

Light steel construction and modular  
homes as alternative building methods in  
South Africa.

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# **1. Chapter 1**

## ***1.1 Research Proposal***

I am going to research alternative building methods focussing on Light steel frame construction and modular homes. The construction industry is an ever changing environment where new technology is always at the forefront. The intention of this paper is to find out whether these two alternative building methods can become an everyday building practice. The following main questions which will be researched will give insight into problems existing in the current built environment and how the alternative methods could solve them.

## ***1.2. Problem***

Will light steel construction and modular homes be a good choice and be a viable option for alternative building methods in South Africa?

### **1.2.1 Chapter 2**

Why would you use alternative building methods opposed to conventional building methods?

- Hypothesis

As pressure comes to bear in the construction industry to supply alternatives to the more traditional methods of construction, light weight steel framing and modular homes, exhibits many attractive features for the Designer, Builder and Owner. It offers quality, cost efficiency and speed of erection for low-rise residential and non-residential buildings.

### **1.2.2 Chapter 3**

Is light steel framed construction and modular homes cost efficient and sustainable?

- Hypothesis

Both of these methods are very easy to erect and time and money will be saved in the erection process. All of the materials used in the erection process are of an excellent quality and has been tested and proven to work. All materials used on the outside shell of the buildings have been used for many years overseas and also on conventional buildings in South Africa. Cost efficiency will be a deciding factor when people decide on the building method to be used to construct their building.

### **1.2.3 Chapter 4**

Can Light steel frame construction and modular homes be used as an alternative for low income housing?

- Hypothesis

This means that the homes must be affordable for those who have a median income. In South Africa low income housing is very important. With these alternative building methods homes of many different sizes can be built and with the ease of erection more homes can be built in less time. Another problem that might arise is that the people living in these low cost housing schemes might not know a lot about the construction of the houses and how to maintain them.

### **1.2.4 Chapter 5**

How do you maintain light steel frame structures and modular homes?

- Hypothesis

Maintenance on homes can be one of the deciding factors when choosing the best method to build your home. Maintenance costs on both of these methods would be the same as conventional building methods. It doesn't take a lot of time to replace and fix anything on these houses and it can be done with great ease. Maintaining these homes are basically the same as for conventional homes, but only people with knowledge about light steel frame structures or modular homes will be able to do sufficient repairs.



### ***1.3. Research methodology***

It will have to be proven that these alternative methods will be a better option than building a structure with the conventional methods. Firstly I will research all of the advantages and disadvantages of the alternative methods and compare it with current methods. I will have to look at all of the aspects contributing to low income housing and not only to the cost of the house. This will include maintenance, lifecycle costs and sustainability.

I have attended a course on lightweight steel frame construction and plan to talk to the people at SASFA about their projects and visit their construction sites and training facilities for firsthand experience

Light steel framed construction is a very new building technique in South Africa, so a lot of the research will have to be based on existing buildings overseas.

### ***1.4. Delimitations***

Light steel frame structures and modular buildings are new building methods in South Africa and it will be difficult to get sufficient information about the use of these alternatives in South Africa and a lot of information will have to be used from overseas where these alternative methods are well established.

## 2. Chapter 2

- Sub-Problem

Why use these alternative methods?

## Introduction

### 2.1. Light steel frame building

Light steel frame building is a well known building method in Australia, the US and Europe, and has been in use for more than 50 years. It is used for low and medium rise residential and office buildings, schools and many other types of buildings; in fact it can be used for any type of building. Strange enough, this building method was never established in South Africa. The main purpose of this introduction is to give insight into the erection process to better understand how light steel frame construction works.

Typical Steel framed house

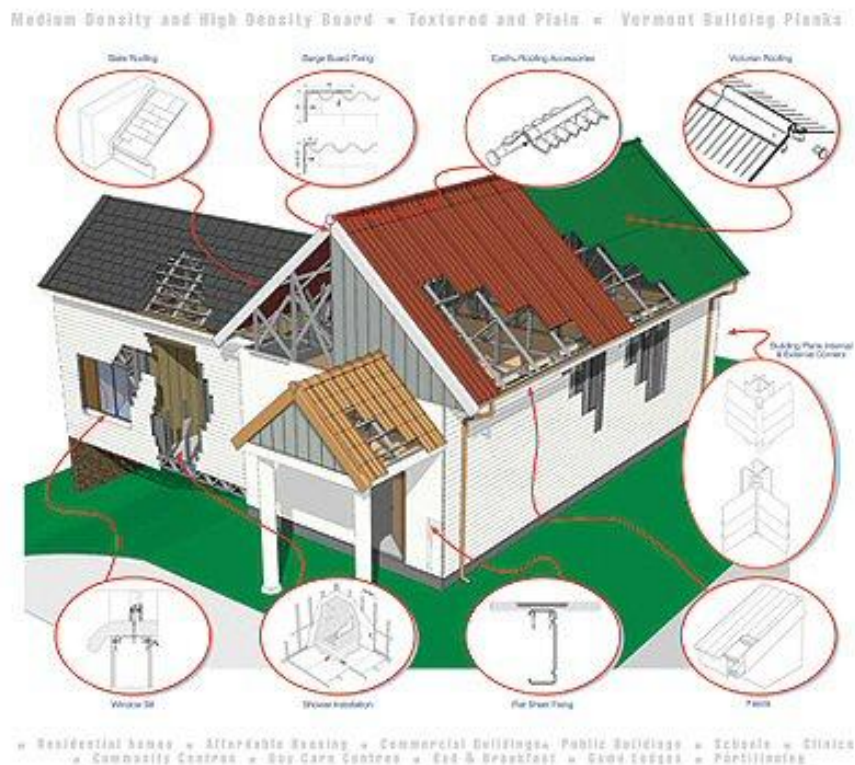


Figure 1

<http://www.bultrading.co.za/fca.html>

### ***2.1.1 What is light steel frame building?***

Light steel frame building is a building method, and should not be confused with prefabricated or 'kit' buildings. It has been described as 'off-site' building, as a lot of the manufacturing takes place in factories, and the components are assembled on site. It consists of structural wall panels and/or trusses, assembled using cold formed steel sections made from thin gauge high strength galvanized steel sheets. Sections are joined together, typically in a factory, using rivets or self tapping screws, to form structural wall panels and/or roof trusses which are transported to site for erection on foundations and floor slabs.

Similar to timber frame construction, the wall frames are clad externally and internally on site with a range of alternative cladding materials with services (electrical and plumbing) and insulation material installed in the wall cavity. Any type of roofing material can be used.

Light steel frame buildings offer environmentally friendly, structurally sound buildings; speed of construction; excellent thermal insulation; accuracy and quality finishes.

## **2.2. The process**

- Approval by authorities

As a first step, a normal building plan has to be drawn up by an architect or draughtsperson.

As light steel frame building is not yet included in the National Building Regulations as a conventional building method, plans have to be submitted for approval together with a rational design by a competent person, normally an engineer. The South African light steel frame association (SASFA) building code can be used as basis for the design.

- Manufacturing and assembly

Building plans, preferably in electronic format, are used by the manufacturer of the light steel frames to carry out the structural design and detailing of the frame. The dimensional data for the frame members is electronically transmitted to the sophisticated profiling equipment which is fed from a coil of galvanized steel strip. It forms the section via a set of progressive rollers, cuts each section to exact length and punches holes for fasteners in the required places. These machines even indent the sections at fastener locations to provide a flat surface for the cladding materials.

A unique reference number is automatically stencilled on each section to ensure that it is installed in the location specified on the structural layout drawings, also generated by the design software.

As the sections are produced, a team of factory workers assembles the frames and trusses under conditions ideal for quality control. Wall frames are provided with cross bracing, consisting of galvanised steel strips, to ensure the frames are square and rigid. The completed frames and trusses are stacked, ready for transport to the building site. If the latter is in a remote location, the manufacturer may elect to transport the sections for the frames and trusses strapped in bundles for site assembly, thus saving on logistics costs.

- Some truss manufacturers also produce sections in long lengths, to be cut and assembled on site according to supplied detailed drawings. (Sasfa course in light steel frame erection, student support materials, revision 1, 2009)

## **2.3. General Building practice**

Before setting out the positions of wall frames, the dimensions, level and square of the slab/floor should be checked. Starting with a level and a square slab or sub-floor (within allowable tolerances) to erect any type of building upon is essential to the end quality of the building.

Although it is possible, in most cases, to accommodate some “out-of-level” and/or “out-of-square” or incorrect slab dimensions, this will require more work and possibly some modification of the assembled frames. If the level and/or square of the slab are found to be outside of the allowable tolerances, the owner should be informed before any work is carried out.

### ***2.3.1 Floor surface***

The flatness of the floor surface is to be within  $\pm 10\text{mm}$  over the entire room, but not exceeding  $\pm 5\text{mm}$  over any 3m length, unless specifically designed with a slope.

Allowable variations to slab dimensions will be limited by:

- In the case of undersize- How far from the bottom plate is allowed to overhang the slab edge. Unless manufacturers specifications state otherwise, 90mm wide should not overhang the slab by more than 20mm. Remedial work may be able to be carried out to extend a slab, however, the slab engineer and frame manufacturer should be consulted before such work is done.

- In the case of oversize- The type of cladding will generally limit how far the slab can extend beyond the frame, e.g. the slab may be able to extend into the cavity of brick veneer cladding. Remedial work may be able to be carried out to extend the frame to suite the slab, however, the slab engineer and frame manufacturer should be consulted
- Although there are no guidelines on allowable “out-of-square”, this will always result in one or more dimensions to be incorrect and remedial work as above may have to be performed.( Sasfa course in light steel frame erection, student support materials, revision 1, 2009)

## 2.4. Steel building practice



Figure 2

[www.engineeringnews.co.za/article/light-steel-framed-housing.html](http://www.engineeringnews.co.za/article/light-steel-framed-housing.html)

Just as with any building material, steel requires special care in its use. Consideration should be given to the following items:

- Cutting

The cutting of the flange of any structural member is not recommended under most conditions. The modification of any member of a steel house frame must be carried out with the utmost consideration of the structural effect and only with the consent of the fabricator.

When cutting a flange, the choice of correct reinforcement, including fixings, is best left to the manufacturer of the system.

-Holes and notches in stud and plates

Steel wall frames generally have pre-made holes in studs, plates and noggins to allow for the installation of services such as electrical and plumbing.

