbon dioxide (CO_2) neutral and is a highly effective insulator, creating excellent living conditions. One specific advantage of wood is its ability to reduce energy use. Timber construction has a higher heat insulation value than conventional construction methods, even with lower wall thickness. An external wall constructed using timber may have only half the thickness of a brick or concrete wall and yet provide double the thermal insulation (Anderson & Oberschulte, 1992: 4).

The key aim of this chapter is to discuss timber-frame properties and their advantages. This assists not only homeowners but policy makers, developers and contractors to choose the most suitable wall material for low income housing projects.

4.2 Wood is good for the environment

As a construction material, wood causes the least impact on the environment compared with concrete or steel. It makes sense that building with wood, a renewable and natural resource would have environmental benefits. This common sense judgement is now being substantiated with scientific data. Life Cycle Assessment (LCA) is a 'performance based' approach used to assess environmental impact. LCA quantifies the overall effects of a product, process, or activity on the environment over its life time. (Central Mortgage & Housing Corporation, 2009). This includes material extraction, manufacturing, transportation, installation, use, maintenance, and disposal or reuse. Life Cycle Assessment has shown that wood products offer clear environmental advantages over other materials. When considering the environmental impact using Life Cycle Assessment, wood outperforms steel and concrete in the following ways:

- Embodied energy in production;
- Emission of greenhouse gases;
- Release of pollutants into the air;
- Generation of water pollutants; and
- Production of solid wastes (Central Mortgage & Housing Corporation, 2009).

4.3 Energy efficiency

If wood is burned as an energy source, the carbon stored in the wood combines with oxygen and escapes into the atmosphere as carbon dioxide. With sustainable forest utilisation, the carbon dioxide released is re-sequestered by the re-growing trees and the cycle is closed. Thus, the concentration of carbon dioxide in the atmosphere does not increase (Swiss Federal Office of the Environment, 2009).

Wood is 400-times less heat conductive than steel and 8.5 times less conductive than concrete; therefore homes built with wood framing take less energy to heat and cool. Wood construction can meet the energy codes of all climates. In extreme climates, such as Alaska and the Canadian Arctic, the adoption of double wood-frame wall systems keeps homeowners warm when temperatures drop in winter to -40°F. New energy code requirements in several European countries have prompted a switch from traditional masonry construction to wood (Western Red Cedar, 2012).

4.4 Timber-frame is a renewable material

As the world's only renewable building material, wood cannot only be recycled, but regenerated as well. What is more, trees provide benefits to the environment while they grow, taking in carbon dioxide and releasing oxygen (Central Mortgage & Housing Corporation, 2009).

Wood siding substitutes, such as concrete, vinyl and aluminium are manufactured from materials extracted from the earth and once removed, they can never be replaced. When substitute sidings age beyond their useful life, they become part of landfills (Central Mortgage & Housing Corporation, 2009).

4.5 Seismic quality

Light-frame construction can resist some shear or dynamic loads and, loading under its limitations in an assembly plant, it would crumble. The seismic resistance of timber-frame structures is relatively high, provided the quality of materials and construction are satisfactory. Generally, the building tends to be lightweight, especially when compared to brick or stone, which helps reduce earthquake forces on the structures. In addition, because of the relatively large number of walls and the use of numerous nailed connections, wood frame houses have traditionally performed well in earthquakes so that deaths and serious injuries are rare (Arnold, 1995: 4).

Timber-frame is a more precise building method resulting in less wastefulness; the nature of construction is such that it allows building right up to trees and shrubbery whereas with brick construction, this is not the case. The seismic performance of wood-frame construction is greatly enhanced by its non-structural components (Central Mortgage & Housing Corporation, 2009). The architectural finishes and numerous non-load-bearing walls increase the amount of energy the building can dissipate during an earthquake because these additional systems absorb energy as they are damaged.

4.6 Flexibility

The flexibility of timber construction methods makes it easier to vary a building's orientation on site, its floor plan, the number of rooms, the interior design and the overall appearance, while timber's thermal efficiency means walls can be slimmer, releasing up to 10% more space than other building methods. External finishes depend on personal preference; walls can be clad in wood, tiles, brick, or plastered; roofs can be clad in tiles, slates, concrete or metal (Rackard, 2013).

Wood's immense flexibility as shown in Figure 12 where it forms a circular structure may make it the best choice for specific and the easiest construction material for renovations. Wood buildings can be redesigned to suit changing needs, whether this involves adding a new room or moving a window or door. Making changes is virtually impossible when walls are poured in concrete or when expensive and time-consuming reworking of the construction material is needed off site (Grand Solution Manual, 2013).

Figure 12: Timber Structure to show that not only wood will produce straight panels but also circular panels (Smit, 2003).

Wood is lighter than other construction materials such as masonry, concrete or steel; thus it is easier to transport. It can be sized and cut on site, reducing the number of workers and the amount of heavy lifting equipment needed on a construction site (British Colombia Wood, 2009).

4.7 Durability and Adaptability

Light-frame construction can be very durable. However, the life span of a structure constructed of wood, is relatively minuscule to that of one constructed of concrete or masonry.

Homes that are tough and durable, beautiful and practical, timber-frame houses have walls made of specially treated timber frames, lined with either reflective or blanket insulation material, encased in a weatherproof cladding on the outside and a fire-rated lining material on the inside. The outer 'skin' on a timber-frame home is not only beautiful, but it is also very tough, weather resistant, impact resistant, corrosion resistant and ultra violet (UV) light stable. It takes paint or varnish beautifully, providing a structure that needs very little maintenance over the years (Smith, 2008).

As proof, the world is full of examples of ancient, wood frame buildings that remain structurally sound such as Norway's beautiful Stave Churches, which were built hundreds of years ago and are still in use today. In fact, extended service life is one of the key advantages wood offers as a building material (British Colombia Wood, 2009).

4.8 Strength

Timber is strong in both tension and compression and has a high strength to weight ratio. As with both steel and concrete, timber has physical limitations, but once these are accommodated, it is possible to design structures of almost any size with it. Australia's largest timber spans 100m, while buildings and bridges in other countries, such as Europe and the USA span much further (SALMA, 1989: 46).

4.9 Aesthetic quality

As a building material, wood is incomparable in regard to its prettiness. What appeals the most about wood is an aesthetic beauty as shown in Figure 13, which gives off a timeless elegance and, durability as well as the way timber lends itself to craftsmanship (Spencer, 1993: 71).

Figure 13: Timber-frame house in Bethlehem displays a timber-frame beauty (own information)

4.10 Acoustic Performance

A timber-frame house is a warm, comfortable and safe place in which to live. Wood is a natural, renewable resource that combines strength with versatility, and is an excellent insulator. Timber-frame buildings can offer a better level of acoustic and thermal insulation making them quieter and more comfortable to live or work in than other forms of construction, if insulated well (Smith, 2008).

4.11 Insulation

Timber-frame, as a highly insulated lightweight structure, follows the principle of conserving, within the external shell, the heat generated therein and in also preventing the external cold and heat elements from penetrating and influencing temperatures internally; that is to say, it keeps heat in, and keeps heat and cold out. With an insulated, solid masonry construction, before heat generated internally can be enjoyed, it has to warm up the structure. Once warmed, it will assist in keeping the internal area warm. This however, takes a considerable time to achieve. An easy experiment to prove this can be undertaken by merely putting a hand on an external wall inside a masonry built house on a cold day when the inside temperature is acceptable. The wall will feel colder than the room (Burchell, 1984: 83).

4.12 Less wastage of materials in timber-frame construction

According to Burchell (1984: 85), with a high element of prefabrication, fully engineered and designed on a module to suit finishing materials, cutting and wastage of materials on site are kept to a minimum. The savings on waste materials is clearly evident to the experienced eye when seeing a well-run timber-frame housing site.

4.13 Dry Construction

Timber-frame is a form of dry construction where there is no drying out period and where less water is required. Wet cracks do not occur in this type of construction, whereas they are fairly common in wet construction. Dry construction can continue even in inclement weather, such as in rain or snow (Kothmann, 2009).

4.14 Renovations and Alterations

According to Rudd (2006: 55), because timber frame is a light-weight structure, old structures are easily able to accommodate the weight of the new section. A structural engineer would need to be involved in the planning stage, but once he/she has approved the existing building as being able to cope with the additional load, it is an easy, quick and sensible way of extending a home. More often than not, occupants not have to move out of the house during the construction phase. Houses need to be able to adapt to changes in the life stages of their occupants, as well as to wider changes in the way people live.

A loft conversion is possible only with timber, where the low net weight and exceptional strength of wood elements ensure adequate load-bearing, even over considerable spans. Timber construction reduces the building time for extensions, and the light weight of the components means they can be delivered to sites even with severely restricted access. With proper planning, not only windows and doors, but also many domestic installations can be integrated at the prefabrication stage (Rudd, 2006: 56).

4.15 Life expectancy of timber-frame houses

Today the average service life of a wooden house is between 80 and 100 years, with some builders guaranteeing a lifetime of 125 years. In fact, timber houses can last many hundreds of years, as can be witnessed from the many surviving examples from the middle ages.

In the Western States of America, over 90% of all one family dwellings are constructed of timber-frame. In Scandinavia, the figure is 80%. How long will timber-frame last? This is a fairly common question asked when discussing timber-frame houses. The answer is that a timber-framed house, properly designed and constructed, can last for many years if treated well from fungus and termites. It will last as long as the same house properly designed and constructed in traditional masonry (Burchell, 1984: 14).

Table 4: Summary of some of advantages and potential problems of timber construction

ADVANTAGES OF TIMBER CONSTRUCTION	POTENTIAL PROBLEMS OF TIMBER CONSTRUCTION
1. Quick erection time	1. Traditional procurement process
2. Reduced site labour	2. Additional design and engineering time
3. Reduced time to weather the structure	3. Modification of general arrangement drawings if based on masonry construction
4. Low embodied energy if constructed in local timber	4. Lack of experience of following trades.
5. Recyclable	5. Lack of experienced builders and trades
6. Low volume of waste on site requiring removal	6. Susceptibility to decay of timber when exposed to excessive moisture.
7. Can be built to exceed 60 year design life	7. Deficiency of site quality control
8. Energy efficient when constructed to current standards	8. Combustibility of timber requires vigilant quality control to achieve required fire rating of separation and compartment walls.
9. Fast heating due to low thermal mass	
10. Reduce construction waste through efficient control manufacturing	
11. Reduced time on site reduces environmental nuisance and disruption to local residents.	
12. Reduced construction time translates reduced risk exposure	

(TFBA, 2011).

4.16 Conclusion

It is perhaps not surprising that building with wood has many advantages. In this chapter the effectiveness of building with timber has been proved. Wood is lighter than conventional construction materials such as concrete, masonry and steel. Its light-weight properties mean that it can be delivered to sites with restricted access, thereby reducing the number of workers and the amount of heavy lifting equipment needed on a construction site. The light-weight and modular structure of timber houses, make it easier to add an extra floor or an extension. This is a simple practice and the dry lining used in timber construction means less waste and moisture.

Unstable soil conditions such as clay and dune sand that require additional re-enforcement when building with bricks and mortar are suited to timber construction. Timber buildings are warm in winter and cool in summer. Their thermal efficiency is as much as 6 to 8 times greater than that of masonry construction. Timber buildings are environmentally friendly and therefore ideally suited to mountain-side plots, and eco-sensitive areas resulting in very little disturbance to the existing vegetation. Furthermore, timber buildings minimise site excavation and costly access with heavier materials.

The use of timber-frames in RDP houses is possible because of the many advantages that timber displays. Timber has many qualities which are advantageous.

CHAPTER 5

5 LOW INCOME HOUSING IN SOUTH AFRICA

5.1 Introduction

According to the United Nations more than one billion people do not have access to adequate housing, and yet housing is recognised as a basic human need (UNHABITAT, 2001: 6). In an effort to realise this right, the South African government has embarked on a housing program to replace shacks with low cost housing for families whose sole provider is unemployed or whose combined monthly household income is below R3 500 per month. These houses are called Reconstruction and Development Programme (RDP) houses. They are usually built on the outskirts of cities where large pieces of land are available. They consist of simple single storey structures, constructed with bricks and mortar. Each is big enough to house a single family.

The South African government, through the RDP system has provided around three million homes to South Africans since the end of apartheid (1994). Those living in shacks on less than an inflation-adjusted amount per month are entitled to apply for RDP housing. The waiting period can be as much as 10 years (Ali, 2013). Only South Africans are eligible to apply and there are certain requirements that one needs to comply with before receiving a RDP house.

