



**LIGHT STEEL FRAMED BUILDINGS**

**&**

**THE ENVIRONMENT**

# **CONTENTS**

1. The Methodology of Light Steel Framing.
  
2. The Manufacturing Process:
  - 2.1 The Steel - LSF.
  - 2.2 The Cladding - Versapanel.
  
3. The Site Construction Process:
  - 3.1 Preparation of the Site.
  - 3.2 Delivery of Materials.
  - 3.3 Use of Machinery.
  - 3.4 Use of Water.
  - 3.5 Use of Energy/Electricity.
  - 3.6 Emissions from Site Equipment.
  - 3.7 Noise Impact.
  - 3.8 Material Waste.
  
4. Sustainability of Resources.

## **1. THE METHODOLOGY OF LIGHT STEEL FRAMING (LSF).**

The material used in the world's fastest growing construction technology has a construction pedigree that spans more than 100 years. Around the turn of the last century it built London's Ritz Hotel. Now, as we enter the next, it is pointing the way forward in domestic, commercial and multi-storey buildings.

The material is **steel**. The technology is **lightweight, load-bearing** steel frames.

This technology is built around the use of zinc coated **corrosion-resistant** steel in a "**warm frame**" which retains heat within the building and keeps external heat out. It has been exhaustively proved, not only in the laboratory, but also in the field: on-site evaluation and accelerated corrosion tests show the expected life of a light steel frame to be well over 100 years. The frames are designed on a CAD system directly from the architect's drawings, factory fabricated to consistently precise tolerances, and erected on site by specially trained teams.

Light Steel Framing has been in use internationally for many decades and the system we apply was originally developed in the United Kingdom. Millions of pounds were spent on the development and testing of the system prior to implementation into Europe. The LSF system was successfully introduced to South Africa for the purpose of testing and Agreement Certification was achieved.

We have subsequently refined the system and integrated the use of external cladding in the form of a **cement/wood particle board**. These boards has proven to be superior to many conventional building materials and prolonged use in areas of extreme freeze/thaw conditions confirmed that the use of the Versapanel boards provides a well **insulated, maintenance free** and **long lasting** construction solution.

As the light steel framing system, including the board cladding, weighs only approximately 10% of a conventionally constructed wall, the requirement for footings and slabs are vastly reduced. This advantage makes the system very suitable for construction where unstable or low load bearing soils occur or in instances where the sub structure of existing buildings would not carry the imposed loads of a conventionally constructed walling situation.

Concerning the founding situation for a light steel framed building, only a raft slab with dropped anchor beam will be required in most instances.

Each frame is designed for its particular location in a building and to carry the loads imposed on it in that position. The installation of the frames is in accordance with a detailed site lay-out plan on which each frame position is numbered. Correspondingly numbered frames are installed on site.

## **2. THE MANUFACTURING PROCESS**

## 2.1 THE STEEL - LSF

Steel is a reusable resource and steel frames can be erected in environmentally sensitive areas with minimal impact.

The steel used for the manufacturing of LSF is graded as 550 MPa, Z 275, galvanized coil stock. This steel is mostly supplied from recycled steel and the cold rolled specification provides a mass to usage ratio of 1 kg/1 meter of formed steel.

The manufacturing process takes place in a light industrial type factory and the requirement to form the various members that makes up the steel framing, is only one single roll forming machine. This machine operates on very low power usage and there is NO water required for this method of manufacturing.

As the production of the frames is taken from a CAD (computer aided design) drawing, and the material off-take is directly from a coil, there is no wastage at all in terms of the lengths of framing used. The only by-product of this production process is the steel cut-outs where the frames are notched for service holes. These pieces of steel is sent back to scrap merchants who in turn puts it into the recycling process.

## 2.2 THE CLADDING – VERSPANEL

High-density wood-cement boards were initially developed in the late 1950s. Further development in the 1960s led to the production of a smooth, fine-grained, cement-enriched surface characteristic of present-day boards. An initial pilot plant for the commercial production of this type of board was constructed in Switzerland in 1968, to be replaced in 1974 by a full-scale plant incorporating air grading of the chips in the formation of the mat.

