COLD-FORMED STEEL STRUCTURES – AN ALTERNATIVE TO THE CLASSIC STEEL STRUCTURES

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Abstract*: Nowadays when the natural resources are very important and we want to do more with minimum of materials, cold-formed steel structures represent a good alternative to classic way of construction because the use of thin elements can reduce the use of materials and in fact the use of energy. Cold-formed steel structures are recently used in civil engineering due to their structural efficiency in various domains, and they are replacing in many cases classic steel structures with hot-rolled formed or welded profiles. The main advantage of these structures is that resistance elements are made of lightweight sections obtained by bending thin steel plates in various forms that are very strong beside it's weight so that the steel become a more efficient material and the building become "greener".*

Keywords*: cold-formed, thin walled, buckling, lightweight..*

1. Introduction

Cold-forming represents an industrial process based on cold-rolling and brake- forming that is used to produce different section shapes starting from a simply flat steel panel. The strength of each section shape is provided by the number of the bendings, angles and proportions between section walls.

Cold-formed steel structures appeared as an economical alternative for classic steel structures and wood structures whose price began to rise in the 1990s. In the begining this kind of structures were not well aceepted due to the lack of design methodology and product recognition, but after years of research

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they became reliable and now are used in most applications including automotive industry, civil engineering, transportation etc.

2. Applications of cold-formed steel structures

In building construction, cold-formed steel products are mainly used as structural members, walls, floors, diaphragms and roofs. There are varieties of cold-formed shapes available as structural members, which include open sections, closed sections, and built-up sections, double channel I-sections. These structural shapes can be used in buildings as eave struts, purlins, girts, studs, headers, floor joists, braces ans other building secondary elements.

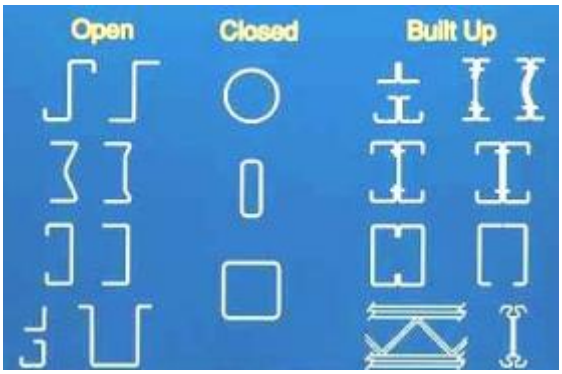

Figure 1. *Cold-formed steel sections*

Various shapes are also available for wall, floor and roof diaphragms and coverings as secondary elements which can have enough strength to support wind and snow loads.

Cold-formed steel elements can be used for residential and light commercial and industrial building construction as independent members or pre-engineered metal buildings. The main advantage is lightweight which can be translated in reduced costs by using less steel for structural elements, for transportation from the factory to the workshop and also for mounting where are not necessary heavy lifting machines – higher efficiency.

A typical metal building system consists of primary rigid frames, secondary members, cladding, and bracing. The primary rigid frames are usually built up using welded plates with sizes optimized to satisfy the design requirements. The secondary members, such as purlins and girts, support the roof and wall coverings and provide lateral stability to the primary rigid frame members. The cold-formed metal roof and wall panels are often used as building claddings. Straps or rods are often used as bracing members that maintain the

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building stability in the direction perpendicular to the primary rigid frames. They are also often used in end-walls for stability of time, material and energy.

3. Advantages of cold-formed steel structures

Cold-formed steel products are shaped at ambient temperatures from steel sheet, strip plate or flat bars by roll-forming machines, press brakes or bending brake operations. They can be produced in large quantity and at high speed with consistent quality.

The process of cold-forming has the effect of increasing the yield strength of steel, the increase being the consequence of cold working well into the strain-hardening range. These increases are predominant in zones where the metal is bent by folding. The effect of cold working is thus to enhance the mean yield stress by 15% - 30%. For purposes of design, the yield stress may be regarded as having been enhanced by a minimum of 15%.

- Lightweight - Cold-formed steel components weigh approximately 35% to 50% less than their wood counterparts, which means that they are easy to handle during construction and transportation.

- High-strength and stiffness – As a result of the cold-forming process, cold-formed steel possesses one of the highest strength-to-weight ratios of any building material. This high strength and stiffness result in more design options, wider spans and better material usage.

- Fast and easy erection and installation – Building components made of cold-formed steel can be fabricated with high accuracy in a plant and then assembled on job sites, which greatly increases erection efficiency and ensures construction quality.

- Dimensionally stable material - Cold-formed steel does not expand or contract with moisture content. In addition, it does not split or warp as time goes by. Therefore, it is dimensionally stable. Cracked gypsum sheathed walls, nail head popping and other common problems with wood-framed structures can be virtually eliminated in buildings with cold-formed steel stud walls

- No formwork needed – The use of cold-formed steel decks eliminates the formwork for pouring concrete floor. In addition, composite action between the steel deck and concrete increases floor strength and stiffness

- Durable material - Cold-formed steel is durable because it is resistant to termites and rotting. In addition, galvanized cold-formed steel products provide long-term resistance to corrosion.

- Economy in transportation and handling - Lightweight cold-formed members or panels are easy to handle and transport. In addition, they can be nested and bundled, reducing the required shipping and storage space.