Typically steel wall frames will have a minimum of pre-made holes:

- In studs
  - Just above the joinery line
  - At light switch height and
  - At power point height
- In top plates and solid noggins
  - A minimum of one hole placed midway between every pair of studs.

For bottom plates, holes are optional but may assist rainwater drainage during construction if framing is exposed to the weather for long periods of time.

As a general guide:

- the maximum hole diameter 50% of the depth of the member
- drill in the centre of the depth of the member
- minimum hole spacing 2,5 times the diameter of the largest hole.
- never drill in the flange
- never drill at a point of support.

## **2.5.Screw fixing**

In areas where perpendicular access is hard, the point of fixing can often be marked with a centre punch to reduce the tendency of the screw to wander. Screws should not be installed too close to the edge of a component member.

## 2.6. Erection procedure

### 2.6.1 Frame Erection

After casting the concrete slab and giving it sufficient time to cure, the wall frames can be erected on top of the slab.

Like in any other building practice an impermeable membrane must be applied to the roof trusses on the top plates before erecting the frames.

- Standing Frames

Frames should be sorted and laid around the job close to their positions.

Starting at a convenient external corner, stand to frames up to produce the corner. Connect the two frames using fabricators recommended fixings and method. Fix temporary props to the end of the walls to ensure that they stay in an upright position. The levels should be checked and the frame plumbed. The frames should be plumbed at the corner using a spirit level of appropriate length and any factory installed braces and temporary braces must be adjusted and fixed while holding the frame plumb.

After the frames are plumb and braces fixed, checked the position of the bottom plates at the corner and fix to the slab ensuring that any packing required is positioned at the fixing point. Align the ends of the frames with the chalk line and fix to the slab.

Proceed with the erection of the remaining frames around the house, internal and external as they come. However be careful to ensure that access is maintained, particularly for large frames, from where the frames have been placed.

Fix down all frames to the slab with the method specified. After all the frames are in places and permanently fixed down, re-check the plumb of all corners and wall junctions. If diagonal tension braces are used, the brace tensioners can be tightened or loosened to move the frame slightly.

- To finish the erection of the frames, the bottom plates in doorways can be removed. This is done by cutting out the bottom plate with a angle grinder. On completion the area should be completely cleared and waste material disposed of safely. Any excess materials should be stacked and stored to allow for use at a later date.( Sasfa course in light steel frame erection, student support materials, revision 1, 2009)

## **2.6.2 Roof Erection.**

Installation tolerances:

- Position: Trusses, rafters, ceiling joists and floor members must be positioned within 20mm from their specified position.
- Straightness: Trusses, rafters, ceiling joists and floor members must be installed with an overall straightness not greater than  $L/500$  where L is the length of the member. Differential in vertical bows between adjacent members must not exceed  $1/150$  of their spacing or 6mm whichever is less.
- Plumb: Out of plumb at any point along the length of the truss from top to bottom, must not exceed the minimum of  $h/100$ , where h is height, unless the trusses are specifically designed to be installed out of plumb.

### **2.6.2.1 Handling and storage**

Handling and storage is generally the same as with conventional timber roof trusses. When lifting trusses lateral bending stresses should be minimised. The light steel trusses are light enough to be lifted by hand.

### **2.6.2.2 Roof systems**



APLIKASI RANGKA ATAP BAJA RINGAN DENGAN BENTENG METAL

Figure 3

[www.caiwcharlotte.com/lightframeroofadvantages.html](http://www.caiwcharlotte.com/lightframeroofadvantages.html)

There are two types of roof systems:



### ➤ Panel roof system

This form of construction is modelled on traditional timber framing with rafters supported on strutting beams and ceiling joists supported on hanging beams.

The roof rafters and ceiling joists are assembled into panels in the fabricator's facilities using 'noggings' spaced so that they act as the roof battens for the roof panels and ceiling battens for the ceiling panels. The light weight of the steel panels allows the frames to be manually handled both in the factory and on site.

The rafters and ceiling joists are typically spaced at 600mm centres. One of the main advantages of this system is that it provides large open areas within the roof that allows good access for maintaining services and the provision of storage space provided this is included in the design. Blind rivets or screws are used to connect the components together to form the panels and self drilling screws are used to connect the panels and beams together on site.

The panel system utilises internal walls to carry roof and ceiling loads. The slab must be designed to carry these loads.

### ➤ Truss roof systems

The truss system is identical to conventional timber roof trusses. Trusses provide clear spans so interior walls can be moved easily during remodelling or when making additions. The truss spacing is determined by the type of roof cladding (ie. tile or steel sheeting), the strength and rigidity of the purlins and safety guidelines for safe installation of cladding. Truss spacing typically varies from 900mm to 1400mm. As steel trusses are very strong and rigid, it is generally more economical to space them further apart. However this has been limited by safety guidelines that limit the spacing of trusses.

- Truss bracing

Bracing to the trusses is essential to prevent them rolling over, the buckling of members, and to provide overall stability to the roof under all relevant loading conditions. Bracing on light steel trusses is based on the same principles as bracing for conventional timber trusses. Diagonal bracing to the top chords is typically at an angle of 30-45° to the ridge line. Generally ceiling battens and ceiling sheets fixed directly to the underside of the bottom chords are sufficient for bottom chord bracing and lateral restraints. The ceiling itself acts as a diaphragm to transfer wind and bracing loads to cross walls.

## Connection of trusses to internal wall frames

### 1. Non-Load bearing walls

Non-load bearing walls should not carry any truss loading at any time. It is common to set non-load bearing walls lower than the supporting walls by an amount equal to the depth of the ceiling battens plus 10mm. If the truss is required to stabilize the top of the wall, this is done by using specially designed 'L' type brackets screwed to the top plate and screwed to the top of the vertical slots.

### 2. Load bearing walls

If internal walls are required for support, the truss itself and the layout shall be marked accordingly. The supporting structure, including footings, must be constructed to allow for this truss load. The tie-down of the trusses to internal load bearing walls must be in accordance with the fabricators specifications.

- Truss tie-down

The general method is to fix down through the bottom chord. Fixings may be one of the following:

- Self tapping screws
- Framing anchors or straps and screws

## **2.7.Fixing lining and cladding**

### ***2.7.1 Insulation and weatherproofing membrane***

Before commencing lining and cladding work, insulation and sarking material must be fixed to wall framing. Insulation material should be installed in/onto wall frames as per building requirements and manufacturer's specifications.

All external walls should be lined with sarking material to help prevent water and moisture penetration. Insulation should follow the recommended method for sarking fixing to steel framework as specified in the manufacturer's specifications for installations.



Figure 4

<http://www.steel-framing-systems.co.uk/>

### **2.7.2 Lining**

There are minimal changes to the procedure for the fixing of plaster board in steel framed building compared with a timber frame, except that screws are generally used. These screws are the normal bugle head plasterboard screws either self-drilling or needle point depending on the thickness of the steel.

- Adhesives

A variety of adhesives are available for fixing floor and wall linings to steel members. Compatible solvents should be used for cleaning adhesives spills and surface squeeze out.

### **2.7.3 Cladding**

Flush fitting and overlapping style claddings are suitable for fixing to steel frames with the use of special fixing clips or self drilling screws. Special care must be taken not to fix to close to the outer corner of the stud so as to prevent deflection of the flanges.



Figure 5

[http://www.bultrading.co.za/fca\\_wood\\_grain.html](http://www.bultrading.co.za/fca_wood_grain.html)

## **2.8. Services in steel frames**

### ***2.8.1 Plumbing***

- In steel frames the plumbing services are installed by running pipes through pre-punched holes in the studs within the cavity. ( Sasfa course in light steel frame erection, student support materials, revision 1, 2009 )

Three main considerations for the plumber are:

- Penetrations in steel: Pre-punched holes should be used whenever possible
- Dissimilar metal: Copper and galvanized steel do not go together. Copper pipes must be lagged or the service hole must have a plastic grommet fitted.
- Fixing methods: Pipe runs and outlets must be securely fixed to prevent vibration- to minimize water hammer and chafing of the pipes.

### ***2.8.2 Electrical***

In steel frames the electrical services are installed very much the same way as the plumbing, that is by running through pre-punched holes in studs or within the cavity.

Three main considerations for the electrician are:

- Penetrations in steel: Pre-punched holes should be used whenever possible.
- Earthing of frame: The frame must be earthed as soon as possible
- Fixing methods: The service hole must have a plastic grommet fitted and wires must be securely fixed to the frame with clips.

## **3.Modular homes**

There are a wide range of modular homes today from which to choose. Starting with the basic modular home and escalating to a top of the line home that could not be any more luxurious if it were site built you will find there are as many styles to choose from as there are finished homes.

Many people confuse the modular home with a mobile home. They are not alike at all. The modular home is the equivalent of an actual home built on site. The only

difference is it is constructed in sections and then placed. Modular homes are required to pass the same requirements as a site built home. They are not mobile because they do not have a frame and wheels.

The Estate modular home is one of the best modular homes you can purchase. The luxury this home provides will be surpassed by none. From the countertops which can be a variety of materials including granite or marble to the solid oak flooring you will be surrounded by the elegance the modular home can provide. There are many with fireplaces, whirlpool tubs, and decks. There is no difference between an Estate modular home and the high-end site built home except for the price.

System built homes make more sense for many people rather than the traditional built home. The homes are built in a factory. They are attached to a foundation and then shipped in sections. The readied site is waiting for the home to be placed and put together. These homes must meet stringent regulation requirements before leaving the factory as well as conforming to the regulations of the state in which they will be placed.

The modular home once placed on a site and put together does not look any different than a site built home. They are just as safe and can be as large or as small as you want. There are modular homes with attached garages, brick or brick veneer the same as a traditional home or vinyl siding.

Modular homes have the same R-values as a conventional brick house and the insulation between wall panels can offer the same sound proofing.

Construction times can be cut by up to 60%. In addition, weather delays and rework due to weather damage are also decreased. More work can be accomplished in the same amount of time due to the production efficiencies gained through factory infrastructure.

## **4.Light steel frame structures as alternative methods**

### ***4.1 Benefits and challenges between lightweight steel structures and conventional masonry buildings***

- Benefits:

-Speed of erection

- Dimensional Accuracy (straight and erect walls with 90 degree corners),

- Predictability of end -product cost, quality, delivery appearance.
- An advantage for sites with problem soil conditions, remote sites or steep sites.
- Environmentally and economically advantageous, as steel is fully recoverable and recyclable. Lightweight homes are easy to modify, add to, or demolish, with minimal site impact.
- More stable than timber as a framing element and is resistant to cracking, rot, termites, and warping.