The government is however, faced with difficulties of delivering quality low income houses in the specified time and budget, due to the rapid rate of urbanisation. This again is the consequence of large numbers of poor and unemployed people migrating from rural areas to the major cities, seeking employment. On realising that they cannot afford to buy or rent houses, they opt to move into shacks or tents in informal settlements. Occasionally people who have benefited from RDP houses will sublet their properties and move back into their shacks. Their spouses might reapply for an RDP house and in some instances they will get another house in this way. In some cases the houses are of poor quality and need urgent repairs. These cases cause delays for people to obtain houses on time, making the backlog even more difficult to eradicate.

This chapter examines housing in line with international bodies such as the United Nations and the South African government's approach to low cost housing. It further investigates some of the problems that lead to the slow delivery of Reconstruction and

Development Programme houses. Also under investigation are alternative building materials or technologies, which should all meet the required acceptable levels of quality, norms and standards, while still facilitating rapid housing delivery.

5.2 Housing as a human right and the South African Constitution

A lack of adequate housing in the cities of developing countries is one of the most pressing problems of the 21st century. According to the United Nations Habitat (2001), over one billion people are estimated to live in "inadequate housing conditions in informal settlements without security of tenure and in conditions that can be described as life and health threatening". Between 40% and 70% of the population in most African cities live in informal settlements (Roseland, 2000).

Section 26 of the Constitution of the Republic of South Africa, 1996, states that everyone has the right to "access to adequate housing". It is the government's duty to take reasonable legislative and other measures, within its available resources, to achieve the progressive realisation of this right. Provincial legislatures and local government share the responsibility with the national government for the delivery of adequate housing. The Constitution also states that "No one may be evicted from their home, or have their home demolished, without an order of court made after considering all the relevant circumstances. No legislation may permit arbitrary evictions" (South Africa. Department of Local Government & Housing, 1994).

Section 27 (c) Chapter two of the Constitution of the Republic of South Africa of 1996, states that everyone has the right to social security, and if they are unable to support themselves and their dependants, appropriate social assistance will be provided (South Africa. Department of Local Government & Housing, 1994).

5.3 Reconstruction and Development Programme (RDP)

The Reconstruction and Development Programme is a South African socio-economic policy framework implemented by the African National Congress (ANC) government of Nelson Madela in 1994 after months of discussions, consultations and negotiations between the ANC, its alliance partners the Congress of South African Trade Unions and the South African Communist Party, and mass organisations in the wider civil society (Pillay & Naude, 2004).

The Reconstruction and Development Programme (RDP) is an integrated, coherent socio-economic policy framework. It seeks to mobilise all the country's resources towards the final eradication of the results of apartheid and the building of a democratic, non-racial and non-sexist future. It alleviates poverty and provides better social services to previously disadvantaged South Africans (White Paper, 1994). The RDP sought to:

1. Meet the basic needs of the population (including shelter);
2. Develop human resources;
3. Build the economy;
4. Democratise the state and society (Rabbani, 1994).

The RDP endorses the principle that all South Africans have a right to a secure place in which to live in peace and dignity. Housing is a human right, as stated in Section 26 of the Constitution of the Republic of South Africa of 1996. One of the RDP's first priorities is to provide for the homeless. At this time, the government has managed to provide around three million homes to South Africans since the end of apartheid (Ali, 2013).

5.4 RDP housing allocation

Every South African citizen is entitled to a roof over his or her head. This is the government's mission through RDP housing which provides adequate housing for all South African citizens as a priority to ensure that the basic human rights to shelter, water, electricity, health care, sanitation and access to education are met. This mission is implemented through the building of cement brick houses to replace the shack dwellings that are seen all over South Africa's townships.

A person is eligible for a housing subsidy subject to the following criteria;

- Household income not exceeding R3 500 per month;
- South African citizen or permanent resident;
- Legally competent to contract (over the age of 21 and of sound mind);
- Married or cohabiting;
- Single with dependants;
- Acquiring a home for the first time and
- Has not previously received a housing subsidy (Pillay & Naude, 2004).

The following are requirements for application for an RDP house at the municipal office:

- Certified copy of applicant's Identity Document.

- Certified copy of the spouse or partner's ID (Identity Document) when the applicant is married or cohabiting.
- A copy of the death certificate in the case of a widow or widower.
- The applicant and spouse or partner must provide proof of income (payslip) if employed.
- The applicant and spouse or partner must be South African citizens with legal ID documents.
- Certified copies of dependant's birth certificates or ID documents.
- Applicant must sign an affidavit.
- Affidavit must be signed by spouse or partner (Greyling, 2009: 8).

When the housing subsidy policy was launched in 1994, government promises of delivering "one million houses in five years" were heard by many as political posturing and post-democratic bravado. And yet, the sceptics were proven wrong as one million houses were indeed delivered, albeit within seven years. By 2010, the Department of Human Settlements estimates that it has delivered somewhere in the region of 2.8 million houses to qualifying beneficiaries throughout South Africa (Tomlinson, 2007). Nonetheless the country's housing deficit has grown to 2.1 million households, the number of informal settlements has skyrocket to more than 2, 600 sites, and there are 1 million urban poor families living in simple shacks in informal settlements (Tomlinson, 2007). This leaves the Department of Human Settlement faced with a housing backlog that needs to be eliminated.

5.5 Housing backlog

In 1994, South Africa first democratically elected government inherited the housing backlog of 1.2 to 2.5 million units as well as the rapid expansion of informal squatter settlement (Karseens, 1999). Current estimates of the backlog stand at about 2.1 to 2.5 million units. As at September 2011, it was estimated that approximately 12 million people were still without adequate housing. Though consistent and reliable statistics on housing are somewhat irregular, 12.8% of South African households lived in a RDP or state-subsidised dwelling, while 13.5% of households have at least one member of the household on a demand database or waiting list for state-subsidised housing according to the 2009 General Household Survey (Masilela, 2012). Some of the reasons for this housing backlog are natural population growth, a trend towards urbanisation, high employment, and inadequate delivery to address historical backlogs. According to the

Department of Local Government and Housing (2005:8) low levels of delivery are caused mainly by insufficient resource allocation and under-spending due to capacity restraints. As a result the backlog remains difficult to remove.

Nonetheless, the Department of Human Settlements has recognised that the backlog in South Africa is not being reduced fast enough and has committed to increase the rate of delivery with a view to wiping out the backlog by 2030. The fastest rate of delivery can also be acquired by using alternative building materials rather than traditional masonry bricks and mortar. Timber-frame as wall system might give a practical solution to slow delivery and poor quality. This is due to the fact that wood is an economical alternative to higher priced structural components, such as steel or concrete while it can also be constructed faster.

5.6 Building material for RDP houses

Building components and building materials have different service lifetimes regarding aesthetic, economic, functional, physical and technical performance over time (Civil Engineering Portal, 2012). It is therefore important to choose the appropriate materials for a house so that durability, stability and aesthetic properties can be achieved.

All RDP houses are 36m² (square meter) and consist of strip foundations. Walls are built of bricks or concrete blocks, depending on the local availability of building material. Floor construction is the ordinary concrete surface bed with laminated vinyl tiles as floor finishes. The roof is corrugated iron roof sheeting. Walls and foundations play an important role in the stability of the structure as well as in the percentage of the total cost and construction time (Civil Engineering Portal, 2012).

Since walls are vital in the construction of a house, alternative wall techniques such as timber-frame walls may be considered on RDP houses. The hypothesis is that timber-frame walls are very cost effective, economic and quick to construct. This may therefore help to eradicate the slow delivery of houses as cost reduction is achieved by the selection of more efficient materials or by an improved design.

5.4 Conclusion

Shelter is considered as one of the basic human needs, yet even today most people still live in inadequate housing such as informal settlements and shacks. The South African government has sought to address the housing crisis directly through the delivery of subsidised housing for low income households, which is fulfilled through the Reconstruction and Development Programme (RDP). The South African government provides a subsidised housing unit to eligible households. Eligibility hinges on people with dependents, resident in South Africa, earning less than R3 500 per month, and who had never owned a home before. These units are usually erected with bricks and mortar.

Although the goal of delivering one million units in five years was realised, the SA government is still faced with housing problems. A large and ever-increasing housing backlog is evident. The causes of this include urbanisation, high unemployment and inadequate delivery to address historical backlogs. As a result housing authorities struggle to cope with severe housing shortages. There is clearly a need to use a building material that is fast to erect, durable and cost effective and the idea of using timber-frame walls as alternative to traditional masonry bricks and mortar walls on RDP houses was prompted.

CHAPTER 6

6 COMPARATIVE COST ANALYSIS OF TIMBER-FRAME AND BRICK WALL CONSTRUCTION

6.1 Introduction

The slow delivery of houses (RDP) and the growth of slums in South Africa need to be dealt with. The Department of Human Settlements (RSA) has undertaken investigations in respect of alternative building technologies which will have all the requisites for quality, norms and standards and still facilitate rapid housing delivery. Building cost-effective houses may help to improve housing delivery. As a result timber-frame walls could come to the rescue, if investigated more thoroughly and given a chance.

Wood light-frame construction is known for its great economic value. Its materials are abundant, easily obtained, and there is a minimum amount of labour needed for construction (Pringle & Bruce, 2011).Timber-frame houses have low running and maintenance costs, even over a long period of time. Not only will timber-frame construction make good economic sense, it can also make social sense as well, as there will be a reduction in defects and accidents. This is mainly because a timber-frame house can be pre manufactured in the factory (Pringle & Bruce, 2011). In this regard, timber-frame should be the preferred building techniques for low income housing.

Timber cost, like any commodity varies hugely. Factors, such as the size of the building, how complicated the structure is going to be and the specification will play an important role in how expensive the wood will be. Additionally, the building materials that make up the timber-frame structure such as gypsum board, insulation and cladding materials will play a vital role in the cost of the timber-frame wall (Holz, 2010: 19). Other aspects that affect the cost of the wall will be labour, overheads and management costs. There will be fewer labourers needed to erect a timber-frame wall than for that built of brick and mortar.

In this chapter, the cost of constructing a masonry brick wall and a timber-frame wall is compared. The two walls were of the same floor area 50m^2 (see Appendix C). For the purpose of the research, a wall of 6.250 m (metre) in length and 2.550m in height (a wall of 15.94 m^2 in total) is used as an example to discuss and explain the different costs and cost implications. The method of price per square metre is used. It consists of multiplying the wall area (gross area less area of openings) by known quantities of material required per square metre. The different rates were evaluated to determine which method of construction is cheaper. No waste factor was taken into consideration. The purpose of this cost analysis is to prove that using timber-frame as alternative to a masonry brick and mortar wall in RDP houses can be cost effective, as well as an economic solution to the slow housing delivery. In addition to the above hypothesis, these houses will be of good quality and can be delivered on time.

The case study (timber structure is cheaper than steel structure) by Keith Kothmann (2009) will be analysed to prove that not only is timber-frame structure cheaper than masonry brick and blocks but it is also less expensive than a steel structure. Kothmann's study shows clearly that wood frames are a better solution to the expensive conventional materials, which are also non-renewable.

6.2 The comparison of a masonry brick wall and a timber-frame wall

The comparison of the cost of masonry brick and timber-frame wall was analysed in order to find which method is the cheapest. The cost implication of the project was noted. The most economical solution would be the one preferred to build RDP houses.

6 .2 .1 The cost of a wall constructed with the masonry brick and mortar method

The wall area method of estimating will be used because of its simplicity and accuracy. It consists of multiplying the net area of 110.69 m^2 - 17.63 m^2 = 93.06 m^2 (gross area less the opening) by known quantities of material required per square metre. In this exercise, the wall was without windows and doors. The prices that were used for this exercise were obtained from Cashbuild in Bethlehem Free State on 17 November 2012.

A Sample of brick wall of 220mm Appendix C (6.25mx2.55m) = 15. 94 m² will be used.

Factor calculations - see Appendix C (Afrisam, mixes of all concrete)

Mortar in a brick

0.220mm + (0.085mm x 2 faces) = 0.39 mm x 0.110mm = **0.0429**/ Brick wall

Material (mortar)

Sand 1 .22 x 0 .043 (factor per m³) @ R 236.75 =	R12. 42
Cement 8.33 x 0.043 (factor per m³)@R 71.05 =	R 25.45
Labour mixing 9 x 0.043@ R19.00 =	R 7.35
	R 45.22

Material bricks

Brick force (2mm/15mm) @ R14.87 per m² =	R14.87
Brick Cement Stocks 105 @ R980/1000 =	R102.90
	R104.64

Labour Building

Bricklayer 1.41 x1.20 @R30.00 =	R50.76
Labourer 1 .41x1.20 @ R18.00 =	R30.46
	R81.22

Total	R231.08
Plant (1%) =	R2.31
	R233.39
Overheads (4 .5%) =	R10.50

TOTAL COST OF THE BRICK WALL = R243.89 per m²

6.2.2 The cost of wall constructed with timber-frame wall system

The prices that are used for this calculation were obtained from Timber Home Kits in Johannesburg on 03 November 2012.