From these early beginnings the industry has grown at a slow, but steady, pace and currently there are approximately thirty plants world-wide, many of which are in the former USSR, with the remainder spread throughout Europe and the Far East. A cement-bonded particleboard mill is small compared with that of a standard particleboard mill: daily production of cement-bonded particleboard is usually restricted to about 100–150 m<sup>3</sup>/day, about a tenth to a twentieth of a modern particleboard line.

The panel is a mixture of wood particles and Portland cement together with some additives.

Following storage for about 3 months, the debarked softwood logs of selected species are reduced to flakes some 10 to 35 mm in length and 0.2 to 0.35 mm in thickness using drum-knife flaking machines. After passing through a hammermill which reduces the width of the flakes, they are separated into surface and core material by screening, and are then mixed with Portland cement and water, generally in the ratio by weight of cement 65%, dry wood 21%, water 11% and chemicals 3%, though some variation in these figures occurs among the manufacturers.

The moisture content of the chips is monitored continuously and the volume of water added to the mix is adjusted accordingly. Small quantities of chemicals are added to the wet mix; one of their purposes is to accelerate cement setting. The mix is fed to the

forming station which spreads, under automatic control, a continuous mat of uniform thickness onto a series of steel caul plates running on a conveyor. The mat is cut into lengths corresponding to the size of the caul plate. A stack of these is compressed at a pressure of about 2.4 to 3.0 N/mm<sup>2</sup> to a third of its original height over a period of 2 to 3 minutes. The batch of cauls, held in a compressed state, is transferred to a heated chamber at 70 to 80 °C for 6 to 8 hours to allow the cement to harden. Then the clamps and cauls are removed and the boards dried, trimmed and stacked for 8 to 18 days to allow the cement to cure.

The softwood logs are obtained from planted tree stocks which are well monitored in terms of sustained growth versus demand, without the need to deforest further stocks.

Versapanel board contains no hazardous volatiles, it is asbestos free and it's process dust is non-aggressive. It may be sawn, planed, sanded, drilled, routed, nailed and screwed.

Versapanel in an untreated state is weather resistant and will not degrade with permanent exposure, even if subjected to freeze/thaw conditions.

Versapanel boards are usually delivered secured in plastic bound, edge protected pallets

### **Product Hazard Information - Health & Safety Statement**

FIRE: Class '0' to BS476

COMPOSITION: Portland Cement, Wood, Water, Non-toxic chemical

TOXIC GAS: Nil

HEALTH: **Skin contact** – classified as non-aggressive dust.

**Eye contact** – Normal neutralising agents

Treatment for removing foreign bodies from eyes.

**Inhalation** - Process dust is non-aggressive, but protection recommended

### **PHYSICAL DATA**

Appearance & Odour: Grey Sheet - No Odour

Boiling Point: NA % Volatile by volume: 0

Vapour Pressure:	NA	Melting Point:	NA
Water Solubility%:	NA	Specific Gravity:	1.25
Evaporation Rate:	Nil	Density:	1250kg/m <sup>3</sup>
Surface pH:	11-13		

#### **FIRE & EXPLOSION DATA**

Flash Point:	NA
Extinguishing Media:	Foam, Water
Unusual Fire or Explosion Hazard:	None
Special Fire Fighting Procedures:	None
Flammability:	NA

#### **OTHER INFORMATION**

Occupational Exposure Standard (OES)

Portland cement OES 10mg/m<sup>3</sup> total dust 5mg/m<sup>3</sup> respirable dust, 8 hr time weighted averages.

Cellulose OES 10mg/m<sup>3</sup> total dust, 5mg/m<sup>3</sup> respirable dust, 8 hr time weighted averages.

Soluble Aluminium Salts OES 2mg/m<sup>3</sup> total inhalable dust.

Waste Disposal – Treat as construction industry waste.