- Challenges:

In comparison with America or Australia, South Africa has a limited history of lightweight home construction. Locally grown timber construction tends to be of comparatively poor quality. Together with limited availability and expense, this has made masonry construction a first preference. Major investment in the education of the industry in the use of this new technology will be necessary. This task should not be underestimated, as conservatism resists change, especially when there is the perception that current building methods are as good as anyone needs.

- General perceptions relate lightweight construction to temporary structures such as site offices and temporary accommodation.
- Accreditation: Local Authorities are not familiar with the technology. There will be delays and disputes during the process of drafting new building regulations and agreement certificates
- Established contractors and suppliers (bricks, sand, cement) to the traditional building sectors may see the new technology as a threat to their business.
- Builders have to familiarize themselves with new methods.

## **5. Modular homes as alternative building methods**

The modular home once placed on a site and put together does not look any different than a site built home. They are just as safe and can be as large or as small as the client wants. There are modular homes with attached garages, brick or brick veneer the same as a traditional home or vinyl siding.

## ***5.1 The factory advantage***

According to Andrew Gianino, (July 2006), President of “The Home store”, the factory system combines engineering and factory production methods to design and build more efficiently and with greater control. When the factory runs smoothly, the efficiency results in greater quality control which in turn results in a better product and also lower costs. In other countries like the United States the idea of building homes in factories is not a recent phenomenon. Prefabricated houses have been built in other countries from the 1890’s. Even some conventional masonry houses today use a growing number of mass-produced, factory built components including roof trusses, interior mouldings, drywalls and kitchen and bath cabinets. More aspects of home construction are being completed in factories because factories help to organise the construction process. These factories use automatic assembly equipment and repetitive assembly line techniques, they also assemble component parts more efficiently and with greater consistency in product quality.

Some of the best products in the world like computers, cars and planes are manufactured in factories. That is why some consumers and industry professionals in Japan consider the modular method of building a superior technique to site- built construction.

The one big problem, especially in South Africa, is the high number of unschooled labour. Very few companies have apprenticeship programs to learn labourers specialist trades such as carpentry. The skilled labour shortage has eroded craftsmanship, driven up prices, and caused delays and poor construction. This is one of the main reasons why modular homes are so enticing; it introduces some control in the building process.

## ***5.2 Advantage in quality***

All of the following aspects contribute to the better quality of modular homes according to A.Gianino(July 2006):

- Trained and strictly supervised workforce
- Larger, more powerful, and more advanced equipment
- Assembly is very precise
- Use of the highest quality materials
- Construction in a climate controlled facility with materials protected from the elements.
- Unparallel structural strength
- Superior energy efficiency

- Accurate quality control systems

### ***5.3 Advantage in planning***

When building a modular home the contractor and the dealer have to complete most, if not all, of the planning steps before beginning construction. The manufacturer cannot begin construction without knowing what it is going to build and how much it is going to charge. This forces the customer and dealer to make final decisions about the homes design and its building specifications.

When pressed for time on construction of a conventional masonry building, the customers and also the builders prefer to start construction and postpone the meetings and decisions to a later date. The thing is that modular dealers won't be able to get away with it. The planning discipline imposed by modular construction is an advantage for customers, because poor planning almost always leads to cost overruns.

A good example is when customers who do not spend enough time thinking through the design of their home often discover some design flaws once construction has started. One week they notice that the closet is too small, the next week they decide that it is better to make the dining room smaller so the kitchen can be larger, and the following week they realize that the door to the study will be swinging into a bookcase. When they make discoveries like this, they have the choice of accepting the layout as is or asking the builder to make the necessary changes, which might include tearing down the walls he has already built. If they decide to make the changes, all of the additional costs are passed on to the customer through expensive change orders.

Another way in which delayed planning can cost a customer money is when "allowances" are used to cover the cost of materials that have not yet been selected, such as cabinets and flooring. This is sometimes done so that construction can be started before every selection has been made. The builder assigns a Rand amount for those items yet to be specified. The allowances are adjusted, often higher, depending on the cost of the customer's final decisions. If someone builds a modular home, the client and his dealer will not have many opportunities to dwell on their decisions, and they will not be subject to as many unbudgeted expenses,( Andrew Gianino)(July 2006).

### ***5.4 Opportunities in design and Services***

In other countries in the earlier years of modular home construction, the homes where affordable as long as people where satisfied with second-rate finish quality and limited design choices. Today, modular homes are still affordable, but with superior quality and a



wide selection of creative designs. Modern assembly lines are producing unique, custom designs that were not possible a few years ago.

Many manufacturers have a wide range of standard plans that are traditional in function and style. Most of the manufacturers also supplement their standard offerings with more modern designs. Many of these modular homes are designed by modern architects as they have also started to explore the possibilities of modular homes. When complex house plans cannot be built completely at the factory, as much as possible is built at the factory and the rest has to be completed on site.

A lot of manufacturers are willing to design a plan that expresses the clients personal preferences. They might start with one of their standard plans and change it to the customers needs or design a home from scratch as long as it can be built economically in their factories. Computer aided design (CAD) has made it possible to prepare custom floor plans quickly and accurately.

The design work begins with the dealer, but the modular manufacturer completes the engineering when it prepares production plans, which detail the actual construction of a house. The combined design and engineering services provided by the dealer and the manufacturer are substantially greater than what is provided by custom site-builders, who are usually small and without the necessary time and resources. Most dealers and manufacturers charge very reasonable fees for their services. When a customer needs detailed design assistance to construct a site-built home, he often must obtain it from an architect, who rightfully will charge thousands of Rands for the work. (Andrew Gianino, July 2007)

## **6. Renovation using light steel framing**

Renovations are another great application of light steel framing. It is an important social and economic requirement and is an increasingly important part of the South African construction industry. The use of light steel construction works great for extensions and adaptations of buildings.

Some of the popular types of renovations are listed below:

### ***6.1 Roof-top Extensions/ Over-roofing***

Over-roofing is a term used for the creation of a new roof structure to an existing building. The main reason for over-roofing are the poor performance of the existing roof (e.g. water leakage ) and the desire to utilise the space in the roof, for example, for communal use or as new apartments. The form of the new roof construction depends largely on whether or not the space is intended habitable use. The value of the new space created can pay for all the renovation work (this will be discussed in the next chapter on cost efficiency).

## Roof-top extension using modules by Unite at Plymouth University



Figure 6

[www.steel-sci.org/ShortVersionBuildingRenovationUsingLightSteelFrami.doc](http://www.steel-sci.org/ShortVersionBuildingRenovationUsingLightSteelFrami.doc)

### ***6.2 Over-cladding***

‘Over-cladding’ is defined as the attachment of new cladding directly over an existing facade, and is different from ‘re-cladding’ where the existing cladding is replaced. Over-cladding is carried out in order to:

- reduce the heat losses through the façade and to meet modern thermal regulations
- improve the appearance of the building
- stop the wear and tear of the existing structure or façade, including water leakage
- Minimise disruption to the occupants during the renovation process.

Over-cladding can use a variety of materials. Insulation is provided behind the new cladding and may be attached to the existing wall with suitable weather protection. Over-cladding often involves use of a sub-frame which is attached either directly to the existing façade, or preferably to the existing floors or primary structure which avoids attachment to a potentially weak existing facade. Storey high sub-frames can be created and their attachment requires some form of adjustment for site tolerances, and to allow for the irregularity of the existing façade.

A prototype over-cladding system, using composite panels spanning vertically between sub-frames, has been subject to exposure trials at Edinburgh University for over 13 years.

The complete specimen is shown in the figure below. It was found that the environmental conditions in the cavity behind the new façade do not lead to a risk of condensation, and that the small air movement is such as not to significantly affect the insulating effect of the external composite panels. The heat losses through the existing façade are reduced by over 60%. ([www.steel-sci.org/ShortVersionBuildingRenovationUsingLightSteelFrami.doc](http://www.steel-sci.org/ShortVersionBuildingRenovationUsingLightSteelFrami.doc))

Edinburg University Over-cladding Test



Figure 7

[www.steel-sci.org/ShortVersionBuildingRenovationUsingLightSteelFrami.doc](http://www.steel-sci.org/ShortVersionBuildingRenovationUsingLightSteelFrami.doc)

### ***6.3 Modular units in renovation***

Buildings may be extended easily using modular or 'volumetric' units which are self-supporting vertically, but which are supported laterally by the existing structure. Modules are generally less than 3.6 m wide so that they can be transported without special escort and are easily lifted into place. Cladding can be pre-attached, or can be installed conventionally on site.

Examples in South Africa

Light steel framing was used successfully in the building process when building the new Greenpoint Stadium in Cape Town. It was mainly used for the facilities and non-load bearing walls within the stadium.

Typical light framed wall at the Greenpoint Stadium



Figure 8

[http://www.bydesign.org.za/projects\\_lsf.htm](http://www.bydesign.org.za/projects_lsf.htm)

Light steel framed wall within the Greenpoint Stadium



Figure 9

[http://www.bydesign.org.za/projects\\_lsf.htm](http://www.bydesign.org.za/projects_lsf.htm)

## 7.Green building

### 7.1 Benefits of green homes

With these alternative building methods it is a lot easier to build green homes. On a personal level, a green home promotes healthy living by protecting your physical and

emotional well-being. It also reduces your home's energy costs. On a global level, green high-performance construction supports a healthy environment by conserving the earth's resources. It also safeguards our planet's life support systems.

A green home is built with sustainable practices, ones that rely on renewable resources. Green builders use land in a way that is sustainable. They reduce the impact of construction on a site's natural vegetation, thus preserving native plants, trees, and topsoil, and they use landscaping that conserves water. Green builders efficiently employ resources, conserving materials and cutting waste where possible. They select materials and equipment that are friendly to the environment. When green builders apply these practices to their heating and cooling systems, they craft homes that use less energy, which benefits our planet. The client benefits as well, since they save money, as much as 50% on utility costs according to Andrew Gianino, (July 2007).

## ***7.2 Factories promotes green building***

Andrew Gionino (July 2007) shows that building green is easier, faster, and more affordable when using modular technology. The hallmarks of high-performance green construction - energy efficiency, healthier indoor environments, and sustainable practices - are more readily accomplished in a factory. The modular building system produces tighter, more energy efficient homes than conventional construction. Efficient assembly line practices and quality control procedures ensure this result. Volume purchases reduce the cost of the green products needed to create a healthy indoor environment. And factory production practices use manpower, materials, and energy more efficiently.