• Frame:

Galvanized drywall channel@ R201.65 per no 1- per lm: R201.65 x 6.00m = R1209.9
(76mm x3.6mm)
Galvanised head channel@ R233.70 per No 1-per lm: R233.70 x 2 = R467.40
(76mmx3.6mmx3m long) R1677.30

Drywall Stud
(51mmx2.7mm) @ R39.52 per No 1- no 1 per lm: R39.52x6.00 = R237.12
Drywall track @ R42.20 per No1- per lm: R42.20x2= R84.4
(51mmx 2.7mmx 3m long) R321.52

• Internal Cladding:
12mm BPB Gypsum board used @ R170.32 x 6No = R1021.92
Internal walls (2.4m x 1.2m Wide)

• Insulation:
50mm Aerolite insulation in @ R17.71per m2 x 165.94 m² = R2938.79
between panels

• External cladding:

OSB Board Chipboard@ R282.41x6No = R1694.46

= R7653.99/15.94
m²

Total cost per m² = R480.17 per m²
Add:
Labour Building
Carpenter 1.41x1.20@R30.00 = R50.76
Labourer 1.41 x1. 20 @ R18.00 = R34. 46
R565.39

Plant (1%) =	R5.65
	R571.04
Overheads (4 .5%) =	R25.70
Total cost m²: =	R 596.74 per m²

6.3 Cost comparison of construction of RDP house walls

The cost of the wall of a RDP house will add up to R 22 696.40 (R243.89 per m^2 x 93.06 m^2) if the RDP house is constructed with bricks, while a timber-frame will be R 55 532.62 (R596.74 per m^2 x 93.06 m^2). The cost includes material and labour. It is based on external and internal walls and not the other building elements, such as roofs, doors, windows and foundations. Other factors that contribute to the price of a house, such as electricity and water were not considered.

6.4 Kothmann Case Study

As the South African government cannot deliver RDP houses on time for the low income groups in South Africa, other options should be investigated. Preference should be given to a wall construction that is faster, affordable, safe and easy to maintain. Wood-frame construction meets all of these requirements, and is proving to be a more cost-effective option especially when compared with other wall systems. To emphasise further the cost effectiveness of timber-frame, Keith Kothmann's 2009 study was analysed. The study was chosen from other studies because the purpose of this research is to find alternative construction that is easy, fast and can reduce the building costs. At the same time, the quality and durability of the structures will not be compromised. Moreover Keith Kothmann's case study is based on actual experience and not theory, which makes it more reliable. This study shows that timber-frame is less expensive than steel-frames.

6.4.1 Case study (timber structure is cheaper than steel structure)

Keith Kothmann (2009) prepared a cost analysis for a one floor, 73,557 square metres elementary school which had been built in 2002 in Flower Mound, Texas in the USA. Kothmann is a Certified Professional Estimator, an engineer and former general contractor from Fort Worth, Texas, with more than 25 years of construction experience.

To provide a fair comparison with no design or appearance changes except the gym ceiling, Kothmann compared three wood-framing options to the as-built post and beam steel structure. His results showed that the initial cost of construction could be substantially reduced by changing the superstructure of the school from steel to wood. Kothmann's study also determined that the life cycle savings realised from the additional thermal resistance provided by the wood roof system would save the district almost $150, 000 (R1,407,000.00) equivalent or more per year in energy costs. This is in addition to the reduced energy consumption from the wood framed walls (Kothmann, 2009).

KOTHMANN'S FINDINGS

Table 5: Kothmann's findings

	Savings per Square metre	Total Savings	% Savings over Steel	Annual Energy Savings with Wood Walls	Completion Time Savings
Option A: Wood roof framing with metal studs (Type IIIA) • Steel columns remain • Change from steel to glulam beams • Change from steel bar joists to wood I-joists • Change from metal deck to rated sheathing	$23.6	$1737970	13.92%		Saves 2 weeks
Option B: Wood roof framing with wood studs (Type VA) • Steel columns remain • Change from steel to glulam beams • Change from steel bar joists to wood I-joists • Change from metal deck to rated sheathing	$28.2	$2071600	6.6%	$13000	Saves 5 weeks
Option C: Wood roof system with load-bearing wood stud walls (Type VA) • Change from post and beam framing to wood I-Joists bearing on top of wood stud exterior and interior walls • Change from metal deck to rated sheathing	$60.7	$4462840	$35.76%	$35.76%	Saves 12 weeks

(Kothmann, 2009)

The duration of construction is another key consideration in the planning of facilities. The Kothmann study analysed the direct cost of reducing construction time by building a wood-frame rather than a steel-frame or concrete facility (Kothmann, 2009). The study found that the project duration of the wood-frame Option A is two weeks less than a conventional steel structure. Wood frame Option B saved five weeks, and Option C resulted in completion 12 weeks earlier than a steel frame building. While the study did not calculate the benefits of earlier occupancy, there are obvious financial benefits associated with a shorter construction schedule (Kothmann, 2009).

The study shows that speed is one of the key benefits of wood-frame construction. Wood products are readily available and usually delivered more quickly than steel, which is often shipped from overseas. Additionally, wood-frame assembly is fast; contractors can often install wood members using boom trucks and other readily available construction equipment instead of cranes, which speed up construction and further reduce costs (Roy, 2004).

6.5 Conclusion

According to the cost analysis between traditional brick and mortar and timber-frame carried out in this chapter, the hypothesis that timber-frame walls are more cost effective than brick and mortar walls is incorrect. Brick and mortar walls are cheaper than timber-frame walls. A brick wall is made up of fewer items, while wood-frame has many items that are costly. Timber-frame walls may become durable if treated well and taken care of, while only paint is required to maintain masonry walls. Based on these results, masonry walls would be the most economical solution and the best option for RDP houses.

The Kothmann study observed that timber-frame buildings are more cost effective than other conventional buildings such as steel-frame houses. It emphasises that there are other factors excluding price itself that contribute to the cost of the building. The speed of construction is one factor that can save money. It makes timber very responsive to market demands. Kothmann discovered than it was quicker to construct a timber-frame structure than a steel-frame structure. This can save time for expensive labourers, skilled workers and it can reduce rentals. Thermal resistance is almost as important in any building as time because every household should save energy.

Timber-frame construction makes good social and economic sense because of the reduction in defects and accidents that can be achieved through this form of site construction. For builders, successful timber-frame construction involves a more efficient building process with greater supply chain integration and less waste, thus saving many thousands of rand on building costs.

CHAPTER 7

7 THE RESEARCH METHODOLOGY

7.1 Introduction

Timber-frame and masonry brick-wall construction were discussed in the previous chapters. The different wall construction systems have different advantages that attract the developers and homeowners. The cost comparison of timber-frame walls and masonry brick and mortar walls were conducted in order to determine which wall system is the more cost effective and economical. The most economical wall construction may be used as an alternative to traditional brick walls on RDP houses.

Since timber-frame housing construction in South Africa is less prevalent than any other form of construction a thorough investigation needs to be conducted to see if the general public is familiar with, or will accept timber-frame construction. Building professionals have a major influence on the type of materials to use. They usually select material according to its structural strength, structural stability, special requirements, thermal performance, acoustic performance and durability. To learn of these professionals' perception and that of the general public towards timber-frame housing, a survey was conducted.

The survey in the form of questionnaires will help to obtain information about people's behaviour and thinking. It will help capture what people say about their opinions and interpretations. This will be implemented by involving qualitative data that are obtained through methods, such as interviews, on-site observations, and focus groups that are in narrative rather than in numerical form. Such data are analysed by looking for themes and patterns and involves reading, rereading, and exploring the data (Maxwell, 1996:6). How the data are gathered will greatly affect the ease of analysis and the efficacy of the findings.

Interviews with two contractors who have exposure and experience in building RDP houses were conducted, primarily because their thoughts and willingness to change would help to promote a better understanding of timber-frame construction and its growth.

7.2 Methodology

Maxwell (1996) argues that methodology is a tool or a way to solve problems and thereby gain new knowledge. Everything that helps the researcher to reach his/her goal is methodology.

The research is chiefly based on a literary study to establish whether timber-frame wall construction is a better alternative to brick walls construction in South Africa. The aim is to determine whether timber-frame walls would be appropriate for RDP houses, as well as to analyse timber-frame as method of construction and building material. To discover more about the problem and sub-problems, a literature study is supported by questionnaires, interviews and field observations.

Three methods of investigation were used:

(i) The literature investigation regarding timber-frame construction was undertaken by reading relevant books, timber manuals, magazines, journals, newspapers, the TFBA and SALMA publications and electronic data. Engineering and building regulations' (SANS 1200 and NBR- SANS 10400 – F: 2010) were consulted to ensure compliance with standards.

ii) Questionnaires were distributed or emailed to key persons including architects, the general public, contractors and engineers.

(ii) Interviews were conducted with contractors, who have previously built RDP houses.

(iii) Field observations were done of housing projects that have been built with brick and mortar.

Thus, the idea of combining these investigations with interviews makes the study more reliable and realistic.

7.3 Qualitative research

The research attempts to gather an in depth understanding of people's behaviour and perception towards timber-frame buildings and the reasons that govern such behaviour. Thus, qualitative data were able to fulfill such a mission. Shank (2002) defines qualitative research as "a form of systematic empirical inquiry into meaning". By systematic he means 'planned, ordered and public'.

Qualitative research methods were developed in the social sciences to enable researchers to study social and cultural phenomena. Examples of qualitative methods are action research, case study research and ethnography. Qualitative data sources include observation and participant observation (fieldwork), interviews and questionnaires, documents and texts, and the researcher's impressions and reactions which are used in this research (Myers 2009).

Qualitative research has the following characteristics:

- Natural setting as source of data;
- Researcher as key instrument of data collection;
- Data collected as words or pictures;
- Analyses social settings and the individuals who inhabit them;
- Analysis of data inductively and, attention to particulars;
- Focus on participants' perspectives and how they make sense of the world;
- Contextualisation of findings, meaning is context-dependent;
- Use of expressive language;
- Persuasion by reason; and
- Need to view social phenomena through eyes of those studied; thus wary of imposing frames of reference on participants a priori as this could be inappropriate (Russell, 2003).

7.4 Questionnaires

Questionnaires are the best known of the research instruments used for gathering information from people and they can be used in conjunction with other techniques such as interviews (Kotler, 1998).

In this study, the questionnaire was based on the literature review of chapter 2 up to chapter 6. The survey questions were designed in a way that the respondents could answer in an almost unlimited number of ways. This would assist the respondents to express themselves without difficulty and increase the chances of obtaining information that could be associated with the real situation. This type of survey is called open-ended questions and was designed to gather information about timber-frame walls as an alternative to brick-wall construction.

The questionnaires consisted of the following two sections:

Section A: - Background (biographical) information. This section of the questionnaire referred to background or biographical information.

Section B: - This section of the questionnaire explored the participants' attitudes, habits perceptions and preferences, if any, with regard to timber-frame construction in South Africa.

Two groups of people were chosen for the study and these were the general public who might not have any technical expertise about timber-frame and brick-wall construction. The other group was building professionals with a high level of knowledge about these two methods of construction.

7.4.1 Questionnaires to the building professionals

The structural questionnaire was distributed among a small, but carefully targeted sample of professionals. These included a number of architects, engineers, contractors, developers and quantity surveyors who have some level of understanding or interest in timber-frame construction. A brief and clear explanation, together with a photo of timber-frame house built by Timber Frame Builders was shown to those who were not familiar with timber-frame houses, especially the members of the general public. Thirty-four questionnaires were sent out to the building professionals through emails and some were personally delivered at the place of work. Table 6 and Figure 14 below show the number of questionnaires sent out.

