



Development of Chinese Light Steel Construction Residential Buildings

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Abstract

Building systems with light steel members, gypsum plasterboards and mineral wool have a wide spread use in the US, Australia and Japan and are gaining market in some European countries. The systems have often load-bearing walls and the floors may be of Light weight steel profiles or concrete. Such systems are suited for industrial production and can contribute to a more efficient building process. This new building technology came to the foreground because of the rapid development in the building industry; surely it has a lot of advantages from the technological point of view, which meet all the requirements these days. But it is more important beside the points of view mentioned above that the construction of these buildings protects the natural environment, and suits the stand points of Sustainable development and guarantees a healthy environment for the users for the whole lifespan of the building. But, these systems are not universally utilized in China. As a matter of fact, they are to agree with the all current situations of China, especially the Light-gauge steel system residence. In the following paper I will justify the existence of light-gauge steel constructional building system in the residential housing with the points mentioned above.

Keywords: Residential construction, Light-Gauge steel, Sustainable development, Building materials

1. Introduction

Light-gauge steel houses are usually built of light thin-walled load bearing structures having different solutions for interior and exterior cladding. This technology is popular and accounts for an important and increasing market share in US, Japan, Australia and Europe. The same method is used for buildings, of small dimensions, of other purposes, that are referred to as small industrial buildings (SIB).

The construction industry in China is fighting with the problem of producing residential buildings that people can afford to live in. Reduced construction costs and more efficient building processes are very much on the agenda together with the restraint of maintained or improved quality. The way forward to these goals is adopting industrial building processes with increased prefabrication. Light-gauge steel system based on cold-formed profiles, gypsum boards and mineral wool fit very well into this trend.

2. Light-Gauge Steel Construction

Light-gauge steel Construction is made by a cold-forming process where sheets of steel are passed through a series of roll forming dies to create their desired shape. The desired strength is achieved by a combination of the thickness or gauge of the steel utilized as well as the shape of the member. The various bends in the member's cross-section add to the stiffness and ultimate strength of the piece. Because of the strength advantage produced by this bending process, steel framing material has a strength-to-weight ratio that is very favorable when compared to most other materials. The gauge or thickness of sheet steel ranges from 0.6mm to 1.8mm. By convention the higher the gauge numbers the thinner the steel. The more lightweight non load-bearing interior walls of residential structures are usually made of 0.6mm-gauge steel, while the exterior load-bearing steel studs are usually built from stronger 1.2mm or 1.6mm gauge steel.

To protect steel from rusting, steel is zinc galvanized. This protection is necessary both during storage, construction and while in use to avoid damage and loss of strength due to rusting. Because of that, this system is not a traditional building type in the Chinese circumstances.

The building system characteristics would be summarized as follows:

- The light construction residential house's frame is assembled from cold formed steel profiles. In the gaps between the elements of the frame heat insulation material is placed and the frame is supplied with surface layers made of various materials, forming a layered structure.

- Generally, the elements of the frame structure are constructed of C and U profiles with a dry, assembly style building technology. Numerous steel fasteners, stiffeners and other complementary profiles are connected to the basic elements of the structure.
- The applied materials filling the gaps between the elements of the frame not only perform heat insulation, but also meet acoustical requirements and they are an efficient fire protection tool. With the application of efficient heat insulation materials a good level of fire protection and an excellent heat and sound insulation can be achieved.
- The inside cover is mostly made by plasterboard. Composite layers by wood as basic material (e.g. OSB) are preferably used as outside wall board cover and floor slabs. With this, we can exploit the advantage of high strength, which provides stiffening function.
- Steel construction components can be pre-measured and pre-cut to exact specifications. On-site adjustments are generally not required.
- Steel components generate minimal waste and all light-gauge steel construction materials are 100% recyclable.

Figs. 1 show steel framed living houses. The structural characteristics are visible in the picture.

3. light-gauge steel assembly methods

The three basic light-gauge steel assembly methods are stick-built construction, panelized systems, and pre-engineered systems. The American Iron and Steel Institute (1994) best describes these three methods as follows:

3.1 Stick-Built Construction

Stick-built construction is virtually the same in wood and steel. This framing method has actually gone through a transformation incorporating many of the techniques used in panelized construction. The steel materials are delivered to the job-site in stock lengths or in some cases cut to length. The layout and assembly of steel framing is the same as for lumber, except components are screwed together rather than nailed. Steel joists can be ordered in long lengths to span the full width of the home. This expedites the framing process and eliminates lap joints. Sheathing and finish materials are fastened with screws or pneumatic pins.

3.2 Panelized Systems

Panelization consists of a system for pre-fabricating walls, floors and/or roof components into sections. This method of construction is most efficient where there is a repetition of panel types and dimensions. Panels can be made in the shop or in the field. A jig is developed for each type of panel. Steel studs and joists are ordered cut-to-length for most panel work, placed into the jig and fastened either by screws or welding. The exterior sheathing, or in some cases, the complete exterior finish, is applied to the panel prior to erection.

Shop panelization can offer several significant advantages to the builder. The panel shop provides a controlled environment where work can proceed regardless of weather conditions. Application of sheathing and finish systems is easier and faster with the panels in a horizontal position. Although the panels must be transported from the panel shop to the job, most often the cost advantages of panelization offset the added transportation costs.

A major benefit of panelization is the speed of erection. A job can usually be framed in about one quarter of the time required to stick-build. When you consider that the exterior finish system may also be part of the panel, the overall time saving may be even greater.