The thermal envelope of a modular home easily meets or exceeds the requirements of green construction. High-performance green windows and doors, matched with ample amounts of insulation, create a well insulated modular shell. Tighter construction is typical because the modular structure can be built from the inside out in the factory's climate controlled facility. Conventional, on-site builders first sheath the exterior of the home to protect the structure from the elements. They next install the mechanical systems and insulation in the walls and cover the finished product with drywall. This sequence makes it difficult to seal behind the drywall penetrations required to complete the plumbing, electrical, and heating systems. A modular home begins with the mechanical systems installed through the drywall before the exterior sheathing is glued and nailed in place. This allows assembly line workers to directly seal the drywall penetrations.

Another reason modular technology produces tighter homes is that the components are joined with stronger fastening systems. Many components are attached with both glue and conventional fasteners. Since the grade of glue is often stronger than the screws, nails, and bolts, this modular technique bonds the materials very tightly together. And since the glue fills many of the cracks and crevices that naturally occur between framing materials, the fastening system further reduces air infiltration.

The tighter construction typical of high-performance modular homes offers another advantage besides lower energy costs. It reduces the amount of pollen, dust, moisture, and other outside pollutants that can get inside a home. Because this tightness limits the amount of stale air that can escape a house, modular homes - like all tight, energy efficient homes - need to take steps to ensure the inside air stays healthy. Green modular manufacturers accomplish this in two ways. They significantly reduce the use of products that emit pollutants, and they install ventilation systems that remove the pollutants that build up inside.

Many of the products used to build today's homes contain chemicals that are released into the air over time. This "off-gassing" or "out-gassing" is particularly unhealthy when the gases include formaldehyde or volatile organic compounds (VOC). Green modular factories select materials that emit less formaldehyde and use paint, primer, sealants, and adhesives that emit little VOC. Green modular manufacturers are able to affordably switch to these healthier materials because of their volume purchases.

Limiting the use of products that emit toxic gases is only half the challenge of creating healthy indoor air. After all, people's everyday activities of breathing, cooking, bathing, and cleaning inevitably create airborne pollutants and moisture. Green modular manufacturers help create a healthy indoor environment by installing ventilation systems that replace the stale air with fresh air from the outside. This can be done affordably with Energy Star approved bathroom fans and kitchen range hoods that exhaust to the outside.

Modular factory production includes a third green characteristic: it enables resource efficiency and sustainable practices. Green modular factories promote resource efficiency by selecting products that reduce the demand for water, energy, and materials. For example, green modular homes include water efficient fixtures, such as low flow toilets and water efficient showerheads and faucets. Green modular manufacturers create less waste by using lumber pre-cut to size and by reusing and recycling what they can of their limited waste. For instance, it is common for a modular factory to recycle cardboard, aluminium, steel, and plastic and to reuse drywall. The limited on-site construction of modular homes conserves energy by reducing the number of trips to and from a job site.

Modular factories promote sustainable practices in several ways, most notably with assembly line procedures that reduce build time, enhance quality, and lower cost. Modular technology even carries sustainability to the building site. With most of the home built at the factory, green modular construction causes less damage to the environment, and imposes less noise and disruption on the neighbourhood.

## **8. Summary**

There are many reasons why one would use these alternative building methods as stated in this chapter. There are many advantages and applications for these building methods through renovations and the ease of planning and erection. Prefabrication of the materials

and assembly of the walls beforehand makes for a cleaner site and also an easier site to handle.

## **9. Conclusion**

The construction industry is an ever changing industry where innovative ideas can make an enormous difference. These alternative building methods can change the future of the South African building industry. Time savings is one of the biggest advantages of these building methods and surely contractors will benefit from these time savings. In South Africa building renovations are also becoming a specialised field and contractors have the chance to use these alternative building methods to their advantage and benefit from it.

## **10. Test for Hypothesis**

These alternative building methods gives a look into the future of the South African construction industry that is rapidly changing. With shorter deadlines and construction moving at a faster pace, these alternative building methods gives the answer for small commercial and residential units and also for renovations. These alternative building methods can definitely be used because of their many advantages over the conventional building methods and good quality. In other countries these methods has been proven to work and more and more people are looking to use these homes and benefit from them.

## 3. Chapter 3

- Sub Problem

Is Light steel framed construction and modular homes cost efficient and sustainable?

3.1. There are many different aspects that contribute to cost savings when building with light steel frames. ( [http://www.steelteksystems.co.za/ST cost Comp May 09.pdf](http://www.steelteksystems.co.za/ST_cost_Comp_May_09.pdf) ) .

### **Some of these aspects are listed below.**

- **Simple foundations**

- A lighter, simple design raft foundation can be used as the complete LS structure is 30% of the weight of that of a conventional building.
- The walls of a 200m<sup>2</sup> brick built house will have a mass of approximately 178 tons (including clay bricks, mortar and plaster) compared with the 11,3 tons of an identical light steel frame building.
- The LS Frames are easily fixed to the foundation floor with sleeve anchors.

- **Saving in transport costs**

There is a large cost saving in the transportation of the light steel frames to site as compared to heavy conventional building materials.

- **The ease of construction**

- The LSF structure is clad with 11,5mm OSB board, waterproof membrane and 9mm fibre cement board on the outside of the building.
- The inside is clad with 12,5mm Rhino board with a 100mm fibreglass cavity batt fitted into the wall cavity.
- A team of 8 semi skilled workers are necessary to erect the entire building.
- From the above tables it can be seen that the current comparison between the brick walls and the light steel frame structure result

in significant savings.

- **Energy efficiency**

There is a saving of 10% in operational energy over the life of the building, due to the insulative properties of the materials used and this is a strong motivation for the use of LSF buildings.



- **Time saving**

With the ease of construction and the early enclosure of the building, uninterrupted construction leads to a reduction in build time of 50 to 60%.

- **Structural soundness**

- The galvanized high tensile material that is used can withstand potential structural damage.

- The thermal properties and fire rating of the completed LSF building is 1,5 times better than that of a conventional building.

### **3.2. A short cost comparison between LSF construction and conventional construction**

In the following section a brief comparison is made between materials and labour costs for light steel frame construction and conventional construction. The comparisons are based on a completed admin building of 300m<sup>2</sup>.

Cost comparison between LSF and Conventional buildings

Cost Per Item	Light steel frame			Conventional Building			LSF Savings	
	Units	Per Unit	Total	Units	Per Unit	Total	Cost	%
Building Platform	300m <sup>2</sup>	R650.00	R195000.00	300m <sup>2</sup>	R1300.00	R390000.00	R195000.00	50%
Materials(Per m <sup>2</sup> )	300m <sup>2</sup>	R1666.00	R499800.00	300m <sup>2</sup>	R1877.00	R563100.00	R63300.00	11%
Labour (Man Days)	315	R100.00	R252000.00	675	R100.00	R540000.00	R288000.00	53%
Totals			R946800.00			R1493100.00	R546300.00	36.5%
Rate Rand (Per m <sup>2</sup> )			R3156.00			R4977.00		