Versapanel is produced by the German manufacturer Amroc Baustoffe.

#### **Ecological building with AMROC®- PANEL**



Based on the excellent test results, AMROC Baustoffe GmbH's product **AMROC-PANEL B1** has been awarded the quality mark by the Rosenheim Institute for Building Biology GmbH.



### **3. The Site Construction Process:**

#### **3.1 Preparation of the Site.**

For standard construction methods the site preparation is normally linked to the design of the substructure, and in particular the nature of the footings. In the event of normal strip foundations, the site preparation could be standard compaction prior to the excavation of the in-situ soil for such footings.

This is however not the case in most of the site situations as there may be weak load bearing soils present, or even part landfill. Conditions of high water tables or subsiding soils due to clay content may also be found.

In cases like this, the founding conditions for a conventional building may radically change to the requirement of piling, underpinning, soil excavation to quite a depth in order to re-introduce imported soil for compaction, etc. All of this will requires extensive machinery to be on site (pile rigs, earthmoving equipment, etc).

With an LSF building, the requirement for founding is much less stringent, given the fact that the building only exerts 10% of the mass of a conventional brick & mortar structure. This enables the civil engineer to design a simplified raft slab with dropped anchor beams, which vastly reduce the need for cut & fill operations, beyond the normal preparation of a platform to situate the building on.

The lesser volume of preparation work required translates environmentally in great benefits to not only the immediate impact on the surrounding areas to the site, but also in the reduced need for fuel to operate machinery.

### 3.2 Delivery of Materials.

An often overlooked aspect of construction is the constant delivery of materials by trucks. This not only applies to the disruption of the area due to noise, but also to the environmental aspects of added fuel emissions, etc.

With an LSF methodology, the only major transport requirements will be the delivery of the ready mixed concrete and the Versapanel boards. The period required for such transport will be at the start of a project and will form a very small part of the project programming.

Further deliveries will be by trucks less than 5 tons, thus requiring no further articulated vehicles to attend to site.

### 3.3 Use of Machinery.

Under this category the use of machinery consists of:

- a) machinery & equipment required to place materials and,
- b) machinery & equipment required for the installation of materials.

a) Placement of materials.

The conventional construction of multi-storey buildings will require heavy machinery and trucks. This will be in the form of concrete trucks to deliver the concrete for the upper slabs, trucks delivering formwork, dumpers carting concrete for placement, hoist platform, etc.

On many occasions the design of upper floors may require mobile or tower cranes to place steel or concrete elements.

In instances where mistakes were made in concrete works, the use of jack hammers is a "normal" occurrence on a building site.

With the use of the LSF system, the fact that the frame and board manufacturing takes place off-site, the requirement for heavy machinery and tools is totally removed. The only activity on site with the framing is the assembly of the pre-manufactured frame components. This assembly takes place in an enclosed area and the only tools required are cordless screwdrivers.

The other equipment required on site will be a forklift, which will be used only for the off-loading of the boards, and the occasional moving of pallets to be placed close to points of use.

Board installers (external teams only) will make use of a scissor platform, while the finishing teams will use telescopic platforms. Neither of these equipment types will be used continuously.

b) Installation of materials.

The main activities around the installation of LSF and the boards are as follows:

Fixing of ground level frames – drilling into concrete with hand drills.

Bolting together of frames – drilling holes through frames for bolting.

Installation of boards – using self drilling screws with a power drill.

Cutting of boards – using a table or circular saw.

It will be evident that the only tools in use will be hand tools, with no requirement for heavier tools or equipment.

### 3.4 Use of Water.

***Quote from the Steel Federation of SA: "Water consumption will become as critical as electrical energy in the near future, as South Africa's water resources are being stretched".***

The LSF system of construction requires NO water.

Unlike conventional construction methods where vast quantities of water is required for plastering, bricklaying, cleaning of wall cavities, equipment cleaning, etc, LSF uses no water in the installation of the framing and the boards.



A very limited amount of water is used for mixing the compound to apply to the joints in the boards.