Table 6: Number of questionnaires sent to the professionals

Category	Number	Via Email	Delivered by hand
Architects	6	4	2
Developers	3	3	
Contractors	8	6	2
Structural Engineers	10	9	1
Quantity Surveyors	7	2	5
Total	34	24	10

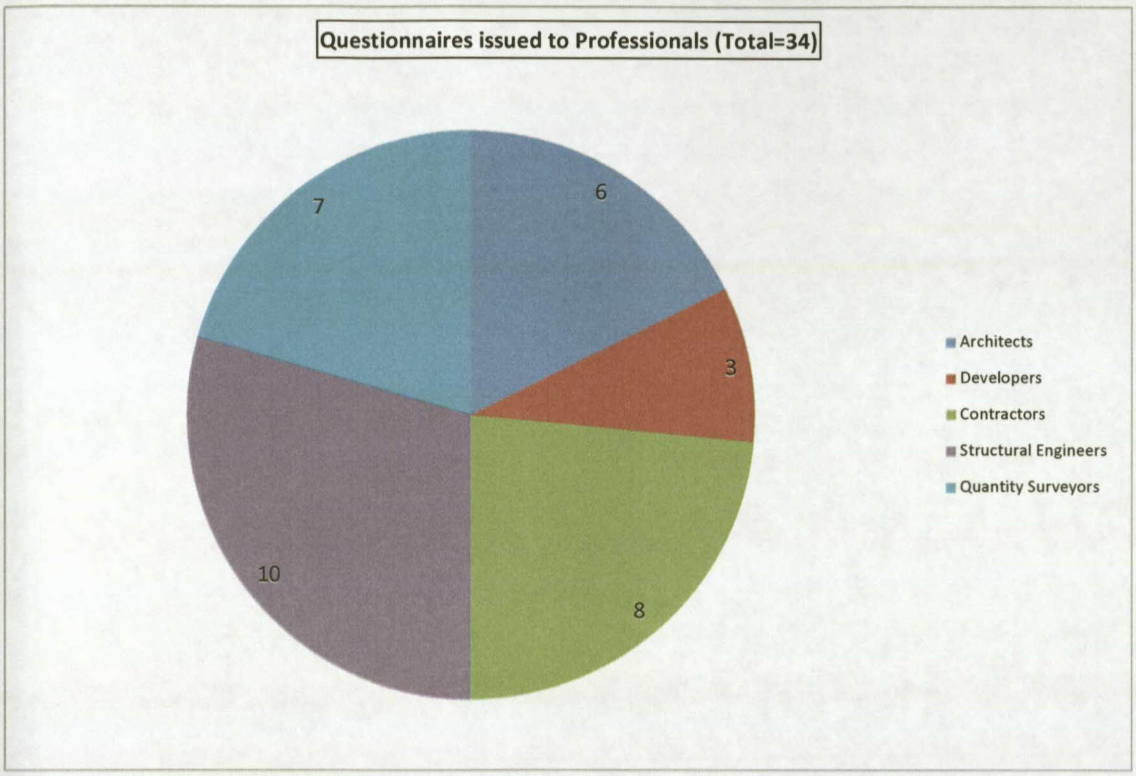


Figure 14: Questionnaires issued to professionals

Table 7: Categories of building professionals respondents

Professional Affiliations	Qualification Obtained	Years of experience	Number
Architects	B Architecture	15	1
	B Architecture	11	1
	B Honours in Architecture	4	1
Developers	BSc Property Development	8	1
	BSc Quantity Surveying	13	1
Contractors	B Tech Civil Engineering	10	2
	Diploma in Civil Engineering	13	1
	BSc Civil Engineering	6	2
	Diploma in Civil Engineering	5	1
Structural Engineers	BSc Civil Engineering	7	3
	BSc Civil Engineering	17	2
	BSc Civil Engineering	9	4
Quantity Surveyors	BSc Quantity Surveying	12	3
	BSc Quantity Surveying	9	1
Total			24

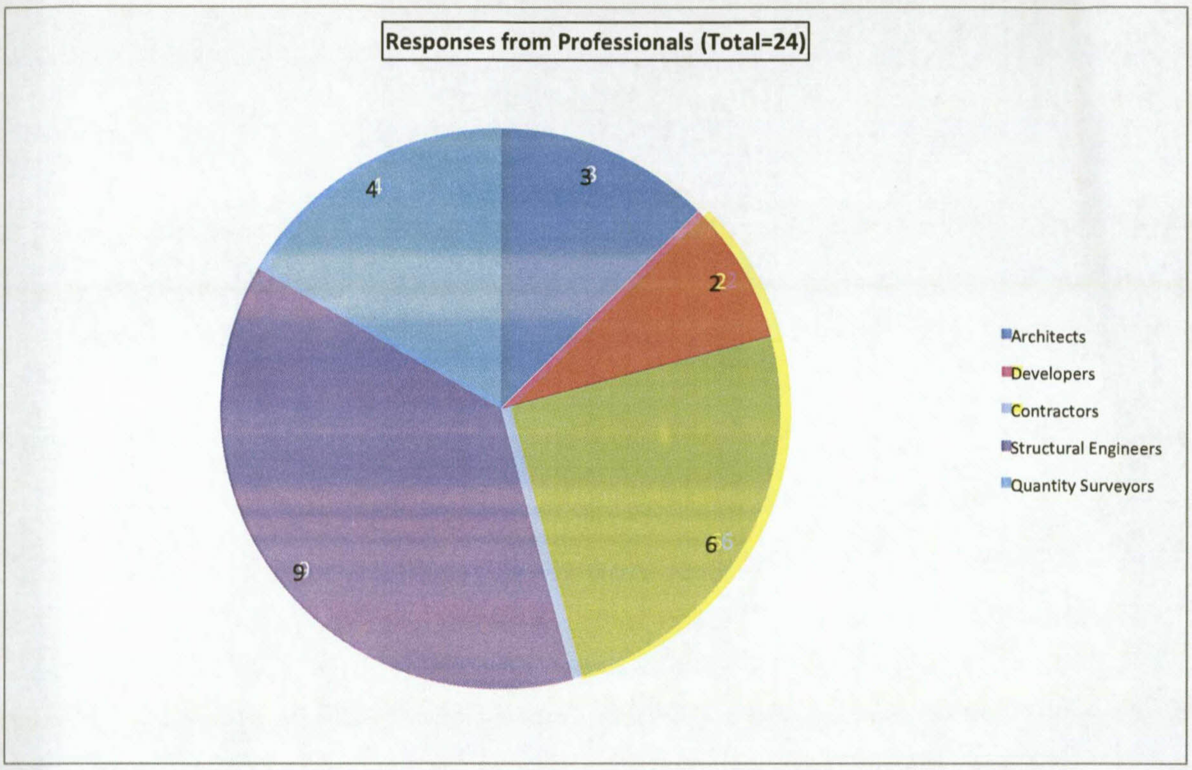


Figure 15: Responses from professionals

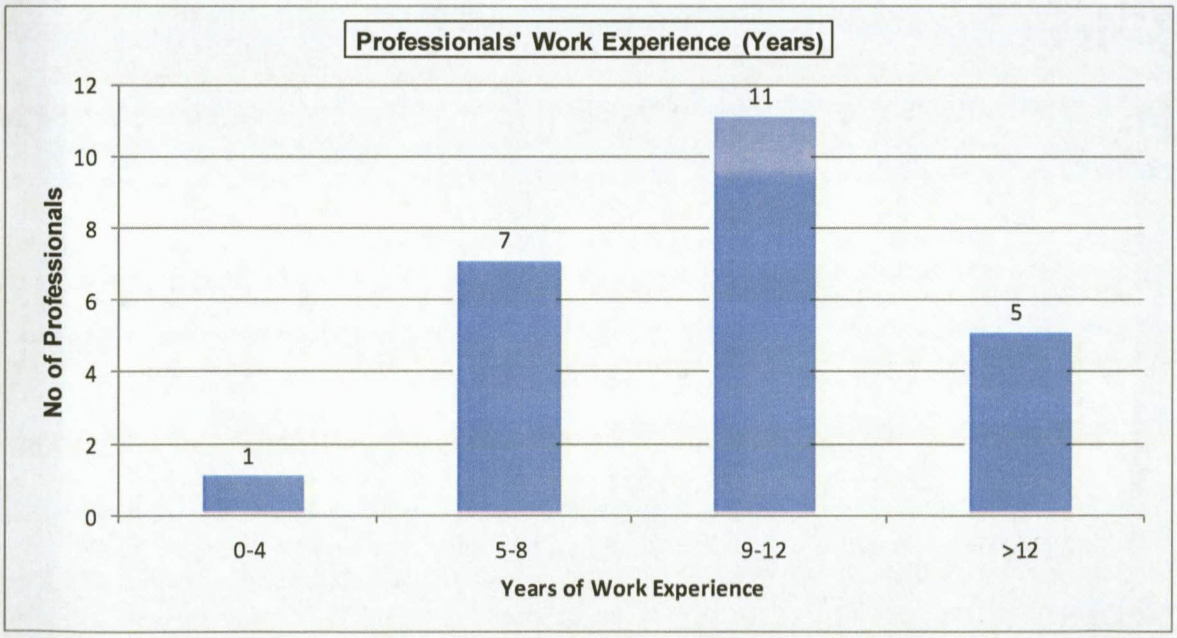


Figure 16: A bar chart showing years of experience of the building professionals

Table 7, Figure 15 and Figure 16 above demonstrate the participants who filled in the questionnaires and are characterised according to their disciplines, qualifications and years of experience. Only twenty-four people responded. The questionnaire under discussion is attached and can be seen in Appendix A.

7.4.2 Questionnaires to the general public

The structural questionnaire attached in Appendix A, was circulated among the general public, with a brief explanation of what a timber-frame wall is. A photo of a timber-frame house built by Timber Frame Builders was shown to those who were not familiar with timber-frame houses. Only those who understand English were selected. Some are professionals outside the construction industry and others are not employed. A total of twenty questionnaires were sent out to the general public at the place of work, shopping malls and churches.

Table 8: Questionnaires handed out to the general public

Categories	Via Email	Delivered by hand
Accountants	1	2
Human Resource Officer	1	
Secretaries	1	2
Police Officers	1	2
Not employed		10
Total	4	16

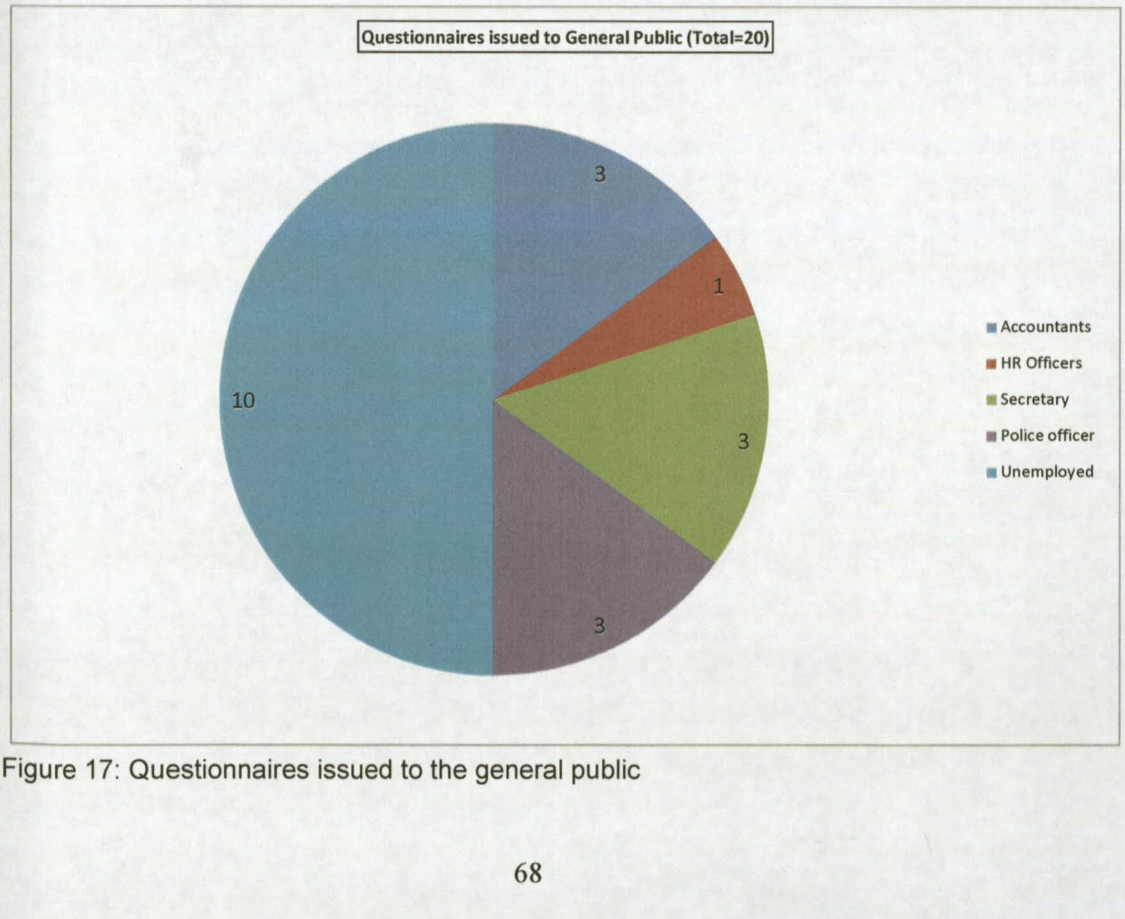


Figure 17: Questionnaires issued to the general public

A total of seventeen questionnaires were received from the participants as shown in Table 9 and Figure 18 below.