3.3 Pre-Engineered Systems

Because of steel's high strength and design flexibility, innovative systems are possible which are not possible using other materials. Engineered systems typically space the primary load carrying members more than 24 inches on center, sometimes up to 8 feet. These systems use either secondary horizontal members to distribute wind loads to the columns or lighter weight steel in-fill studs between columns. Furring channels used to support sheathing materials also provide a break in the heat flow path to the exterior, which increases thermal efficiency.

Many of the pre-engineered systems provide framing members that are pre-cut to length with pre-drilled holes for bolts or screws. Most of the fabrication labor is done by supplier, allowing a home in as little as one day.

Figs. 2-9 show light-gauge steel houses during the building process.

4. Environment and Sustainable development Viewpoints

The ecological approach has pointed out that the current high-level energy consumption, characteristic of people's activity nowadays, the level of exploitation and the pollution of the natural environment lead to a global catastrophe. To decrease this danger, it is absolutely necessary to economize basic materials and energy, as well as extended Sustainable development is required. The macro-level changes mentioned above should appear in all micro-level processes in the construction generally and in the building of concrete houses. This can be put in reality by following the directives of environment friendly, energy-conscious design and building.

In the ecological architecture the most important issue is the enforcement of the viewpoints of sustainable development and public health protection. During the building, the Sustainable development is reachable by reducing significantly the energy consumption by

- Application of building materials with low embodied energy;
- Employment of recyclable building materials;
- Usage of a building technology with low energy need, etc.

The health protection viewpoints have to be taken into consideration during the total lifespan. Naturally, the health protection refers not only to the inhabitants but also to people living in the wider environment and globally to the whole humanity. The principles of health protection suggest the application of possibly natural materials and technologies, which are absolutely harmless to people.

5. Feasibility analysis in China

Light construction residential building is more and more frequently used in China. Although the application quantity is still low, in the last decade it came to the foreground due to numerous advantages.

- As the rapid development of China's iron and steel industry, steel production in 2004 reached 200 million t, as the world's largest producer of steel. The variety and standard of steel are to increase which supply the matter foundation of the development of light-gauge steel structure residence.
- The government attaches great importance to the development of steel construction, the Ministry of Construction in the new revised "Building Technology Policy", clearly a positive development. Released in 2002, "Residential Steel Industry Technology Guide" for the development of light steel housing policy and technical support to ensure that this will be a positive role in promoting the development of China's steel building industry.
- Cold-formed light-gauge steel structure residence meets the requirement of building industry. Building industry is the sustainable development of cities to further deepen.

6. Problems of light steel residence development

Although the light steel is the best choice to replace the existing masonry and concrete materials, the current system of light steel structure residential applications in China is limited. Rural and small towns have not yet applied. The main reason to explore as follows:

- Light steel frame components are light-gauge steel structure' key materials. Especially, they are about 1 mm with C and U-shaped steel, the current domestic production of such components can be very few manufacturers. A serious shortage of production is to result in excessive cost.
- Their standard is not in conformity with the norms of domestic. Because of this limit, light steel structure residential steel building will be a significant increase in its cost; it lost the competitiveness of traditional architecture.
- The traditional concept of consumer. They are not familiar with the new structure residence, so resist.

7. Advices

- Introducing foreign advanced technology, suited to China's production of cold-formed steel component system and the production line, large-scale promotion in the domestic.
- Research institutes, universities and enterprises to actively carry out cold-formed steel residential component parts of the theoretical and experimental research. And to standardize the form of the final set, for design engineer to based on.
- Fundamentally change the traditional residential impression of light steel structure residence to people, so that the advantages of light steel structure residential is known by people.

It can be predicted that light steel structure residential will be a wide range of development in the 21st century of China.

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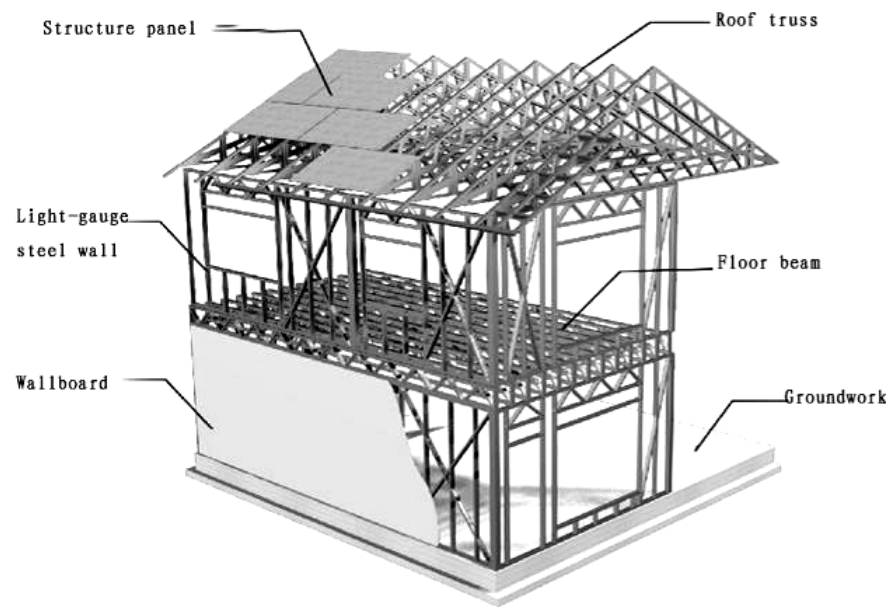


Figure 1. steel framed living houses



Figure 2. The basis of the construction



Figure 3. The laying of light steel floor joist



Figure 4. Lifting roof truss



Figure 5. Housing roof truss



Figure 6. Retaining wall skeleton



Figure 7. The laying of roof and wall panels(OSB)



Figure 8. Fixed ceiling light steel frame



Figure 9. Light-gauge steel residential