No water is required for the curing of concrete slabs, neither is water wasted due to running taps, broken hoses, etc.

### 3.5 Use of Energy/Electricity.

A building's use of natural resources determines its environmental sustainability. The main criteria that differentiate LSF from masonry buildings are energy consumption, logistics, water use and recycling potential.

The energy required for a building can be categorised into embodied energy and operational energy. The total embodied energy of a building is defined as the energy consumed by all the processes involved in the production of building materials and the manufacturing of building components, through to delivery and erection of the final product.

On the other hand, operational energy is the energy, which is mainly electricity, required to operate and use the building.

Embodied energy is an important component in the life-cycle assessment of the energy efficiency of a building. It accounts for as much as 20% of the total energy consumption of a building, including operational energy use, over a 50-year period.

Different materials contain significantly differing quantities of embodied energy. Concrete, for instance will differ from timber, gypsum, aluminium and steel.

Although embodied energy calculations are fairly complex, it can be concluded that LSF systems contain significantly lower levels of embodied energy when compared with conventional heavy building methods and, further, the embodied energy of light-steel-frame systems is comparable to that of timber frame structures.

Meanwhile, in terms of operational energy consumption, LSF buildings offer more comfortable internal temperatures than masonry construction without heating or cooling. Significant energy is saved in the heating and cooling of LSF structures as deviations from the desired internal temperatures are lower, and less energy is consumed to heat up and cool down the internal walls. According to the Steel Federation of SA, energy savings could amount to 30% of the energy used for heating and cooling conventional buildings.

As indicated in the "Use of Machinery" above, the energy/electrical requirement for the on-site activities are also much lower than for conventional buildings.

#### **Research extract:**

## **CSIR research confirms the superior energy efficiency of light steel frame building**

18th November 2011  
TEXT SIZE



A recent research project by the Built Environment division of the Council for Scientific and Industrial Research (CSIR) confirmed that a light steel frame (LSF) dwelling, built to SANS 517, will result in significant savings of electricity used for heating and cooling of the building, compared with a conventionally built heavy masonry building.

To obtain an objective prediction of the thermal performance of a LSF dwelling compared with a masonry building in the different South African climate zones, the South African Light Steel Frame Building Association (Sasfa) approached the CSIR to carry out the analyses.

A typical 120 m<sup>2</sup> single-storey house was used for the comparison. The LSF and the masonry houses were specified to be geometrically identical, with identical orientation. The LSF house complies in all respects to SANS 517 Light Steel Frame Building.

The CSIR's Built Environment division decided to use the Ecotect V 5.6 software to carry out the computer analyses. To eliminate the effect of user input data, which could influence the outcome, it was decided to use a passive analysis, that is, without making assumptions regarding the occupancy and usage patterns of the house. The heating effect of lights and appliances was also not taken into account.

The analyses were aimed at determining the number of hours of uncomfortably high or low temperatures in each of the buildings. The buildings were considered to be naturally ventilated and the thermal comfort temperature range for naturally ventilated buildings in Pretoria is 17.8 °C to 28.3 °C. The adaptive model of thermal comfort was used in calculating the levels of thermal comfort in the two houses.

The electricity needed for heating and cooling each of the buildings to thermal comfort levels (ranging from 20 °C to 24 °C, as recommended by SANS 204) was also determined.

The major differences between the two types of building are the thermal insulation and the thermal mass. The walls in a LSF building have better thermal insulation, but lower thermal mass than masonry buildings. The higher thermal mass in the walls of brick buildings reduces the diurnal internal temperature swings towards the average temperature, which could be too high or too low for comfort.

### **Findings**

Results indicate that the LSF house will be warmer than a base case masonry building in summer, as well as in winter. As example, the indoor temperature of the LSF building was within the thermal comfort range for 74% of the time in Pretoria's climate, compared with 71% for the masonry base case – only a small advantage. However, the analyses indicate that electricity required to heat the base case brick building to comfort levels will, on average, be double that required for the LSF building, ranging from 89% more in Pretoria, to 112% more in Bloemfontein. If cooling to comfortable temperatures is required, it will take on average three times more electricity to cool the brick building down to thermal comfort levels compared with a LSF building.