Table 9: Categories of general public responded

Categories	Number
Accountants	3
Human Resource Officers	1
Secretaries	2
Police Officers	3
Not employed	8
Total	17

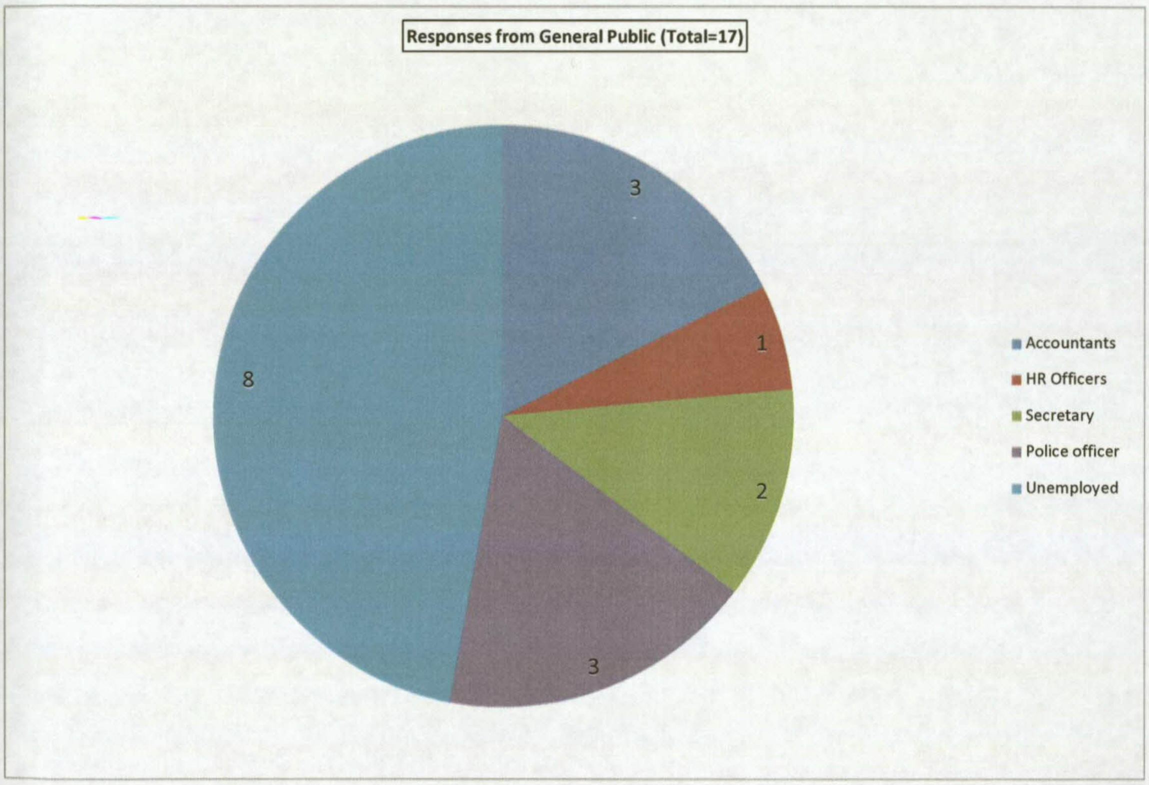


Figure 18: Responses from general public

7.5 Interviews

Interviews are especially suitable when the problem is complex, since the interviewer can rephrase the questions, as well as pose related questions to penetrate the problem

(Roos, Woxblom & McCluskey, 2010). With the possible difficulty involved of how to express uncertainties in mind, personal in-depth interviews were conducted.

Messrs Thulane Baloyi and Peter Tshabalala, who work for small construction companies, but with extensive experience of between four and eight years respectively, were interviewed. They work at companies that have built most of the RDP houses in the Qwa-Qwa and Bethlehem areas. Mr Baloyi's interview was on 06 September 2011 at 10h00 at his office in Bethlehem while Mr Tshabalala's interview took place at 11h00, 10 September 2011 in Qwa-Qwa at his house. The interviews lasted about forty-five minutes with each individual. The reason for choosing the two contractors was to establish perceptions regarding this alternative method of construction. The aim was to discover how much they knew about timber-frame construction; and the possibility of using timber-frame for low income buildings. The question posed was: Would it be possible for them to learn and adapt easily if the government proposed this alternative type of wall?

The interview questions were based on the literature studied about the timber-frame and brick-wall method of construction. The questions were created with the intention of keeping the interview process on track; part of what McCracken (1988) refers to as the 'grand tour' where 'prompts' are used to recover subject areas being missed. This involved asking broad, non-directive questions which allowed the respondents to reply in a manner which reflected his particular context, experience and understanding. This method of questioning allowed the respondents to recall and explain in detail experiences in the building industry.

7.6 Field Work

Observations on the current project took place at various times between 2009 and 2012 in Bethlehem and Lesotho. They were done in order to identify how long it takes to build a timber-frame house and a masonry block or brick and mortar house. The approach produced gratifying results as the two methods were witnessed both during construction and as final products. In addition, the television programme 'Extreme MakeOver' (Dstv, channel 174) was very helpful demonstrating how a wood-frame house is constructed in a short amount of time.

7.7 Conclusion

This chapter discussed the research methodology employed in this study, as well as the benefits of using the instruments of data collection, such as questionnaires, interviews and a field study. Given the context in which this study is founded, the researcher is confident that the data gathered throughout the course of this research, are reliable and valid. Chapter eight will discuss the findings of the data.

CHAPTER 8

8 FINDINGS

8.1 Introduction

This chapter focuses on the data collection and analysis. An analysis is done on the basis of the data which have been collected through questionnaires and interviews in this study and a discussion will ensue with the help of tables, charts and graphs. This is mainly to make the results easy to understand. Details are given in the paragraphs that follow.

8.2 Data collection procedure

Data have been collected through questionnaires (see Appendix A) and interview (see Appendix B). The questionnaires were emailed, hand-delivered and then collected by the researcher from 34 building professionals and 20 members of the general public. Only 24 questionnaires were completed and returned by the professionals, with the other 17 filled in by the general public. The aforementioned data have been analysed through a statistical analysis system (SAS) .The programme is very advanced and accurate. The results of the analysis are given in the bar chart (Figure 19) and in Table 10 below.

8.3 Questionnaires to the building professionals

In the questionnaires completed by the building professionals, 100% of the participants had seen timber-frame houses previously. Only 50% of these professionals, as illustrated in Figure 19, were educated about timber-frame structural design and on the behaviour of timber in adverse weather conditions. Furthermore, structural engineers agreed that because of its light weight, it can resist some shear or dynamic loads. This helps reduce earthquake forces on the structure. All the respondents agreed that its light weight could be an advantage over steel and concrete and for its great economic value. For some professionals, however, their views were combined with the overall positive view of timber construction and a desire to learn more.

When the respondents were asked if they were educated about timber-frame construction at school the data were obtained and recorded in Figure 19. As can be seen in Figure 19 below, only 50% of the building professionals who took part in completing the questionnaires were educated about timber-frame construction. This is not a surprising finding, considering that most houses are built from brick and mortar in South Africa.

The building professionals were asked if South Africa has enough skilled workers for the construction of timber-frame houses. Sixty-two point five percent (62.5%) think South Africa does not have sufficient skilled labourers to construct timber-frame houses. This is evident in the fewer numbers of carpenters compared to bricklayers in South Africa. None of the participants think that there is enough plantation forests in South Africa. However 30% mentioned that there is enough land for plantations, if the demand is there.

Figure 19 below illustrates clearly that, 15 out of the 24 respondents (62.5%) said South Africa does not possess enough skilled people for the erection of wood-frame dwellings. On the other hand, 37.5 % said that the country has enough skills. This finding shows how unskilled South Africans regard timber-frame construction and illustrates that perhaps efforts to educate or provide more training needs to be increased.

Seventy-five percent of the personnel do not have any idea whether South African banks finance this type of construction. They argued that the banks always give bonds for brick houses and not timber houses. Even the developers are not doing enough to market timber-frame houses and 25% of the respondents were of the opinion that banks do, in fact, finance timber-frame housing. They pointed to the many timber-frame lodges and cabins in the country. They all believed that the insurance would be higher for timber-frame than masonry houses because timbers are prone to fire, fungus and insects. They also mentioned that timber-frame houses would deteriorate faster if there are not treated and given proper care.

Based on the Figure 19 below, it can safely be concluded that the building professionals do not know that South African banks finance wood-frame structures and 75% of the respondents indicated that they do not have any idea if SA banks give loans to people who build timber-frame homes. Conversely, 25% indicated that there is finance for wood-frame houses. This is alarming and shows that not enough is being done to promote this alternative method of construction. They all agree that wood houses are more aesthetically pleasing and demonstrate a timeless elegance and durability, as well as the way timber lends itself to craftsmanship. They would all like to stay in these buildings if they were structurally sound and given enough treatment for fungus and insects.

When the respondents were asked if the timber-frame method of construction could be used in RDP houses or could replace bricks as a type of material for houses in any South African location, the following data were obtained: Fifty percent of the participants are not convinced that timber-frame construction can be used for RDP houses or for any house for that matter. They all agreed that the majority of low income households would be susceptible to fire during cold weather which can be dangerous to the houses. Most RDP houses accommodate more than 5 people and they would deteriorate due, to excess moisture (bath rooms) affecting the life span of the houses. They argued that timber-frame houses are high maintenance and have a short life span. This would bring more problems than solutions to homeowners.

Figure 19 below shows clearly that 50% of the respondents would not consider using wood walls instead of brick walls for RDP houses. Nonetheless, 50% think it is an appropriate method. Based on the information above, one can conclude that the timber-frame house has a chance in the South African market if it performs well structurally and if professionals are eager to accept it.

Responses according to the building professionals are summarised in Table 10 and Figure 19 below.

Table 10: Responses from building professionals

Professionals	Yes	No	Total	Percentage	Percentage
				Yes	No
timber education	12	12	24	50%	50%
enough skills	9	15	24	37.5%	62.5%
finance from banks	6	18	24	25%	75%
timber frames for RDP house	12	12	24	50%	50%

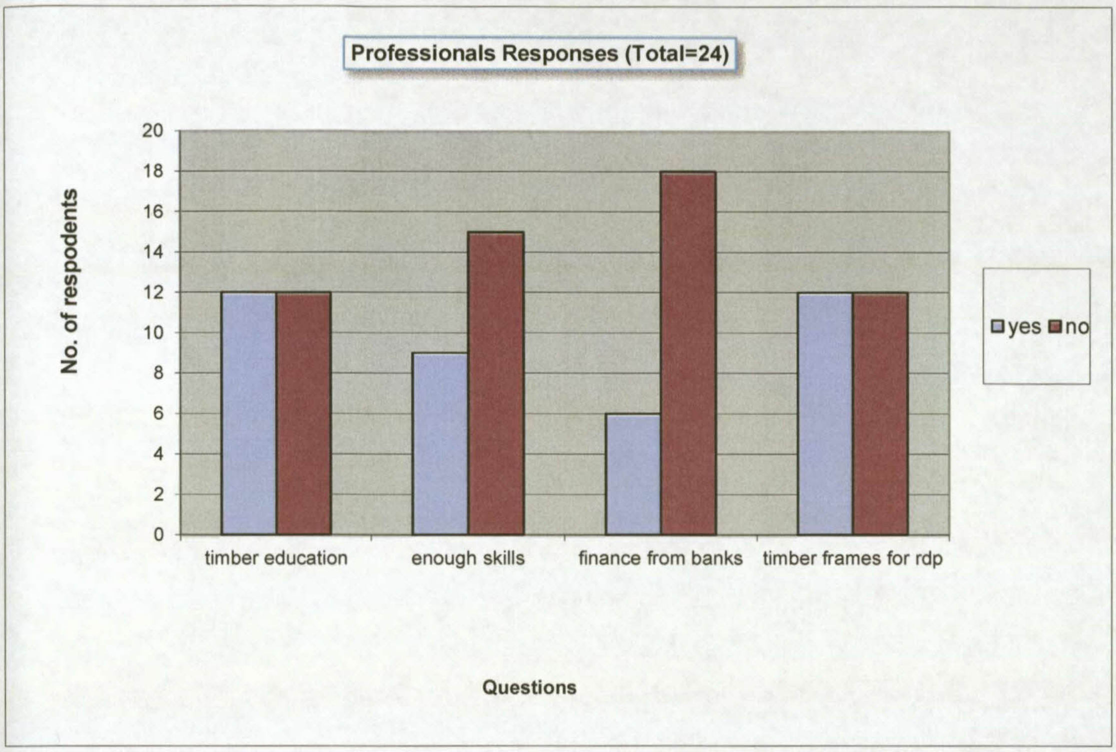


Figure 19: A bar chart showing responses from professionals

8.4 Questionnaires to the general public

Eighty-eight point twenty-four percent (88.24 %) of the general public have seen timber-frame houses previously. All the people think that they would not be suitable for RDP houses. Most of them, (70%) think that wood construction can be used only for cabins for guards, for shacks or for small storage houses. Fire and decay are the main concern. They all argued that wood is naturally consumed by fire and its use as fuel and as a source of charcoal is well known.