- Non-combustible material - Steel is a non-combustible material and will not contribute fuel to the spread of a fire. This results in better fire resistance and lower insurance premiums.

- Recyclable nature - Steel products used in construction are infinitely recyclable, with no degradation in structural properties. It can be recycled and reused. Steel-framed housing dramatically reduces the amount of trees consumed for residential construction, thus conserving one of nature's most precious resources.

- Energy efficiency – A variety of color options for metal roofs and panels provides consumers with many choices to select products that save energy. For low-heating degree day climates, high-emissive white or light painted roofs display solar reflectance of at least 65% and thermal emittance of 80 percent. This results in reducing air conditioning costs and the smog and pollution that are created by the production of that energy.

Some of the main advantages of cold-rolled sections, as compared with their hot-rolled counetrparts are as follows:

- Cross sectional shapes are formed to close tolerances and these can be sonsistently repeated for as long as required.

- Cold- rolling can be employed to produce almost any desired shape to any desired length

- High strength to weight ratio is achieved in cold-rolled products

4. Disadvantages of cold-formed steel structures

There are some disadvantages that must be taken into account when we should choose between cold-formed and classic hot-formed or welded elements because thin-walled structures are suffering from some limitations regarding their strength due to various structural instabilities generated by wall slenderness.

Compared to hot-rolled steel elements the main disadvantages of cold-formed steel elements are:

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- Very sensitive to local and global buckling in various modes and combinations of these, due to their slender section walls (**see figure 2**)

- Low ductility of the elements because is used higher strength steel with no yielding zone (see **figure 3**)

- Design procedures more complex which can involve counter-measures to prevent undesirable losses of stability of any kind.

- Low fire resistance because of the small cross-sectional area. This disadvantage can be avoided by using protection panels which can provide fire resistance for up to 2 hours

- Very important residual stresses because the fabrication processes that are concentrated in the section's corners

- Geometric imperfections with high influence in sterngth and seinsitivity of failure mechanism.

The main disadvantages can be avoided by using practical methods in order to decrease the sensivity of these structures to lose their stability. Failure mechanism depends on the length of the member or the distance between stiffeners so the structural engineers should take into account methods of reducing elements slenderness by disposing intermediate and secondary members in order to prevent the buckling.

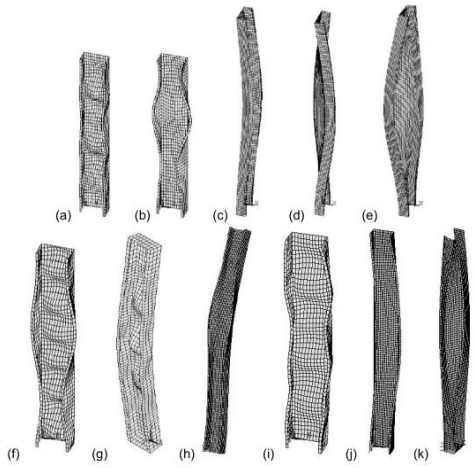

Figure 2. *Buckling modes for a C-shape profile in compression*

In order to create stronger thin walled sections the steel producers are using high grade steel (with high tensile strngth and low ductility).

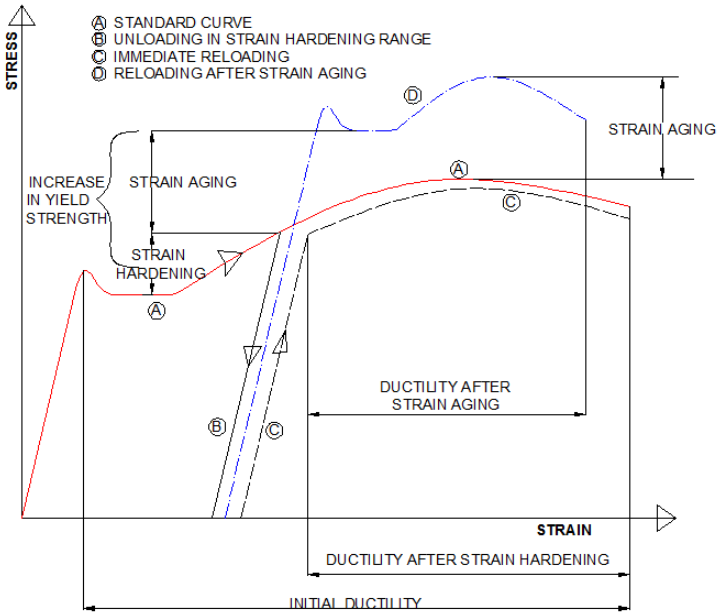

Figure 3. *Effects of strain hardening and strain aging on stress-strain characteristics of structural steel*

The changes in the mechanical properties, brought about by cold-forming process are considered as being caused mainly by strain hardening, The Bauschinger effect and strain aging. In order to utilize the increased strength of cold-formed light gage structural shapes the type, grade and quality of the steel and the amount and kind of cold work performed should be closely controlled in order to avoid secondary problems.

4. Conclusions

Cold formed steel has become a competitive building material as a result of industry-wide efforts. Once the design methods and research activities regarding thin-walled structures are evolving, the people become more confident in this alternative which they are promoting for more applications in order to optimize the use of materials and save the planet by recicling steel.

5. Acknowledgements

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