This significant increase in the amount of electricity required to heat or cool the internal spaces can be ascribed to the thermal mass of the masonry building – besides having to heat the air inside the building, the walls of the masonry building absorb some of the heat, resulting in additional energy consumption. The inverse happens when cooling, when the heavy masonry walls have to be cooled down together with the air inside the building.

The LSF building will require less than half the electricity to heat and cool to thermal comfort levels than the brick base case building, and still notably less than the other two insulated masonry alternatives.

### **Conclusion**

The CSIR's comparative thermal analyses indicate that LSF buildings offer improved energy efficiency compared with conventional masonry buildings – this means significant savings (between 20% and 90%) of electricity required for heating of residential buildings.

**End of Extract/....**

## **3.6 Emissions from Site Equipment.**

With the application of LSF methodology, the instance of exhaust emissions from site operated and used equipment is vastly reduced. Most of the engine driven equipment is not used on a continuous basis, and the equipment used has much less of an engine and emission capacity than e.g. cranes, etc.

### 3.7 Noise Impact.

As indicated previously, noise is limited to irregular use of driven equipment (platforms and forklift), and mostly to the use of hand tools like drilling machines.

As the delivery of materials is mostly not dependent on big trucks (e.g. bricks, sand, equipment), the vehicular noise is also minimised.

### 3.8 Material Waste.

A conventional building site will produce rubble, cement wastage, bags, timber off-cuts, and all sorts of waste materials. All of these must be reconciled on site in untidy heaps of waste, and then collected by truck.

Using LSF the only material waste will be the off-cuts from the boards. This will be minimal as off-cuts are normally used further for window and door reveals, trims, etc.

Any waste materials that are to be disposed of will be placed in a "waste-away" type skip for regular collection.

## 4. Sustainability of Resources.

The sustainability of resources not only lies in the resource requirements for an LSF building, but also in the depletion of resources that are required to effectively maintain conventional construction methods.

The following is an extract from an EIA (Environmental Impact Assessment) done on the manufacturing of bricks:

*"The removal of topsoil for urban uses mainly for brick-making is growing rapidly due to the tremendous growth in urbanization and industrialization in many developing countries. Unfortunately, brick kilns are mostly situated on fertile agricultural land, as brick manufacturers need silty clay loam to silty clay soils with good drainage conditions. The urbanization and the requirement of brick manufacturers has resulted in change in land use pattern as the good agricultural land has been turned into agriculturally unproductive lands around several growing cities of the developing world. Quite often soils used in brick-making have high fertility status and their opportunity cost is also high especially when the soil/brick-earth is removed from river basins with intensive agricultural production.*

*Often, many farmers are forced to sell soil for brick-making because their neighbours have sold soil which leaves a deep gap in the surface levels between those who have sold soil and those who have not. Another important dimension to the problem is the excessive depth over which the soil is removed above the agreed depth of soil extraction, which renders land unsuitable for agriculture. The removal of topsoil has direct impact on agricultural crop production via reduced fertility status of soils. As the*

*addition of organic matter in the forms of human and animal wastes and plant residues occurs only over the top layers of soil, removal of topsoil leads to loss of soil fertility.*

*Therefore, the negative impact of topsoil removal is quantified in terms of both the reduction in agricultural output and the cost of replacing the nutrients lost. The quantification is important because while procuring brick earth/soil, this cost is never considered, as this is a societal cost."*

Further, it is reported that the low mass of LSF building materials significantly contributes to its sustainability. The mass of a double-leaf masonry wall, plastered on both sides, could be as much as 450 kg/m<sup>2</sup>. This is more than ten times higher than the 36 kg/m<sup>2</sup> of LSF exterior walls, including the mass of the steel frame, the cladding, lining and insulation.

A LSF building offers a sustainable alternative to masonry construction, with reduced environmental effects.