Figure 20 below shows clearly that the majority of the respondents (88.24%) are familiar with wood-frame dwellings, whereas only 11.76% seemed not to have seen the structures previously. This suggests that timber-frame construction is not a new method of building and a few houses built with timber can be seen throughout South Africa.

Twenty-eight percent (28%) of the participants think that this alternative wall construction method would be accepted for low income buildings in South Africa. Poor sound acoustics was mentioned as one of disadvantages of wood. They maintained that timber floors are very noisy. Some people believe that timber-frame walls cannot be renovated as easily as masonry walls which can be effortlessly renovated with a new coat of paint.

The bar chart (Figure 20) below indicates that 76.47% do not agree that timber-frame homes would be accepted by the South African public. Therefore, one can conclude that the general public will not give wood-frame construction a chance in the erection of their homes. Forty-seven percent said they would stay in timber-frame houses if the opportunity availed itself, while 52.94% said they were afraid they might burn while living in them. Furthermore, they all believe that the timber-frame method of construction would deplete all the forests in the country.

The results demonstrate that 52.94% would not stay in timber-frame homes, while 47.06% would. Based on Table 11 below, it shows that the majority confirmed that they do not trust wood-frame houses.

Responses according to the general public are summarised in Table 11 and Figure 20 below:

Table 11: Responses from the general public

General Public	Yes	No	Total	Percentage	Percentage
				Yes	No
Have seen timber house	15	2	17	88.24%	11.76%
Timber house accepted by public	4	13	17	23.53%	76.47%
Would stay in timber house	8	9	17	47.06%	52.94%

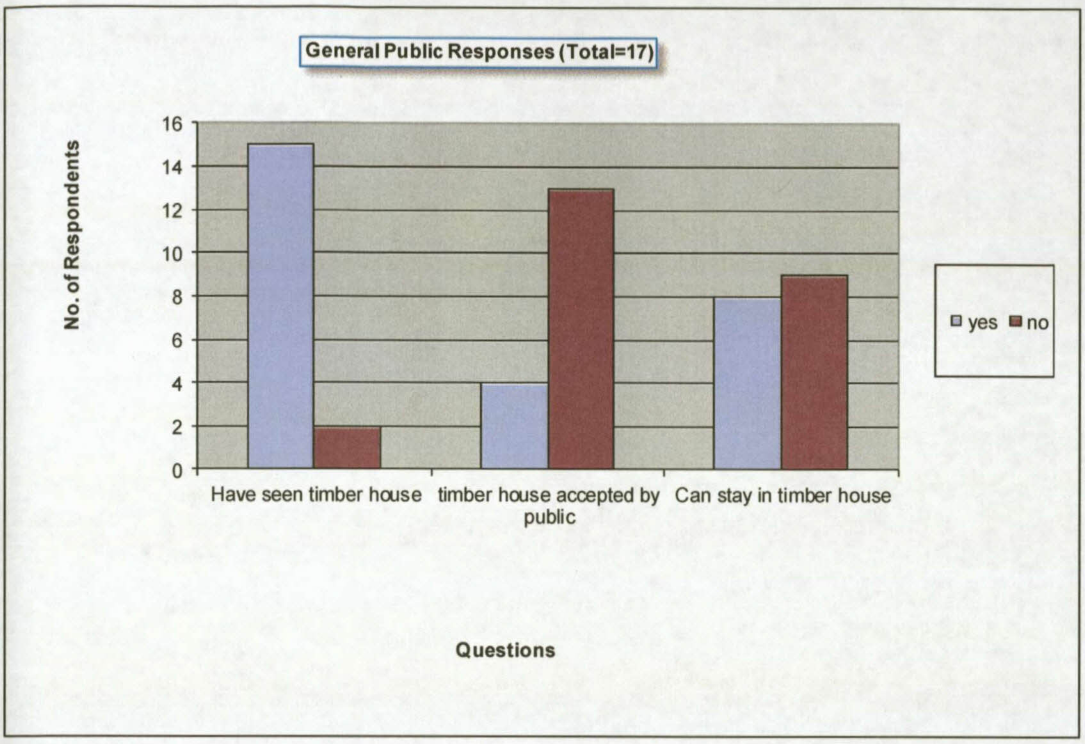


Figure 20: General public responses

8.5 Interviews to two contractors

Two contractors from two small construction companies were interviewed. The first contractor (Mr Thulane Baloyi) has a slight idea of how timber-frame construction works. The second contractor (Mr Peter Tshabalala) has seen timber-frame houses before but is not familiar with this alternative wall system. The two were quite interested to learn about timber-frame construction.

Mr Tshabalala said if wood construction can benefit homeowners he will be more interested to use it as an alternative wall system for RDP houses. Time and cost are major factors in the construction of any building. As a result both contractors were satisfied to discover that timber-frame construction can save time and money if used correctly. They agreed that if the government introduced a timber wall system they would embrace it without hesitation. They said not much of work is being done to promote timber-frame construction and that might be why there is little known about it.

8.6 Conclusion

Most of the participants who completed the questionnaires were not convinced that timber-frame walls can replace traditional brick and mortar walls in the construction of RDP houses in South Africa. Even though an explanation of how timber-frame construction works was given, people, especially the general public remain sceptical about timber-frame construction. The general public have not yet accepted timber-frame construction as they are afraid of change. As result, it is not going to be easy to implement. More training is encouraged for all building stakeholders and ordinary people to learn more about timber-frame so that they will be able to give fair criticism.

CHAPTER 9

9 CONCLUSIONS AND RECOMMENDATIONS

9.1 Introduction

As discussed in Chapter one of this research report, the aim of this study is to determine whether masonry, being the most used material in residential housing construction in South Africa, can be replaced by timber-frame construction on RDP houses to improve the quality and durability of houses, on the other hand, while saving time and money. Furthermore, the objective is to point out and analyse the effectiveness of using the timber-frame system.

9.2 Conclusion

There are possibilities that timber-frame structures can become common and competitive in South Africa. The fact that there are houses spotted all over the country makes it clear that timber-frame construction is effective if used according to National Building Regulations standards.

In the study timber-frame and brick and mortar walls were compared. The two methods of construction mainly differ regarding walls, as other building elements such as the foundation, roof, doors and windows remain the same. The comparison was done to see which of these methods performed better in certain areas such as durability and structural, acoustic and thermal performance. The most effective, efficient and economic method will be used as an alternative to traditional brick and mortar which has been used to build low income (RDP) houses in South Africa.

The alternative wall construction method was analysed. Preference will be given to the wall system which will reduce waste, reduce the amount of materials required, and simplify assembly and increase accuracy and speed of construction. Timber-frame walls were shown to be as competitive as brick walls and were a much better option in terms of time. The less time spent on building a house, the less expensive it is. The time spent constructing a timber-frame home is far less than for a brick building. This can be beneficial to the government for increasing the percentages of RDP houses built per year. Materials for two wall systems were discussed since no house can be built without the fundamental knowledge of building materials. It was recognised that a timber-frame wall requires many different materials for the wall to be substantial.

The difference between conventional masonry and timber-frame was emphasised. Timber-frame houses are erected by carpenters whereas brick houses are built by bricklayers. Other features for the erection of houses such as foundations, windows, doors and roofs remain the same for both systems. The advantages and properties of timber-frame houses were discussed. There are many reasons why timber is an ideal construction material. It is renewable, durable and a good insulator - warm in winter and cool in summer. From this section it is clear that wood-framed houses are as competent like brick or block houses. Stakeholders in the building industry should take note of the importance of using timber-frame.

The RDP was explained, along with all the materials that are used for construction of its houses. The buildings are usually simple structures and erected with bricks or blocks. Even though the South African government is doing all it can to provide people who need shelter, there are still lot of people on the waiting list. The slow delivery of RDP houses causes a backlog which needs to be solved. Timber-frame construction, because of its quick erection, can speed up the delivery process if given a chance.

Emphasis was placed on the cost implications. Timber-frame construction proved to be more expensive than brick walls. The hypothesis that timber-frame is more cost effective than masonry brick walls was therefore not achieved. However, timber-frame wall construction seemed to be cheaper than other form of construction such as steel-frame. This was verified by Kothmann's case study. The advantages of timber-frame buildings and the differences between conventional building methods and timber-frames were also compared to highlight the effectiveness of timber frames.

Timber-frame housing construction in South Africa is not yet as popular as masonry brick walls, although further investigation on this needs to be conducted. A survey consisting of questionnaires and interviews was done to determine whether the alternative wall construction method is known and would be accepted by the general public and building professionals. The results indicate that the majority of people do not really understand and are not aware of the benefits of using timber-frame construction. It might be that insufficient education or training was given to the building specialists about this alternative method of construction. This might be why most people think South Africa does not possess the skill to erect wood-frame dwellings. The construction industry in

South Africa needs to encourage more institutional knowledge in timber-frames, because lack of background knowledge of the material makes it difficult for building disciplines to encourage the use of it. In addition to these an alarming percentage of the participants had no idea that they can get loans to build timber-frame houses, as well as insurance. It is clear that not enough is being done to promote the timber market.

Timber-frame was found unsuitable to use as building material for RDP houses. It is perceived to pose a greater risk of fire than any other form of construction material. It is also costly as timber-frame needs to be treated and maintained in order to have a long lifespan. This is true because for any building to survive measures should be taken to improve the life-cycle of building and preserve its original status. This is the same for masonry brick walls that require plaster and paint to withstand the test of time. As with any mortgage, insurance is provided for wood-frames to guard against any disaster.

Social perceptions and attitudes about timber-frame housing have a negative influence on its use. More awareness about this construction method is still needed and its use needs to be promoted.

The goal of this study was to determine whether timber-frame walls can replace traditional brick and mortar walls to improve quality, facilitate faster construction solutions and durability, while at the same time being cost effective. Will timber-frame wall construction be a better alternative to brick and mortar wall construction in South Africa? And can timber-frame wall construction be appropriate for RDP houses? The problem was partially solved because brick and mortar walls were demonstrated to still be the better option for RDP houses in terms of cost, maintenance and durability. Brick performed better in water resistance, thermal performance, acoustics and structural strength. In terms of the speed of construction, environmental sustainability and aesthetics, timber-frame is still a method of construction to be reckoned with.

9.3 Recommendations

It is recommended that other forms of wall construction such as steel-frame and poly-blocks should be explored to find the less costly method than masonry brick walls. Since most building professionals were not educated about timber-frame, the South African government should focus on developing further training courses for architects , quantity surveyors, developers, engineers, technical inspectors and contractors about the construction of timber-frames. The full advantages of timber-frame technology will be experienced only when professionals themselves become more familiar with it through education.

Appendix A

Questionnaire

TIMBER-FRAME WALLS AS ALTERNATIVE TO BRICK WALLS CONSTRUCTION

QUESTIONNAIRE

JULY 2012

QUESTIONNAIRE

INTRODUCTION

Timber framing is the method of creating a house using heavy timbers jointed together with mortise and tenon. This questionnaire is aimed at determining the perceptions of people in South Africa about using timber-frame as alternative to brick or block walls on RDP houses. The figure below shows a house erected with timber.