Table 1

Cost comparison between LSF and Conventional buildings

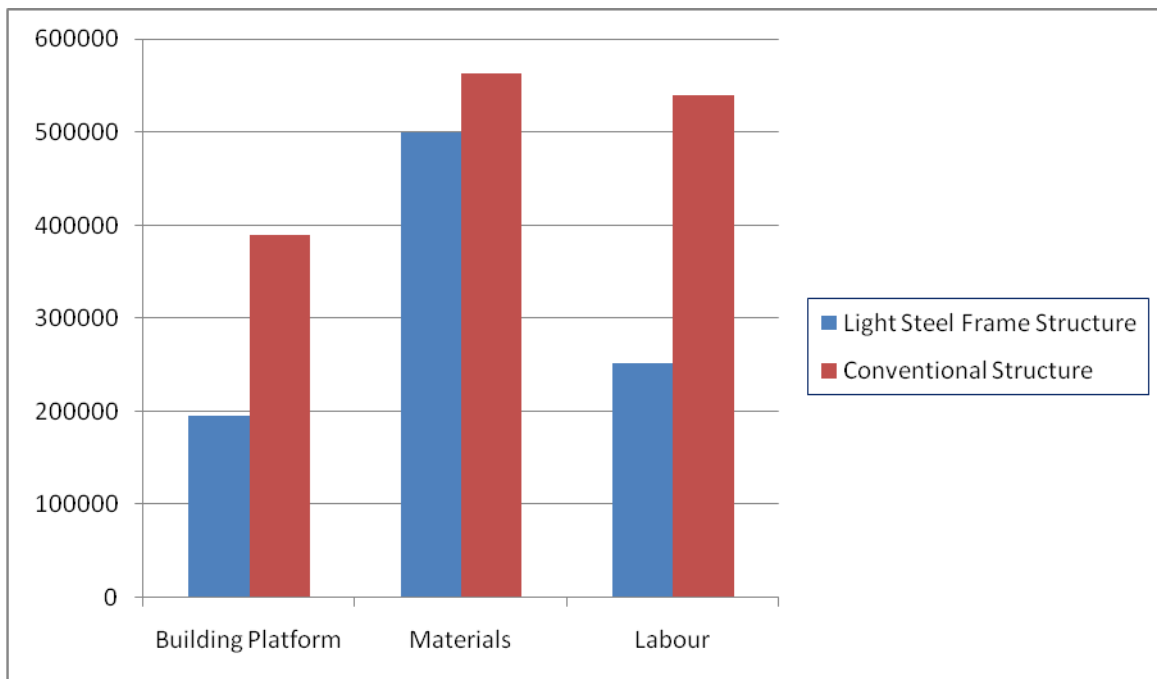


Figure 10

<http://www.steelteksystems.co.za/ST cost Comp May 09.pdf>

Savings by using LSF instead of Conventional buildings

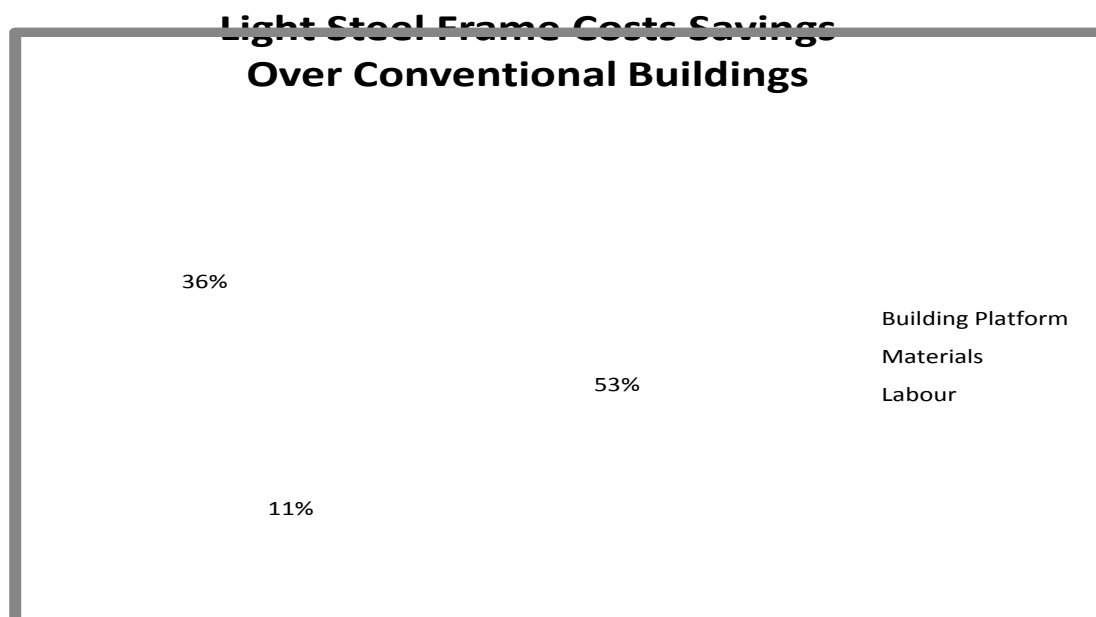


Figure 11

<http://www.steelteksystems.co.za/ST cost Comp May 09.pdf>

## Weight comparison between Light Steel frame buildings and masonry buildings

<b>COMPARISON:</b>			
<b>BRICK WALLS</b>			
<b>Clay bricks</b>	<b>No bricks*</b>	<b>total mass tons</b>	
External Walls	17.160	56.6	
Internal Walls	9.804	32.3	
	26.964	89.0	
<b>Mortar</b>	<b>sand mass tons</b>	<b>cement mass tons</b>	<b>total mass tons</b>
	40.0	4.3	44.3
<b>Plaster</b>	<b>sand mass tons</b>	<b>cement mass tons</b>	<b>total mass tons</b>
	40.0	4.5	44.5
<b>Total mass, brick walls</b>			<b>177.8 tons</b>
* includes 6% breakages			
** material supplier recommendations			
<b>LIGHT STEEL FRAME BUILDING (WALLS ONLY)</b>			
			<b>total mass tons</b>
Steel frame 0.75mm 550 MPa #			2.07
External cladding 12mm Verapanel			3.31
Internal lining 15mm gypsum board			5.89
Insulation (100mm) fibre mat, 15kg/m <sup>3</sup>			0.23
<b>Total mass Light Steel Frame Walls</b>			<b>11.5 tons</b>

Table 2

[www.bydesign.org.za/lightsteelframe.html](http://www.bydesign.org.za/lightsteelframe.html)

### 3.3. Economic Assessment of Over-roofing and Over-cladding

In the previous chapter over-roofing and over-cladding was discussed as another great application of modular homes.

A full economic assessment of over-roofing and / or over-cladding must take into account the following annual savings and income, in addition to the broad social and environmental benefits. The readily quantifiable financial benefits are:

- Savings in heating bills for both the occupants and owner
- Increased rental charges due to an improved internal and external environment

- Increased revenue (or sales) from the creation of new habitable space or additional facilities
- Reduced maintenance and repair costs of the existing roof or facade.

Other demonstrable savings of these renovation projects, in comparison to the alternative of demolition and re-building are the:

- Cost of having to re-house the occupants temporarily
- Cost and disruption of demolition and re-building in terms of site infrastructure.
- Time delays required by demolition and re-building

An economic assessment has been made by the SCI of the over-roofing and over-cladding of a typical 12 storey high-rise building in West London consisting of 96 two bedroom apartments. Over-roofing created eight new apartments and over-cladding of the whole facade (including new windows) reduced heat losses by over 70%.

Direct annual fuel cost savings of about R1900 per apartment were estimated, which is equivalent to over R180,000 per annum for the whole building. Assuming a 2% increase in the real cost of energy, the present value of the fuel cost savings over 20 years amount to R2,460,000 or R360/m<sup>2</sup> of existing floor area.

However, additional annual revenue is generated by reduced maintenance, increased rental revenue from existing apartments and rental revenue from the new roof-top apartments (R800/m<sup>2</sup> of new floor area per annum). Thus, total savings (including fuel cost savings) have been estimated to be in excess of R940,000 per annum, with a present value over 20 years of nearly R10,300,000 or R1730/m<sup>2</sup> of total floor area.

The cost of the over-roofing scheme was taken as R12,000/m<sup>2</sup> of new floor area, and the cost of the over-cladding scheme was taken as R3000/m<sup>2</sup> facade area, which are typical costs of recent projects. This gave a total cost of the renovation scheme of R10 million, which is equivalent to R1350 m<sup>2</sup> of total floor area.

It follows that the renovation scheme is self-financing over a 20 year period based on the easily quantifiable benefits. Inclusion of other environmental benefits, as listed above, would make the argument for renovation even more compelling.

Added to these economic benefits is the predicted reduction in CO<sub>2</sub> emissions of 513 tonnes per year. Furthermore, these benefits will continue long after the 'pay-back' period.

This economic assessment is based on a project in London, so the amounts won't be directly applicable to South Africa, but it gives a very good indication of the cost savings. ([www.steel-sci.org/News/ConstructionYearbook08.html](http://www.steel-sci.org/News/ConstructionYearbook08.html)) (Aug 2010)

### 3.4. Steel versus concrete

An updated cost comparison study for commercial buildings highlights that structural steel frame solutions continue to be faster and more cost effective than reinforced concrete alternatives.

The independent study, which includes costings, structural design and programming by Davis Langdon, Arup and MACE respectively, was first carried out in 1993. It considers two buildings typical of modern commercial construction. Building A is based on a developer's specification for a 2,600 square metre office in Manchester and Building B represents a prestige office of 18,000 square metres in central London. For both buildings a range of steel, composite and concrete based frame solutions are fully designed, costed and programmed. The effect of the structural frame solution on other major variable cost items such as foundations, cladding and services is also considered. Summary results are presented below.

<b>Building A</b>					
	Composite steel beam and slab	Slimdek (steel shallow floor solution)	Long span steel cellular beams	Reinforced concrete flat slab	In situ concrete frames with precast floors
Frame & Floor cost (£/m <sup>2</sup> GFA)	71	90	91	118	101
Frame construction time (weeks)	7	6	6	8	8
Overall building cost (£/m <sup>2</sup> GFA)	916	925	947	979	962
Overall construction time (weeks)	42	40	41	43	43

<b>Building B</b>					
	Composite steel beam and slab	Slimdek (steel shallow floor solution)	Long span steel cellular beams	Reinforced concrete flat slab	In situ concrete frames with precast floors
Frame & Floor cost (£/m <sup>2</sup> GFA)	83	100	105	144	170
Frame construction time (weeks)	13	13	13	18	19
Overall building cost (£/m <sup>2</sup> GFA)	1530	1525	1543	1635	1638
Overall construction time (weeks)	67	67	68	76	77

Table 3

<http://www.reidsteel.com/brochure.htm>

The latest study is based on designs and prices at the fourth quarter of 2003. The graph opposite highlights that the cost gap between steel and concrete based framing solutions has widened in recent years. It uses the average of the 2003 frame and floor costs as a basis and tracks actual costs back to 1995 using recognised Department of Trade and Industry construction cost indices. In 1995 the average cost advantage for the steel schemes was around 10%, at the end of 2003 this had

increased to 32%. When inflation is considered, the cost of the steel schemes has reduced by 14% in real terms. Over the same period the real cost of the concrete options has increased by 16%. The reduction in cost of the steel options is testimony to the competitiveness of the industry which has driven efficiency gains and continuous development for structural steelwork as well as associated products such as steel floor decking and fire protection.

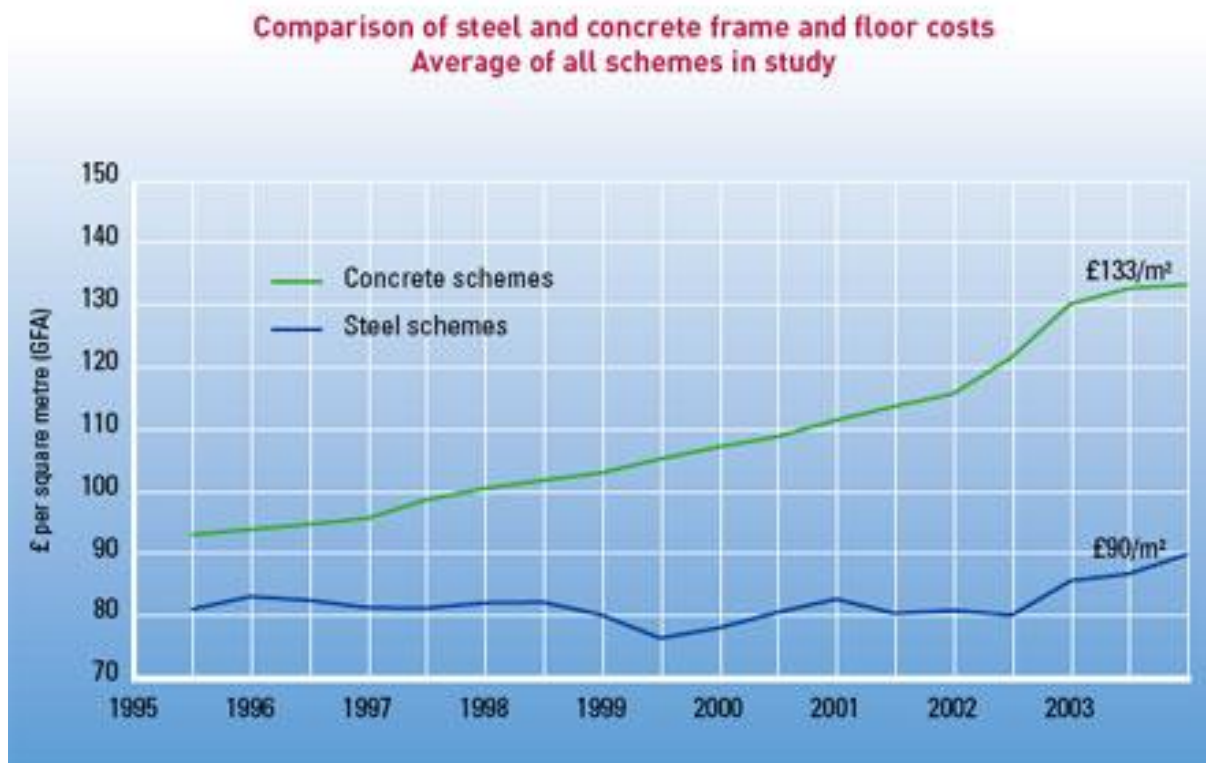


Figure 12

<http://www.reidsteel.com/brochure.htm>

## 3.5.Sustainability

### 3.5.1 Sustainable development

The need for sustainable development, which 'ensures a better quality of life for everyone, now and for generations to come', is becoming increasingly important. Construction is an important industry for achieving sustainable development, because of both its contribution to the South African economy, and the significant environmental and social impacts that buildings and other structures can have.

