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Light-gauge steel frame development in the Southern Cape

INTRODUCTION

In 2007 the light steel frame system was introduced in the Southern Cape under the guidance of the Southern African Institute of Steel Construction (SAISC). Shortly thereafter two manufacturing plants opened their doors, one in George and the other in Mossel Bay.

The system consists of automated roll-formers with cutting, punching, bending and dimple-forming modules. The roll-former machine is controlled by computer and a specifically developed CAD program (Framecad) to enable it to produce ready-for-use sections from 0,75 – 1,0 mm pre-galvanised plates. The sections are then screwed together to form various components (such as panels, trusses or girder trusses) that can be joined together to build the frame of a house, for example.

SASFA CODE OF PRACTICE

The SASFA (Southern African Light Steel Frame Building Association) Code for Low-rise Light Steel Frame Buildings was published in October 2007. This code provides the rules and requirements for the design, fabrication and construction of buildings with light-gauge steel frames, primarily houses and other buildings of limited size. Supervision of an engineer is recommended, and is compulsory for buildings falling outside the scope of the code. The code has since been superseded by SANS 517:2009.

HOUSING SYSTEM OR STRUCTURAL MATERIAL?

From May to August 2008 experience was gained on this system through a dozen housing projects. Lighter foundations were designed to suit the reduced weight and higher flexibility of the steel. Various beam and connection options were also analysed and discussed.

After the initial phase, two project proposals exposed the need to move beyond the scope of the code. The first was the proposed Hornlee Village in Knysna, where the developer was planning a number of four-storey blocks of flats, comprising eight units each, with an average unit size of 60 m^2. A three-dimensional steel frame made up of I-beams was proposed to serve as skeleton for the light-gauge steel.

The second proposal came from Titan Aviation in George, who required an extension to their 23 m span helicopter hangar.

The architect requested a comparison between a truss made from angle iron and one made from light-gauge steel. The light-gauge truss showed considerable promise in both cases.

Although the two proposals did not progress to construction, the experience gained was used in later projects, such as the following three projects that were completed successfully.

House Blue Myrtle, Vleesbaai

In October 2008 Ictus Studio Architects headed the design and construction of a double-storey luxury sea-facing house with the intent to utilise light-gauge steel for the structure.

A raft foundation, made up of two parts that hinge around the internal retaining wall, was designed to make use of the greater ductility of steel compared to masonry. Square hollow-section steel was used for the external columns supporting both the balcony and the overhanging roof. Each column had a different orientation to improve the aesthetics of the façade. Two square hollow sections were also used as internal columns to support the floor and roof over the wide opening.

The wall panels were planned to accommodate the curved roof, and in the main bedroom a curved wall was built. All services were accommodated within the walls.

The roof and first floor joists were slotted into the wall panels and sides, hanging from the bearer trusses. The connectors were made from hand-machined plates, while the ring beam on the outer ring of the balcony consisted of two standard C-sections forming an enlarged box section.

The house was completed in 2009 and valuable experience was gained in the use of light-gauge steel together with standard square hollow sections. This project proved that it is possible to construct aesthetic buildings with light-gauge steel. The project was shortlisted for the 2010 SAISC awards.

Mezzanine floor for Bali Trading, Riversdale

The client required a mezzanine floor as a furniture showroom. Design and construction had to take place within two months and with minimum disruption to the existing store on the ground level. The U-shaped floor area of 290 m^2 was therefore constructed in two stages, allowing the shop to continue doing business during construction. A series of three parallel trusses and one cross-bearer truss allowed the use of 5 m light-girder trusses spaced at 500 mm centres to be used on top of the bearer trusses. Each bearer truss was made up of two lattice girders side by side and screwed together with plate stiffeners at maximum hogging and sagging moments. The continuous-bearer trusses were supported at 5 m centres, and at the end by angle iron brackets to the steel portal frame. The seven supporting columns consisted of two 400 mm deep lattice trusses each. No strengthening of the floor was required as it had been designed for 110 mm masonry walls.

This simple arrangement made for fast and easy construction. The total structural weight was about 2 600 kg or 8,85 kg/m^2 for a 2 kN/m^2 load. The project was completed within the four-week construction period, illustrating that the material can be used efficiently in suspended flooring applications.

1 House Blue Myrtle: frame exposed during construction
2 House Blue Myrtle: front view of house after completion
3 House Blue Myrtle: trusses as feature in living room
4 Bali Trading mezzanine floor: lattice girder truss on joist, and stiffeners exposed
5 Bali Trading mezzanine floor: the floor two weeks later as part of the showroom
6 Steyns-Holzfaller shop and flats: hot-rolled skeleton inner frame and a light-gauge outer frame before cladding

Steyns-Holzfaller shop and flats, Danabaai

In August 2010 planning and design commenced for the construction of a two-storey 760 m² building comprising a hardware store on the ground floor and four apartments on the first floor.

The use of the 'solid wall' system was requested to improve wall insulation and reduce noise. This system consists mainly of vertical sections clad both sides with fibre cement boards. Horizontal steel sections are fixed and holes are made at strategic positions. Hereafter a light-weight concrete mix with polystyrene bubbles is pumped into the cavity. The solid wall system was also used upstairs as firewalls. The typical wall will induce a load of only 1,2 kN/m onto the slab.

The core structure consisted of three portal-type frames with square tubing columns and horizontal I-beams. A composite floor was developed, drawing on factory trials and experience gained from previous projects.

A concrete slab was chosen to reduce fire risk and noise transmission, as well as to reduce the weight, and hence the cost. The composite slab was made up of light-gauge steel joists of 300 mm deep, with a 58 mm concrete slab cast on permanent plywood shutters. The shear connectors consisted of two types of bent plate sourced from machine offcuts that would also act as spacers for the steel mesh. Hogging reinforcing steel was placed in the concrete in both

directions to make the composite slab continuous in both directions.

The project was completed nearly on schedule. Delays were caused by subcontractors not delivering components to specifications. Although the hogging steel details were changed, unwanted web sagging in the joist trusses occurred during casting. This was rectified by propping the trusses until the concrete had cured and composite action developed sufficient strength.

SUMMARY

The use of light-gauge steel was initially associated with the construction of houses. Due to a combination of economic need, constant requests and a willing team, the scope of usage has been broadened. The three projects discussed above prove that light-gauge steel can be used successfully outside the scope of the design code and the suppliers' CAD programs. The notion that light-gauge steel is a housing system only has been challenged. Light-gauge steel should rather be seen as a variation of cold-formed steel design, using screws for the connections.

Continued development will improve both the scope and the efficiency of construction with light-gauge steel. Some possible improvements are:

- In view of the limits of the CAD operators, the practice of making workshop drawings should be enforced.
- An erection code similar to SANS 10243 (timber) may assist the erectors to prevent damaging panels, speed up construction, and increase safety.
- The support from the SAISC was encouraging, but more focus could be placed on project management and the important role of the architect in areas where formal contracts are not used.
- Investors in machinery and building equipment could be approached to develop more productive methods.

The introduction of light-gauge steel to the Southern Cape raised considerable interest, with a number of entrepreneurs becoming involved. Many lessons were learnt, and mistakes were made. This is all part of pushing the boundary. □

7 Steyns-Holzfaller shop and flats: composite slab made up of concrete and light-gauge steel joists

8 Steyns-Holzfaller shop and flats: pumping of light-weight concrete into wall panels

9 Steyns-Holzfaller shop and flats: front view of building during construction of second floor