Figure 21: Timber-frame house (Timber Frame Builders Association, 2009)

Kindly complete the questionnaire carefully and send it to the details below:

To:

Attention: Maneo Mabesa

Fax: 036 342 3114

E-Mail: maneom@gmail.co.za

NOTE: THE QUESTIONNAIRE CONSIST OF SECTION A & SECTION B

BOTH SECTIONS MUST BE COMPLETED BY ALL PARTICIPANTS

THANK YOU

APPENDIX A:

QUESTIONNAIRE - TIMBER-FRAME WALLS AS ALTERNATIVE TO BRICK WALLS CONSTRUCTION.

SECTION A
BACKGROUND

1. Firm/Company Location

2. Professional Affiliation (Architect, Engineer, Contractor/Builder, Developer, Other)

3. Qualification Obtained

4. Gender

5. Ethnicity

SECTION B
TIMBER-FRAME WALLS

1. How familiar are you with timber-frame residential houses?

2. How much influence do you have over design and specification decisions?

3. If you received professional schooling, to what extent were you educated about timber-frame construction issues during your degree or training program?

4. Do you think South Africa has enough skill for construction of timber-frame houses?

5. Do you think South Africa has enough forest to use for construction of timber-frame houses?

6. Are there any banks in South Africa that finance timber-frame houses?
7. Will insurance be higher on a timber-frame house than on a masonry house?

8. Do you think timber-frames can replace bricks as a type of materials for houses in any South African's location?

9. Do you think timber-frame house is more attractive than masonry house?

10. Would you live in a house built with these construction methods if you had the opportunity to do so?

11. Do you think this type of construction can be used in RDP houses?

12. Do you think timber-frame houses are high maintenance than masonry houses?

13. Do you think timber-frame building cost more than masonry building?

14. Would you consider buying a house constructed with these construction methods?

15. Do you think a life span of timber-frame houses same as masonry houses?

16. Do you think this type of houses will be accepted by the general public?

APPENDIX B:

INTERVIEW QUESTIONS

TIMBER-FRAME WALLS AS ALTERNATIVE TO BRICK WALLS CONSTRUCTION.

---

1. How long have you been in the construction industry?

2. Do you have experience in the construction of RDP houses?

3. How many houses have you build so far?

4. Do you have experience in timber-framing?

5. Do you have any idea how timber-framing works?

6. Have you seen a timber-frame house before?

7. Which method of construction is faster between masonry brick and timber-frame walls?

8. Do you think timber-frame wall can replace brick and mortar wall in the construction of RDP houses?

9. Which method is cheaper between timber-frame and brick wall construction?

10. Do you think timber-frame house is more attractive than masonry house?

11. If the South African government propose to use timber-frame as alternative to masonry brick wall will you accept?

12. Would it be possible for you to learn and adapt easily to this alternative walls?

BIBLIOGRAPHY

Adams, C. & Elizabeth, L. 2005. *Alternative Construction – Contemporary Natural Buildings Methods*. Ney Jersey: John Wiley & Sons.

Aeropink. 2012. *Aerolite is a necessity*. [online]. Available from:<http://www.aeropink.co.za> [Accessed: 12 May 2013].

Ali, S. 2013. *Alleviating Energy Poverty in South Africa's Slum*. [online]. Available from: http://newswatch.nationalgeographic.com/author/saleemali/[Accessed:02 May 2013].

Allen, E. & Iano, J. 2004. *Fundamentals of Building Construction: materials and methods*. Canada: John Wiley & Sons.

Aghayere, A. 2007. *Structural Wood Design: A practise oriented approach*. USA: John Wiley & Sons.

American Institute of Timber Construction. 2004. *Timber Construction Manual*. USA: American Institute of Timber Construction.

Anderson, L.O. & Oberschulte. 1992. *Wood Frame House Construction*. USA: Craftsman Book Company.

Arnold, C. 1986. Journal of Architectural and Planning Research, USA, vol 3, p 43, November.

Arnold, C. 1995. Building Systems Development. USA: Elsevier.

Baker-Laporte, P., Elliot, E. & Banta, J. 2001. *Prescriptions for a Healthy House: A Practical Guide for Architects, Builders & Homeowners*. 2008. USA: New Society.

Baloyi, T. 2011. (Contractor: MJ Mokoena) Personal interview about timber frame houses. 06 September 2011. Bethlehem.

Barry, R. 1988. *The Construction of Buildings*. Britain: British Library.

Bellaloggia, A. 2009. *Ballon Frame Houses & Firemen's Safety*. [online]. Available from: <http://www.realtown.com/ardel/blog> [Accessed: 14 February 2011].

Becker, D. & Wang, D. 2011. *Manual for Evaluating the Thermal Performance of the Hamerschlag Hall Green Roof* [online]. Available from: <http://www.cmu.edu/environment/campus.../hh-manual-thermal-sensing-.pdf> [Accessed: 07 September 2012].

Benson, T., Gruber, J. & Page, J. 1981. *Building the Timber Frame House*. London: Simon & Schuster.

Brinkley, M. 2011. Timber versus concrete. [online]. Available from:<http://www.complete Home.ie/files/timer-v-concrete.pdf>[Accessed 06 July 2011].

Burchell, J. 1984. *Timber Frame Housing*. England: Construction Press.

Burchell, J. & Sunter, F.W. 1987.*Design & Build in Timber Frame*. England: Longman Scientific & Technical.

Cashbuild. 2012. Brick wall quotation. Bethlehem Free State. 2012 Nov 17.

Central Mortgage and Housing Corporation. 2009. *Canadian Wood Frame House Construction. Canada*: Central Mortgage and Housing Corporation.

Civil Engineering Portal. 2012. *Building Materials*. [online]. Available from: <http:// readnose.wordpress.com/2012/02/09/civil-engineering-portal/> [Accessed: 12 May 2012].

D'Ayal, D. 2004. *Unreinforced Brick Masonry Construction-World Housing* [online]. Available from: <http://www.world-housing.net/wp-content/uploads/2011/08/Type Brick.pdf> [Accessed: 18 August 2010].

Davis, D. 2013. *What Is Masonry* [online]. Available from:< www.wisegeek.org/what-is-brick-masonry.htm> [Accessed: 30 April 2013].

Department of Wood Science. 2009. *Wood*. University of British Columbia. [online]. Available from: <http://www.woodworks.ca/index.php?option=com_content > [Accessed: 16 August 2010].

Domone, P.L.J. 2001. *Construction Material*. Canada: Spon Press.

Du Plessis, L. 2007. Urban *Renaissance and the delivery of sustainable communities: the influence of the physical environment on the quality of life of communities*. Thesis (MSc). Bloemfontein: University of the Free State.

Everett, A. 1972. *Mitchell's Building Construction*. London: B.T Batsford Limited.

Extreme Makeover: Home Edition, Episode 18. 2011. Television, American Broadcasting Company. 2011 Jul 18. Show at six, 2011. Jul 18. 1800hrs.

Freeman, C.J. 1985. *The National Building Regulations*. Republic of South Africa: The Rustica Press.

Grand Solution Manual. 2013. *The traditional building materials*. [online]. Available from: <http//www.aboutcivil.org/grand-solution-manual.htm/> [Accessed: 30 April 2011].

Greyling, C. 2009. *RDP housing system in South Africa*. Thesis (Hons) Pretoria: University of Pretoria.

Gurfinkel, G. 1981. *Wood Engineering*. United States of America: Hunt Publishing Company.

Gypsum Association, 2012. *American Gypsum.* [online]. Available from: http://www.americangypsum.com/literature/ga-literature/ [Accessed: 6 June 2012].

Habitat. 2001. *Cities in a Globalizing World: Global Report on Human Settlement.* USA: Earthscan.

Hodges, D. & Simitses, G. 2005. *Fundamentals of Structural Stability.* 1st ed. USA: Butterworth-Heinemann.

Holz, H. 2010. European Journal of wood and wood products, 107, p.17-19, April.

Howard, I. 2006. *Fire Report – Rockcote System. BRANZ*, 9 November, p.4.

Karseens,N.M. 1999. *savings and affordability in south africa's low-income housing.* [online].Available from:<ww.jstor.org/stable/25830919> [Accessed: 24 May 2013].

Kothmann, K. 2009. *Designing Wood Schools* [online]. Available from: <http://woodworks.org/findpdf.php?file=publications/wood_schools.pdf> [Accessed: 13 April 2011].

Kotler, P. 1998. Questionnaire design. [online]. Available from:<www.deakin.edu.au/buslaw/infosys/research/.../docs/questionairedes.pdf> [Accessed: 21 May 2012].

Lancashire, R. 2008. *Achieving 'thermal comfort' in timber frame building. [online].* Available from:<http:// www.thenbs.com> [Accessed: 12 May 2013].

Lubber, W. F. 1986. Housing, vol.3, p.23-25, July.

Lund, E. [n.d.]. *Alternatives to Lumber & Plywood in Home Construction.* USA: Diane Publishing Co.

Masilela, E. 2012. *Affordable housing in South Africa.* [online]. Available from: < www.eprop.co.za/.../15292-affordable-housing-is-a-national-priority-acc> [Accessed: 21 May 2013].

Maxwell, J.A. 1996. *Designing a Qualitative Study.* [online]. Available from: <www.corwin.com/upm-data/23772_Ch7.pdf> [Accessed 18 July, 2010].

McCracken, G.1988. *The Long Interview.* [online]. Available from:< www.qualitative-research.net> [Accessed 12 May 2013].

McRae, S. 2010. *Energy Efficient Home Building.* [online]. Available from: <http://www. greenliving.nationalgeographic.com> [Accessed: 19 January 2012].

Mishra, G. 2012.*Quantity of cement and sand calculation in mortar.* [online]. Available from:< http://theconstructor.org/practical-guide/quantity-of-cement-sand-calculation-in-mortar/6925/> [Accessed: 10 May 2013].

Myers, M.D. 2009. *Qualitative Research in Business & Management* [online]. Availablefrom: https://bearspace.baylor.edu/.../Qualitative%20Course/.../Qualitative%20> [Accessed: 21 August 2012].

National Building Agency (NBA) and Timber Research and Development Association (TRADA). 1989. *Timber Frame Housing.* Republic of South Africa, Johannesburg.
National Timber Development Council (NTDC). 2001. [online]. Available from:<

http://oak.arch.utas.edu.au> [Accessed: 29 April 2013].

Nutec Cladding. 2012. *Timber Design*. [online]. Available from: <http:/www.timber Design.co.za/tag/nutec-cladding> [Accessed: 12 November 2012].

Ochshom, J. 2010. *Wood Construction*. [online]. Available from: <http://www.google. co.za/url?source=imgres&ct=ref&q=http://courses.cit.cornell.edu/arch262/notes/07b.html&sa=X&ei=course.cit.cornell.edu/arch262/notes/o7b.html> [Accessed: 14 February, 2011].

Osborn, R. 2010. *Framing a House*. USA: The Taunton Press.

Pandey, S. [n.d.]. *Brick* [online]. Available from:< http://www.insidepages.com/.../> [Accessed: 14 February, 2011].

Pillay, A.& Naude, WA. 2004. *Financing low-income housing in South Africa: Borrower experiences and perceptions of banks.* [online]. Available from:<http://doi.org/10.1016/j.habitatint.2005.03.001> [Accessed: 11 May 2012].b

Pringle, T. & Bruce, E. 2011. *House Building Guide*. [online]. Available from: <http:// www.branz.co.nz/cms> [Accessed: 11 May 2013].

Rabbani, F.F. 1994. *ANC'S RECONSTRUCTION & DEVELOPMENT PLAN* [online]. Available from:< http://www.africa.upenn.edu/Govern_Political/ANC_Recon.html >[Accessed: 29 April 2013].

Rackard, N. 2013. Woodskin: The Flexible Timber. [online]. Available from: <http:// *www.archdaily.com/362951/woodskin-the-flexible-timber-skin/*> [Accessed: 01 June 2013].

Rajapakse, R. 2008. *Pile Design & Construction Rules of Thumb*. USA: Elsvier science & technology.

Rocky Mountain Masonry Institute. 2002. What is masonry. [online]. Available from: <http://www.linkedin.com/company/rocky-mountain-masonry-Linked> [Accessed: 12 May 2012.

Roos, A., Woxblom, L. & McCluskey, D. 2010. *Development of timber-framed firms in the construction sector: Is EU policy one source of their innovation*? [online]. 6(12). Available from:<http:// www.metla.fi/silvafennica/abs/sa44/sa445871.htm/< [Accessed :20 May 2012].