Sustainable construction encompasses a wide range of issues, such as re-use of existing built assets, design for minimum waste, minimising resource and energy usage, reducing pollution and respect for people and their local environment.

### ***3.5.2 Effective protection of the environment***

According to Statistics South Africa (April 2008), 45% of the energy consumed nationally is used in the construction and operations of buildings. The energy associated with the occupation of buildings (operational energy) dominates that used in their manufacture and construction (embodied energy).

There are two main issues for the sector in minimising operational energy in buildings. These are the prevention of heat loss through the envelope and the use of the structure to moderate temperature gains as part of the heating and ventilation strategy. Maintaining comfort levels will reduce energy requirements for cooling and improve the productivity of occupants.

### ***3.5.3 Residential buildings***

Light steel framing systems which form the basis of rapid, dry, site construction from off-site manufactured assemblies, provide a stable structure and make high levels of insulation and air-tightness easy to achieve both initially and throughout the lifetime of the building. With increasing demand for housing in urban areas, framing systems incorporating composite flooring systems are being adopted.

In residential construction the key issue for energy efficiency are the insulation levels, thermal bridging and air-tightness of the envelope. Tests have been carried out on a series of light steel framed buildings to demonstrate that high levels of thermal and acoustic insulation can be achieved.

The construction process is also completed keeping in mind the effects on the environment by minimising the impact of its operations and products, by the adaption of sustainable practices and through continuous improvement in environmental performance and control. The measures used to achieve this include the implementation of environmental management systems, off-site manufacture, noise reduction, waste minimisation strategies and recovery, recycling and re-use initiatives.

According to John Barnard, director of the South African Light Steel Frame Building Association (May 2008), the mass of a wall is relevant to the logistical costs and recycling of materials in a building at the end of its life. He says that the lower mass of walls in LSF and the components used in walls have a high recycling potential.

The gypsum board used on the interior side of the walls can be crushed and used as a fertiliser, the fibre cement boards used on the exterior of the walls can be recycled and the steel is often reused for other applications such as galvanised steel roofing sheet.

Barnard says that scrap steel has a high value in the steel industry as the use of scrap in the steelmaking process uses significantly less energy than producing steel from ore. “The energy that has been put into making the steel, however long ago it was, is conserved when that steel is recycled,” he adds.

Steel is one of the most common structural materials used in building and about 70% of steel worldwide is recycled.

The steel smelting processes have also developed to be more energy efficient. “The steel industry has been proactive in cleaning up its act. It has improved its energy efficiency and has cleaner emissions than previously. It is not the same product that it was 100 years ago,” says Barnard. (May 2008)

In addition to its recycling potential at the end of its life, LSF technology is lighter than other conventional building materials, can be packed tightly during transportation and can be assembled at a building site if required, says Barnard, <http://www.engineeringnews.co.za/article/lightsteelframebuildingindustryseesgrowth-2009—11-20>

### **3.6. Summary**

Definite savings will be made when using these alternative building methods through savings on time, labour costs, materials and management only to name a few. It is a very cost efficient way to do renovations and extensions on existing buildings.

### **3.7 Conclusion**

Looking at the comparisons between the alternative building techniques and the conventional building techniques it is clear that major savings will be made. The biggest savings will be through the building platform being less extensive and through labour which will be substantially less than a conventional building. These alternative building methods are also sustainable and with more buildings going green it would be wise to use these alternative building methods.

### **3.8 Test of hypothesis**

These alternative building methods are cost efficient and sustainable. In this chapter it is clear that major savings would be made through certain aspects like less labour being used, lighter building platform has to be built and savings in materials used. The studies done in London shows a significant saving when using these methods to renovate or extend existing buildings and the study done by Davis Langden and that is clearly showed in Figure 12 one can see the difference in cost between steel and concrete schemes and that steel prices have stayed a bit more stable over the years. In recent years sustainability has come to the forefront of the building industry people are looking to build greener buildings that would not harm its surroundings. These alternative methods has minimal waste and the buildings can easily be changed and extended.



## 4. Chapter 4

Sub-problem

Can Light steel framed construction and modular homes be used as an alternative for low income housing?

### 4.1. Low income/ Affordable Housing

➤ Reconstruction and Development Program

These homes must be affordable for households with a median income. In South-Africa more than 60 % of the population falls within this definition. It is not a new realisation though. After the 1994 transition to democracy, it was very important to stabilise housing provisioning. To overcome the fragmented housing regime with its skewed racial focus and to immediately start delivery.

The ANC's Reconstruction and development Programme (RDP) stated that there was a lack of adequate housing and basic services in rural settlements and urban townships and that it had reached a point where severe changes had to be made. The ANC also endorsed 'Housing as a human right' and this made one of the RDP's priorities to provide for the homeless.

In the last four years an average of 250 000 subsidised houses were built every year. The National Housing Finance Corporation (NHFC) and the banking sector's R42-billion Financial Service Charter commitment to the low income housing market has helped to provide houses through innovative access to housing finance.

While a lot of houses were delivered, a problem became apparent between the competing demands of affordability and quality of the delivered houses. Corruption levels were also rising and became very serious. Little attention was given to the areas in which these homes were being built in respect to the supporting social and economic infrastructure.

One very important aspect of this housing incentive is to increase its delivery over the next few years. "Reaching the target of 500 000 new housing opportunities requires funding of R345-billion by 2014, if we integrate the delivery of infrastructure and basic services. We are lobbying for a one-off injection to the budget to kick-start the process of boosting housing delivery," Housing Minister, Lindiwe Sisulu reported.(February 2008)

The National Department of Housing (NDH) developed a plan called the Development of Sustainable human settlements, also known as Breaking New Ground (BNG), through which the government aims to ensure that every citizen has access to permanent housing that provides protection and access to basic services. One of the BNG's objectives is to get rid of all informal settlements by 2014.

## ➤ Challenges

To achieve the 2014 target of eradicating all informal settlements as well as meeting all BNG targets, NDH faces challenges such as the following:

- availability of land
- slow approval process with regards to planning and proclamation of land for development
- escalating building costs; building costs within the housing market have increased by 25 percent year-on-year due to massive infrastructure projects such as the Gautrain and soccer stadiums in preparation for 2010
- sub-standard houses being constructed that have to be broken down and rebuilt
- availability of finance
- migration of rural people to cities in search of job opportunities
- Eskom's decision to delay electricity certificates for new building projects by up to six months

## **4.2 Low- moderate houses**

RDP houses are at the lowest level of the affordable housing market, but the shortage also exists in more expensive, but still affordable houses (those costing less than R200 000).

The Banking association reported that there is a shortage of 625 000 affordable houses in South Africa. At the moment 17 000 units are being supplied a year, while 132 000 is needed to reduce the shortage by 60% in the next 5 years. The banks committed themselves to provide R42-billion worth of housing finance to low-moderate income households. If there aren't enough houses for households to buy, they won't need loans and the banks won't meet their targets.

An analysis was done for the city of Johannesburg demonstrating the skewed housing delivery patterns that occurs notwithstanding the distribution of household affordability for housing. The table shows the number of units delivered per type in Johannesburg, versus the percentage of the population for whom such housing was affordable. The population is skewed towards the bottom of the income pyramid, delivery is skewed towards the top end.

## Housing delivery according to monthly income

Monthly household Income category	% population (Johannesburg)		Housing type affordability (indicative)	Number delivered in 2004	% of total delivery
>R10 001	15%	15%	Mortgage >80m <sup>2</sup> Sectional title	6,217	<b>36%</b>
R7001-R10000	5%	18%	Mortgage <80m <sup>2</sup> Social housing	9,594	<b>56%</b>
R5001-R7000	6%				
R3501-R5000	7%				
R2501-R3500	9%	<b>68%</b>	Subsidised housing (RDP)	1,436	8%
R1501-R2500	10%				
R0-R1501	49%				
<b>Total</b>	<b>100%</b>			<b>17,247</b>	<b>100%</b>

Table 4

[Http://www.affordablehousinginstitute.org/blogs/za/?p=71](http://www.affordablehousinginstitute.org/blogs/za/?p=71)

This table also shows the high percentage of households earning less than R3500 a month and who qualify for RDP housing.

### 4.3. Quality of low income housing

The CSIR (March 2007) showed significant performance and sustainability enhancements for low income housing. Crucial planning is imperative to investigate how urban growth can be made more effective, especially regarding how urban growth can be developed cost effectively.

The CSIR is researching solutions, through pilot projects, to some problems existing within the subsidy housing projects. The pilot project was started by the Department of Science and Technology (DST), where the CSIR will assist in evaluating the efficacy of alternative technologies to improve the sustainability of the two housing projects in the Western and Eastern Cape.

If one wants to look at the sustainability and self efficiency of the housing development, it has to include environmental, technological and ecological issues. "To achieve this, certain basic research questions must be answered, such as what the thresholds/tipping points are of the approach (income, rainfall, wind speed, number of solar hours, number of units, size of land, access to jobs); and what technology is available to extend and maximise these thresholds," explains Llewellyn van Wyk, CSIR architect. (April 2007)

To assist research into innovative technologies in general, and their performance-enhancing capabilities in particular, the CSIR has built two pilot houses on its test site in Pretoria to investigate technology options.

In recommending technologies to the DST, a fundamental component of the CSIR's research is addressing anticipated energy and water shortages facing the country. Certain technologies that are known to offer other benefits, such as job creation, are also being targeted. Similarly, the potential of the specific geographic conditions of the sites and the surrounding areas - for example local soils - must be investigated to see whether it could add value to the development. The location of the sites and the connections of these to existing and adjoining sites - such as public open space systems - must also be explored to ensure that these connections are maximised.

"For our development proposal to serve as a model, it must not burden the financial sustainability of local authorities. One of the ways this can be done is to reduce the dependence of the development on municipal services," comments Van Wyk. "You could, for example, use a range of technologies such as wind generators in conjunction with solar collectors. The introduction and implementation of sustainable urban drainage systems can also be considered together with a range of water treatment technologies."

### ***4.3.1 Scaling up approaches***

The preferred means of scaling up the pilots is through local, provincial and national level involvement - using the pilots for demonstrators that can be managed and expanded by governments.

Three types of packages can serve as possible scaling-up options. Type I follows rigorous monitoring of technology, quantifying the outcomes of these and establishing proof of concept.

Based on the experience gained in the type I approach, the cluster approach - or type II approach - will focus on scaling up the integrated, community-based strategies for achieving sustainable communities around type I approach projects. The type II approach is also proof of concept but at a scale of 10 times higher. Aims of type II include the understanding of technology interventions that need to be provided at a district level (e.g. transport infrastructure, electricity generation and distribution, rainwater harvesting, sustainable urban drainage systems), and thus benefit from economies of scale.

Type III will replicate and scale-up successful integrated, community-level interventions to achieve sustainable communities beyond the immediate vicinity of types I and II.

### ***4.3.2 Kleinmond and Mdantsane housing developments***

The Kleinmond housing development comprises 585 housing units. The additional capital budget value is R18,5 million. The Mdantsane housing project is for 2 005 housing units, with an additional capital budget value of R16 million.

"We propose that type I is used for these two developments, not pursuing radical technologies but rather value-addition through proven fringe technologies incorporated in the current design and construction of subsidy houses," says Van Wyk. (October 2008)

According to [http://csir.co.za/enews/2008\\_oct/be\\_03.html](http://csir.co.za/enews/2008_oct/be_03.html), the following technologies and best practices will be evaluated for implementation in the housing projects:

- Use of local materials: The geotechnical report indicates that the local soils are suitable for use in the construction of the roads within the housing project, thus saving the need for *in situ* material to be carted away, and new material to be imported from borrow pits.
- Road widths and surfaces: The CSIR is suggesting that trafficable road widths be reduced to 3,5 m for service roads and 5,5 m for feeder roads. The difference between the road reserve and the road surface will be compacted and used for parking purposes.
- Urban drainage: The CSIR recommends that storm water be collected and made available as a water resource. As associated problems could include contamination caused by faeces and other wastes, it may be that storm water from above the site is diverted and collected. The implementation of reed beds for soiled water treatment will also be investigated.
- Energy: Small-scale wind generators, solar hot water heaters, low-energy fittings and gas cooking units could be included in the development. The combination of reduced internal energy demand due to improved thermal insulation and low-energy fittings,

coupled to energy generation of solar and windmills, offers an opportunity to reduce the frequency of outages within the community while reducing energy costs to the occupants.

- Housing construction: Investigations focus on the three main components of housing construction, namely sub-structure (foundations, foundation walls, and foundation slab), super-structure (walls, windows, doors up to wall-plate level), and roof structure (trusses, purlins, roof sheets, gable walls). Each component is evaluated to minimise construction material and time, while improving construction quality and indoor comfort.
- Manufactured construction technology: As many of the construction elements as possible should be constructed on a modular basis and assembled on site as prefabricated elements. These include prewired electrical wiring looms, pre-plumbed water and drainage runs, roofs and infill panels.

To undertake this research, a standard low-cost housing unit has been built, together with a suburban variation of the same house plan. This is being done to establish two benchmarks, namely typical performance values of a current low-cost housing unit, and typical performance values for an equivalent suburban house using conventional housing technologies. The research seeks to determine whether technology interventions can be developed and introduced to improve the performance of the low-cost house to that of the conventional house without substantially increasing construction cost.

"Our two pilot houses will be monitored for performance of technologies and best practices for a minimum period of 12 months. We are already encouraged by the lessons obtained in the construction phase, even though we have been busy for only five months. We are also greatly encouraged by the interest shown by our industry partners, many of whom are participating with the CSIR in investigating new technologies *in situ*. Once the concept is replicated in the Kleinmond and Mdantsane housing developments, we hope to engage with the DST and other partners regarding a 10-year scaling-up effort across South Africa," Van Wyk concludes. (October 2008)

#### **4.4 Will modular homes and light weight steel construction be a good alternative for affordable housing?**

The houses in the CSIR's pilot project were designed to enable government-funded low income houses of 40 m<sup>2</sup> to be easily extended by occupants, for example to become a three bedroom house. Technology within the capability of the occupant and the house deliverer has been used. "A modular design approach was followed along the principle of design-to-fit, resulting in zero waste produced as building blocks don't have to be cut. The modular design fits together with the standing structure as part of the bigger unit

The orientation of the house was maximised, ensuring bedrooms can make use of sunlight, with the living room facing north.

It is recognised that some contractors working in the low income market often do not lay foundations to standard. To eliminate cracked walls resulting from sub-standard foundations, a CSIR-developed technology - ultra-thin continuously-reinforced concrete used for roads - was adapted to form the foundation slab of the house. "Local labour can be used to construct such foundations," says Van Wyk. (October 2008)

One big difference to current houses is that the design of the bathroom/kitchen area was rationalised, and a waste outlet manifold used that is pre-manufactured, quality-tested and installed on site. This has reduced the extent of the plumbing installation substantially while ensuring that the installation is done to the required standard.

Low income houses have no ceiling at present and thus no insulation, which results in incredible variations in temperatures. The thermal performance of the roof was improved dramatically with the addition of an insulation material that doubles up as a ceiling.

## **4.5 Prefab houses for low income housing**

These houses can be pre-assembled and delivered to site.

Features of Prefabricated houses

- 1)low cost
- 2)convenient
- 3)duarable

According to <http://www.biztrademarket.com/home/196224/products/532366.shtml> ,the prefabricated house mainly consists of a light steel structure wall system and the roof. They are all made of standardized components, and connected by bolts. We can design ,make the prefab house according to the customers specific requirements.

- The houses can be assembled and disassembled for dozens of times and can be removed 10 times.
- All the steel components are painted and anti-rust which can be normally used for more than 20 years.
- The steel structure makes the house resisting heavy wind of 100km/h and 7 grade earthquake.

- The wall system of color steel sandwich panel has a good fire proof and heat insulation performance.
- Waterproof design of steel structure.
- Environment-protection without any building rubbish.
- The transportation is convenient and one 40HQ container can load about 250m<sup>2</sup> house body materials.

Basic prefabricated house.



**Figure 13**

<http://www.biztrademarket.com/home/196224/products/532366.shtml>

## **4.6 Summary**

One of the greatest benefits when using these alternative building methods to construct affordable homes is the speed of erection. Delivery of units will be maximized while the quality will also be improved. At the moment one of the biggest problem with the RDP houses is the speed of delivery which causes the housing backlog in South Africa.



This system has developed into a construction technology that addresses eight key challenges embodied in the low cost and affordable housing shortages facing developing countries namely:

- lack of resources
- insufficient funds
- skills shortage
- time constraint
- work flow control
- time constraints
- waste
- speeds up delivery of low cost housing

A few disadvantages of normal brick or block construction are:

- Labour intensive
- Compressive capacity only
- Skilled labour
- Mortar shrinkage
- Thermal expansion and contraction
- Leveling
- Erratic supplies = erratic delivery
- Waste
- Rework
- Slow delivery
- Inconsistent quality
- Unpredictable cash flow
- Increased cost

## **4.7 Conclusion**

There is a housing problem in South Africa and the subsidized housing backlog is putting a lot of pressure on the government to deliver these types of housing. A study done by the CSIR shows that modular homes can be used for RDP houses and also to enlarge the existing houses. By using modular homes and light steel construction, the delivery would speed up, and better quality homes could be built for less.

## **4.8 Test of hypothesis**

Modular homes and light steel framed structures can both be used for low income housing and people would benefit from building or even renting these houses. The delivery of low income houses can be scaled up through the short construction periods and these construction methods also have the advantage of pre-assembly or factory assembly which would stop any unnecessary mistakes creeping in. The light steel construction industry is rapidly growing and SASFA already has 36 companies who are members who manufacture and erect these homes. The government has to do something about the housing backlog and these alternative building methods might just be the answer. The RDP houses can be put up at almost double the rate and at a lower cost. The use of these methods can also be tied into skills development by giving workshops to the community on how to do regular upkeep and maintenance on these homes and could create jobs.

## 5. Chapter 5

### Sub-problem

#### How can one maintain light steel frame structures and modular homes?

In South Africa most materials for the cladding and roofing of a light steel frame structure is provided by NuTec roofing and cladding solutions. All of the criteria for the materials can be seen as guidelines and preventative measures maintenance purposes.

### 5.1 Materials:

#### Cladding



Figure 14

<http://www.steel-framing-systems.co.uk/>

#### 1. Cladding

Nutec building planks are manufactured from a combination of Portland cement, silica and organic fibres, and do not contain any asbestos fibres. These materials have considerable strength in their own right and will not deteriorate with age. It is usually installed in a ship lapped pattern and requiring a relatively light steel or timber structure. They are very easy to erect. These building planks are unaffected by moisture and can therefore withstand the harshest South African weather conditions. They are also well known for their high degree of dimensional stability. Building planks can be used for the construction of external and internal walls.

Exposed and windy conditions- Walls exposed to wind and rain should be fully backed with a durable waterproofing membrane in sheet form which should be fixed between the building planks and the vertical studs.

Ventilation- The cavity formed between the steel frame and the building planks should be ventilated. In this type of construction various types of foil are usually used as a moisture barrier and as insulator. Ventilating the cavity will permit the evaporation of any condensate which may collect on the insulation material.

## 2. Window sills

Nutec window sills are made from the same materials as the building planks and also have the same strength and durability. The sills have a smooth finish and do not require any surface treatment for protection. The sills can be painted on site with any water-based paint.

## 3. Ceiling boards

Nutec ceiling boards are not affected by moisture and are ideal for use in damp areas. These ceiling boards are non-combustible and will therefore inhibit the spread of fire. They provide perfect protection against flying sparks. The material will not rot and cannot be damaged by termites and rodents. The space between the ceiling and the roof must be well ventilated to prevent condensation on the ceiling boards.