Roy, R. 2004. *Timber Framing For the Rest of Us*. Canada: New Society Publishers.

Roseland, M. 2000. Sustainable community development: integrating environmental,economic, and social objectives [online]. Available from:<http:www.sciencedirect.com/science/article/pii/> [Accessed: 12 May 2011].

Rudd, R. 2006. *Timber Buildings*. Singapore:[s.n.].

Russell, C.K. 2003. *Evaluation of qualitative research studies* [online]. Available from:< *ebn.bmj.com*> [Accessed:09 May 2013].

Scot, S. 2007. *Complete Book of Framing: An illustrated Guide for Residential Construction*. USA: R.S. Means Company. Incorporated.

Sencer, S. 2007. *Accoya off the blocks*. Timber Trades Journal.

Shank, G.D. 2002. *Qualitative research. A personal skills Approach*. [online]. Availablefrom:<ww.clarku.edu/.../Qualitative%20Research,%20A%20personal%20sill s>[Accessed: 19 May 2013].

Shaul, E.C. 2004. *Planting Nature: Tress and the manipulation of environmental stewardship in America*. America: University of California Press.

Silverman, D. 2005. *Qualitative Research Methods*.[online]. Available from:< mir.epfl.ch/webdav/site/mir/shared/Syllabus%20version%205.pdf> [Accessed 18 July 2010].

Smit, I. 2003. *Reaching For The Limits With Timber Construction*. Canada: John Wiley & Sons.

Smith, K. 2008. *Engineered Wood: Building Material* [online]. Available from: < http://homerenorepair.suite101.com/article.cfm/greenhomebuilding> [Accessed: 11 June 2009].

South African Lumber Millers Association. 1989. *The Manual of Timber Frame*. Republic of South Africa: The Rustica Press.

South Africa, Department of Local Government and Housing.1994. White Paper on *A New Housing Policy and Strategy*. [online]. Available from:<www.info.gov.za/ whitepapers/1994/housing.htm> [Accessed: 13 November 2011].

South Africa. Department of Local Government and Housing. 2005. *Latest Housing Statistics*. Bloemfontein. Government Printer.

South African National Standards. 1985.*The application of National Building Regulation*. Pretoria. Government Printer.

Spencer, W.P. 1993. Residential Framing: *A Home Builder's Construction Guide*. Canada: Sterling publishing company, Incorporated.

Stulz, R. & Mukerji, K. 1993. *Appropriate Building Material* [online]. Available from: <http://-www.amazon.com/Appropriate-Building...Stulz/dp/1853392251> [Accessed: 10 July 2012].

Swiss Federal Office for the environment. 2009. *Environmental Policy between Regulation and market. Switzerland*. [online]. Available from: <http://www.eea. europa.eu/data-and-maps/data-providers-and-partners/swiss-federal-office-for-the-environment> [Accessed: 21 June 2011].

Timber Frame Builders Association. 2011. *Timber Houses*. [online]. Available from: < www.getclosure.co.za/.../timber-frame-builders-association-of-south-afri..> [Accessed:11 February 2011].

Timber Home Kits. 2012. *Timber-frame wall quotation*. Johannesburg. 2012 Nov 03.

Thallon, R. 2000. Graphic Guide to Frame Construction: *Details for Builders and Design*. USA: Tauton Press.

The South African Wood Preservers Association, 1990. *Timber Preservatives* [online]. Available from: <http://www.sawpa.org.za/ >[Accessed:10 July 2011].

Tomlinson, M.R. 2007. FINMARK TRUST: *A LITERATURE REVIEW ON HOUSING FINANCE DEVELOPMENT IN SUB-SAHARAN AFRICA*.[online].Available from:< *http://www.finmark.org.za/wp-content/uploads/Litreview_HFAfrica.pdf>[Accessed 01May 2013].*

Tshabalala, P. 2011. (Contractor: PJ Mavundla). Personal interview about timber frame house. 10 September 2011.Qwa-Qwa.

United States of America. Department of Energy. 2000. *Elements of an Energy EfficientHouse.* [online]. Available from: < http://www.nrel.gov/docs/fy00osit/27835.pdf [Accessed: 14 May 2012].

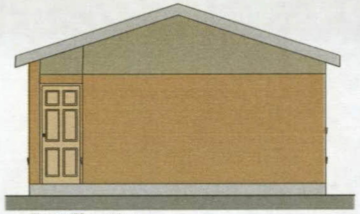
Vdelson, J. 2007. Marketing Green Building Services. America: Taylor & Francis.

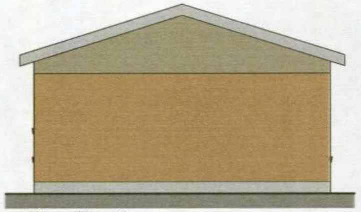
Wagner, J.D. 2005. *House Frame: Plan, Design, Build.* Carolina: Creative Homeowner.

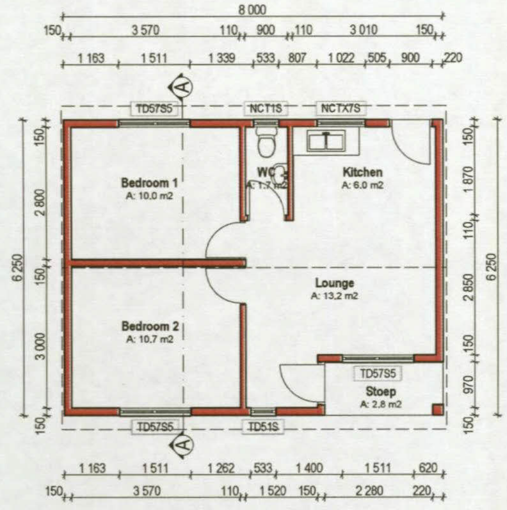
Western Red Cedar Export Association. 2013. *The Advantages of Working with Wood.* [online]. Available from:< www.granddesignslive.com.au/blog-comment/65.aspx>[Accessed: 19 February 2013].

Appendix C

A HOUSE PLAN

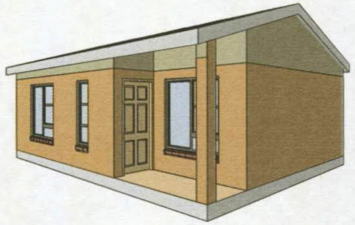


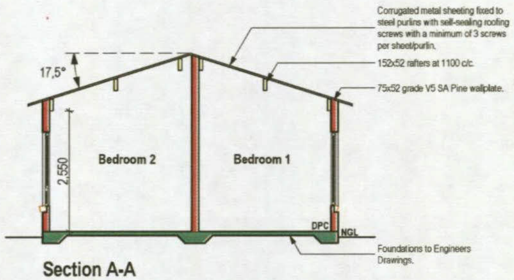




Ground Floor Plan

Scale 1:100





Section A-A

Scale 1:100

WINDOW SCHEDULE

	width 1511 mm	
	height 1559 mm	
	TD57S5	
	top hung	
	material	steel frame
	width 533 mm	
	height 949 mm	
	NCT1S	
	top hung	
	material	steel frame
	width 1022 mm	
	height 949 mm	
	NCTX7S	
	top hung	
	material	steel frame
	width 533 mm	
	height 1559 mm	
	TD51S	
	top hung	
	material	steel frame

SPECIFICATION

ROOF:
0.5mm Cranked corrugated roof sheeting fix to steel purlins with self-sealing roofing screws with a minimum of 3 screws per sheet/purlin, 1200mm galv. hoop iron straps of 4mm wire embedded into wall 600mm deep.
17,5° roof pitch.
All timber to be S.A. pine grade V4

FLOOR SLAB:
GROUND
Specified finish on Engineer specified flooring with meranti skirting with quarter round quadrant.

WALLS:
All external walls to be 150mm solid walls with brickforce every (4)fourth course.
Internal walls to be 150mm walls as per indication
2 coats acrylic pvc plaster
d.p.c below all external and internal walls.
3 courses brick reinforcement above wallplate level and walls. Brickforce every 4th course vertically
Flashing encased with counter flashing to all wall and roof junctions.
Lintels above all door and window openings excluding arches
Cills to be plastered internally and externally

WINDOWS:
As per catalogue
All glazing to comply with part N of SABS 0400.

GENERAL NOTE:
All window areas to be 10% of floor area of a specific room and these windows to have 5% operable.
Foundations not to project over any boundary
Pre-stressed conc. lintels 110x75mm over all window and door openings not exceeding 3m with brick force over
Lintels to have a minimum bearing of 220mm on either side of the opening.
All levels, details and dimensions to be checked on site before commencement of work.
Finished floor level of garage to be 30mm lower than of the house.
All drainage pipes running under the floor must be incased with 150mm concrete.

GENERAL NOTES

GENERAL

- This drawing is copyright reserved and remains the property of the architect.
- All work to be executed in strict compliance with SABS 0400
- All dimensions to be checked on the site and any discrepancies to be reported to the Architect immediately before commencing with any work.
- Written dimensions to be used in preference to scaled dimensions.
- Drawings my not be scaled from prints.
- All electrical and drainage work to be executed by registered artisans.
- Where required, Architects drawings to be read in conjunction with Engineers drawings.
- Where required, Architects drawings to be read in conjunction with Manufacturer's specification.
- All specified or equal approved specifications to be used.
- Finished floor levels to be a minimum of 150mm above natural ground level unless otherwise shown. Firewalls to underside of roof covering. Minimum 150mm threshold plus fire door to garage where interleading with house.
- All doors to the exterior that open outwards are to have a 15mm step up to the inside on the inside of the door leaf, and those opening inward are to have a 15mm step up along the longitudinal centreline of the door leaf.
- All concrete foundations to be a minimum of 700mm x 200mm unless shown otherwise. Top of concrete foundation to be a minimum of 300mm below ground level unless otherwise shown.

DRAINAGE

- All plumbing work to be carried out by licensed Drainlayers and plumbers.
- IE's to all bends and junctions to be easily accessible. IE's to have marked covers at ground level. Rodding eyes to be provided where necessary.
- All soil pipes to be 100mm diameter glazed earthenware or pvc drains and to have a minimum fall of 1:60. Top of drain to be at least 300mm below G.L.
- All waste pipes to be 50mm internal diameter. All waste fittings to have deep "P" resealed traps and to be fully accessible for repairs and cleaning.
- All vent pipes to extend 900mm above roof level. Waste pipes exceeding 6m to be vented. S.V.P.'s to all W.C's having more than 1200mm vertical discharge.
- All soil and waste fittings to be accessible along their entire length for maintenance and repairs. All drains are to be accessible at 25m centres by means of M.H's or cleaning eyes. A manhole to be provided within 1,2m of the stand boundary.
- All drains under building to be straight runs, with IE's at the ends. The works to be encased in 100mm concrete. (15MPa min)
- Stormwater to run naturally with slope.
- All paving to be laid in falls.

WATERPROOFING AND DAMPPROOFING

- 375 micron brickgrip polythene D.P.C.
- D.P.C.'s under all walls and screen walls to be 150mm above finished ground level.
- D.P.C.'s under cills, behind weather boards and under ridge tiles. Vertical D.P.C.'s to all changes in floor level. Surface beds to be on approved waterproofing forming a continuous sealed membrane with the D.P.C.'s under walls. Flashings to all changes of roof levels and to chimneys. Impervious copings to all parapets.
- Remove stormwater from building and site.
- Waterproofing to roof slabs: All waterproofing to roof slabs to be Derbigum SP4 sheeting, all to be laid (including flashing and counter-flashing) strictly in accordance with manufacturer's instructions, with U87 bituminous paint to all exposed surfaces and guaranteed unconditionally for ten years.

NATURAL LIGHT AND GLAZING

- All habitable rooms to have a minimum 10% natural light.
- All glazing to comply with part N of the N.B.R. and SABC 0137-2000 Code of Practice safety and laminated glass to conform to SABS 1263.
- Aluminium doors and windows to conform to A.A.A.M.S.A. standards.
- Minimum thickness of glazing panes: panes not exceeding 0,75sq.m=3mm thick, panes not exceeding 1,5sq.m=4mm thick, panes exceeding 1,5sq.m=6mm thick.
- Safety glass to window panes lower than 300mm from finished floor level.

DRAWING NOTES

OWNER SIGNATURE

DRAWING TITLE

Sketch Plans

SCALE	DATE	DRAWN BY	DRAWING NR
		CHECKED BY	