## Roofing

Any roofing material can be used on light steel frame structures.

# 5.2 Maintenance:

### ***5.2.1 Preparing surfaces:***

Paints and coatings have to be correctly applied to the products to ensure that the life expectancy of the coating can be fully realised.

#### -Weathered sheets and surfaces

Sheets that have been exposed may show some softening of the surface. If such sheet needs to be painted, all softened materials must be removed down to a hard surface

#### -Cleaning of and treatment of fungal growth

Fungal growth on the external surfaces of buildings is a natural and prevalent phenomenon in certain areas. This presents a maintenance problem and in severe cases may restrict the free flow of water from the roof areas which could cause roof leaks. Painting the materials will retard the fungal growth and is also a recognised practice for minimising further fungal growth. The fungal growth must be removed down to a clean surface and repainted.

Maintenance starts from day one



Figure 15

### 5.3 Maintaining modular homes

According to <http://www.articlebase.com/home-and-family-articles/modular-homes-478388.html>, maintenance is important to ward off the unexpected catastrophes from neglect. Even though a modular home is better reinforced than a site-built home, this does not preclude the need for maintenance. Depending on whether the person just moved in or whether they have lived in a modular home for years, different areas may need attention. The following include some recommendations for keeping a modular home in shape.

- Safety measures -Be sure fire extinguishers are located in necessary areas throughout the house. This should include one around the kitchen area, furnace area, electrical panel, and fireplaces. Also one near the bedrooms is important. Likewise smoke detectors and carbon monoxide detectors should be in place and checked biannually for proper functioning.
- Caulking - As the home settles over time, small cracks in existing caulking can occur around doors, windows, trim, etc. This should be assessed at least every 6 months using an approved caulk for the material for which it is applied. This helps maintain energy efficiency and keeps moisture from accessing unwarranted areas.
- Filters - Air conditioning filters should be inspected monthly and replaced or cleaned if needed. This promotes energy efficiency as well, and it also promotes cleaner, healthier air. Another filter to be considered is in the range hood. This collects cooking fumes and also benefits from frequent cleaning or replacement.

- Electrical - As part of routine maintenance, all grounded electrical receptacles should be tested every 6 months to be sure the ground interruption operates correctly. This is simply done by pressing the buttons on the receptacles while electricity is flowing to an appliance or device. Also, any extension cords around the home should be assessed for damage or overload.
  
- Plumbing - Every 6 months faucets should have aerators cleaned, and all pipes and fittings should be checked and tightened as needed. Leaks need attention of course and may only need gasket replacement.
  
- Roofing - Tiles or shingles should be inspected annually and repaired as needed. This can prevent a leak before it develops and also limit the scope of the repair. Likewise, gutters should be cleaned and emptied at least annually. This may require more frequent attention if there is abundant foliage and debris present.
  
- HVAC systems - in addition to filter changes, HVAC should be inspected and serviced annually to ensure optimal functioning and energy efficiency.
  
- Wood care - cabinetry and other areas of finished wood surfaces should annually be attended to by placing a coat of wax protection to ensure durability and aesthetic appearance.
  
- Chimney and masonry care - annual inspections for cracks and shifting is important and chimneys specifically should be professionally cleaned once a year.
  
- Sealants - consideration of sealing tile grout to resist staining and mildew is strongly recommended. Driveway and garage floor sealants are also other are of consideration to protect from cracking. Depending on the product, this needs to be repeated at appropriate intervals.

By attending to these areas of a modular home, the expense of repairs will be reduced over time.

## **5.4 Summary**

Both of these building methods are easy to maintain and aren't very different from the conventional masonry built homes. The manufacturers of the materials used in these building methods give the exact fixing procedure and guides on how and where their

products should be used. Maintaining these types of homes are very easy if the correct fixing procedures are used.

## **5.5 Conclusion**

These methods will work in South Africa because they are easy to maintain and maintaining these homes are almost the same as for a conventional masonry built home. Regular upkeep will ensure a prolonged lifecycle of the building and also prevent major problems from happening.

## **5.6 Test of Hypothesis**

Like any other building structure, regular upkeep and maintenance is essential to the life cycle of the building. The external envelopes of these alternative building methods are the same as can be found on many conventional buildings and maintenance won't be any more complicated. All of the materials used have maintenance booklets given by the manufacturers

One of the main concerns with steel construction is corrosion. Some of the main causes are:

-Dissimilar metals: Copper and brass plumbing pipes and fittings need to be isolated from the zinc coated frame with grommets or other means. Care is also required when selecting fasteners that will be in contact with the frame.

-Slab edge dampness: Sometimes original measures intended to prevent ground moisture from reaching the upper surface of the slab cannot be relied for the design life of the building and may not be inspectable, maintainable or repairable.

Maintenance on a light steel frame structure or modular structure will not be any more difficult or time consuming than doing maintenance on a conventional home. The manufacturers booklets are also very thorough and gives exact specifications on how the products must be maintained.

## **6. Chapter 6**

### **Conclusion**

#### **6.1 Chapter 1**

Sub-problem

How can one maintain light steel framed structures and modular homes?

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- Slab edge dampness: Sometimes original measures intended to prevent ground moisture from reaching the upper surface of the slab cannot be relied for the design life of the building and may not be inspectable, maintainable or repairable

#### **6.2 Chapter 2**

Sub-problem:

Why would one use these alternative building methods opposed to conventional building methods?

There are so many advantages to using these alternative building methods which include:

- Speed of erection
- Dimensional Accuracy (straight and erect walls with 90 degree corners),
- Predictability of end -product cost, quality, delivery appearance.
- An advantage for sites with problem soil conditions, remote sites or steep sites.



- Environmentally and economically advantageous, as steel is fully recoverable and recyclable. Lightweight homes are easy to modify, add to, or demolish, with minimal site impact.

- More stable than timber as a framing element and is resistant to cracking, rot, termites, and warping

Time is money and these days everyone wants their projects finished in the shortest time. With these alternative building methods the construction period is drastically shortened. A standard size home can be built in 22 days. These construction methods also use less labour to complete which in turn brings cost savings to the project.

Renovations are another great application of light steel framing. It is an important social and economic requirement and is an increasingly important part of the South African construction industry. The use of light steel construction works great for extensions and adaptations of buildings. The great thing about these alternative building methods is the reduction of waste. The contractor will benefit from the decrease in material waste especially on a small site or where renovations are done in inner city areas.

With these alternative building methods it is a lot easier to build green homes. On a personal level, a green home promotes healthy living by protecting your physical and emotional well-being. It also reduces your home's energy costs. On a global level, green high-performance construction supports a healthy environment by conserving the earth's resources. It also safeguards our planet's life support systems.

## **6.3 Chapter 3**

Sub-problem

Is light steel framed construction and modular homes cost efficient and sustainable?

1. The biggest savings one has when using these alternative building techniques are with the speed of erection and shorter construction periods. This in turn will cut the labour costs during construction. Construction times can be cut by up to 60%. In addition, weather delays and rework due to weather damage are also decreased. More work can be accomplished in the same amount of time due to the production efficiencies gained through factory infrastructure

Some of the major savings are listed below:

-Simple foundations

-Saving in transport costs

-The ease of construction

-Energy efficiency

-Time savings

-Structural soundness

## 2. Costs compared with masonry homes

When comparing light steel framed homes with a conventional buildings the following savings were identified:

-Building platform =50% savings

-Materials (per m<sup>2</sup>) =11% savings

-Labour (Man days) = 53% savings

- Total cost of building = 36.5%

Light steel framed homes and modular homes are definitely cheaper than building a conventional building and of the same quality. These alternative building methods are sustainable and are designed to be energy efficient and also keeping the impact on the environment in mind. These alternative building methods are both great for extensions of existing buildings where time and minimal waste is of the essence.

## 6.4 Chapter 5

Sub-problem:

Can light steel framed houses and modular houses be used as an alternative for low-income housing?

There is a housing problem in South Africa and the subsidized housing backlog is putting a lot of pressure on the government to deliver these types of housing. A study done by the CSIR shows that modular homes can be used for RDP houses and also to enlarge the existing houses. By using modular homes and light steel construction, the delivery would speed up, and better quality homes could be built for less.

Modular homes and light steel framed structures can both be used for low income housing and people would benefit from building or even renting these houses. The delivery of low income houses can be scaled up through the short construction periods and these construction methods also have the advantage of pre-assembly or factory assembly which would stop any unnecessary mistakes creeping in. The light steel construction industry is rapidly growing and SASFA already has 36 companies who are members who manufacture and erect these homes. The government has to do something about the housing backlog

and these alternative building methods might just be the answer. The RDP houses can be put up at almost double the rate and at a lower cost. The use of these methods can also be tied into skills development by giving workshops to the community on how to do regular upkeep and maintenance on these homes and could create jobs.

## **6.5 Conclusion**

Light steel framed structures

According to SASFA, the development of the light steel frame building industry in South Africa started in 2006. To date, 31 companies in South Africa have installed light steel frame (LSF) manufacturing facilities. They have a combined manufacturing capacity of 53-million linear metres of LSF sections, and can process some 48 t/y of high-strength galvanised steel sheet a year, based on one shift operation, five days a week. Expressed differently, the manufacturers have sufficient profiling capacity to produce light steel trusses covering 1,8-million square meters of floor area, as well as complete buildings (wall frames and trusses) for a total of 2,1-million square meters. Some 51% of the local industry's capacity is based in Gauteng province, but could be moved to other provinces, or even neighbouring countries, if dictated by demand. Expressed differently, the manufacturers have sufficient profiling of capacity to produce light steel trusses covering 1,8-million m floor area, as well as complete buildings (wall frames and trusses) for . Some 51% of the local industry's capacity is a total of 2,1-million m based in Gauteng, but could be moved to other provinces, or even neighbouring countries if dictated by demand.

## **6.6 Test of hypothesis**

Out of the above chapters it is clear that Light steel framed structures and modular homes would be a great alternative building method in South Africa and that it would also be a viable option when deciding on which building method to use. The Light steel frame industry is rapidly growing and more suppliers and builders are open to using these new building methods. South Africa has a lot of families who live well below the median income for someone living in a low income housing scheme. These alternative building methods can be used in these low income housing developments and delivery would be scaled up and it would also be cheaper than building conventional masonry homes. These alternative building methods are just as easy to maintain as conventional buildings and it won't be necessary to spend extra time or money on maintenance. The many advantages like speed of erection, dimensional accuracy and the predictability of end product and cost makes it a very attractive building method

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