An Insight into Cold Rolled Steel and its Application to Mid-Rise Building

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What is Cold Rolled Steel?
Thin sheet steel products are extensively used in building industry, and range from purlins to roof sheeting and floor decking. Generally these are available for use as basic building elements for assembly at site or as prefabricated frames or panels. These thin steel sections are cold-formed, i.e. their manufacturing process involves forming steel sections in a cold state (i.e. without application of heat) from steel sheets of uniform thickness. These are given the generic title Cold Formed Steel Sections. Sometimes they are also called Light Gauge Steel Sections or Cold Rolled Steel Sections.

An Insight into Cold Rolled Steel
The thickness of steel sheet used in cold formed construction is usually 1 to 3 mm. Much thicker material up to 8 mm can be formed if pre-galvanized material is not required for the particular application. The method of manufacturing is important as it differentiates these products from hot rolled steel sections. Normally, the yield strength of steel sheets used in cold-formed sections is at least 280 N/mm², although there is a trend to use steels of higher strengths, and sometimes as low as 230 N/mm². Manufacturers of cold formed steel sections purchase steel coils of 1.0 to 1.25 m width, slit them longitudinally to the...
correct width appropriate to the section required and then feed them into a series of roll forms. These rolls, containing male and female dies, are arranged in pairs, moving in opposite direction so that as the sheet is fed through them its shape is gradually altered to the required profile. The number of pairs of rolls (called stages) depends on the complexity of the cross sectional shape and varies from 5 to 15. At the end of the rolling stage a flying shearing machine cuts the member into the desired lengths. An alternative method of forming is by press - braking which is limited to short lengths of around 6 m and for relatively simple shapes. In this process short lengths of strip are pressed between a male and a female die to fabricate one fold at a time and obtain the final required shape of the section. Cold rolling is used when large volume of long products is required and press breaking is used when small volumes of short length products are produced.

Galvanizing (or zinc coating) of the preformed coil provides very satisfactory protection against corrosion in internal environments. A coating of 275 g/m² (total for both faces) is the usual standard for internal environments. This corresponds to zinc coating of 0.04 mm. Thicker coatings are essential when moisture is present for long periods of time. Other than galvanizing, different methods of pre-rolling and post-rolling corrosion protection measures are also used. Although the cold rolled products were developed during the First World War, their extensive use worldwide has grown only during the last 20 years because of their versatility and suitability for a range of lighter load bearing applications. Thus the wide range of available products has extended their use to primary beams, floor units, roof trusses and building frames. Indeed it is difficult to think of any industry in which Cold Rolled Steel products do not exist in one form or the other. Besides building industry, they are employed in motor vehicles, railways, aircrafts, ships, agricultural machinery, electrical equipment, storage racks, house hold appliances and so on. In recent years, with the evolution of attractive coatings and the distinctive profiles that can be manufactured, cold formed steel construction has been used for highly pleasing designs in practically every sector of building construction.

Applications of Cold Rolled Steel in

(A) Roof Framing

Several innovations have taken place in roof framing over the past few years; the most notable being the widespread use of custom designed and formed roof truss and component systems. Until the early 1990s, most cold-formed steel trusses had been made using back-to-back wall stud or joist (c-shaped) members. With the development of custom truss web and chord profiles, as well as the accompanying specialty software, specifying a steel roof truss has become very similar to specifying a plate connected wood truss. Engineers, architects, and building officials are already familiar with the submittal sheets and component and detail sheets for the wood products; the steel submittals are very similar, and often are provided by the same component manufacturing companies. The engineer of record, as always, needs to pay special attention to review of these documents and bracing issues: for both individual truss members and for the overall truss system. The Light Gauge Steel Engineers Association (LGSEA) provides some guidance on these bracing systems in their tech note for permanent truss bracing, and for temporary system bracing. Also, the AISI’s Committee on Framing Standards publishes a truss design standard, which outlines some of the design responsibilities: what entity is responsible for designing the truss connections, as well as the bracing systems and supports. With these innovative truss shapes, truss companies and connector companies such as USP and Simpson Strong-Tie have developed specialty connectors for truss-to-truss, truss-to-structure, and multiple-truss connections. One company, Aegis Metal Framing, has developed a special bracing device that can be used to both brace the chord members of adjacent trusses, as well as space the trusses at 16”, 24”, or 48” on center. Rosette Systems out of Finland has a truss manufacturing system that uses a special forming process to tie the web and chord members together without connectors or welding. Although these braces and fastener less connections are not covered in the code, the manufacturers have test data and software to assist the designer and engineer of record. Refer Figure 1 for application of cold rolled steel in roof framing.

(B) Floor and Rafter Framing

Floor and Rafter framing has come a long way in the last few
years as well. Systems from at least three manufacturers are either available in the marketplace or in the process of product development, with large, stiffened web perforations to allow the passage of services (such as electrical, plumbing, and some small ductwork). When calculating a joist with a large perforation, the resultant strengths are often prohibitively low, using a strict interpretation of the code. However, by adding the stiffening lip around the hole, additional strength can be gained with lighter materials, with little or no sacrifice in structural capacity. Again, because these type of stiffened perforations are not specifically addressed in the specification, designers need to rely on manufacturer’s data and span tables to specify these products. Also, special detailing requirements may be needed at special conditions, such as support connections and bracing locations. There are some innovative bracing techniques for these members; Infact there are installations where a 6-inch stud member was inserted through the 6-inch holes of a joist system, and fastened to each member using cold-formed angles. Refer Figure 2.

(C) Door and Window Openings

At least one of these systems comes with a specialty end track (rim joist) for the framing members, with tabs that allow for the spacing and connection of the webs of the joists. These rim joist members have some span capability, and when lightly loaded, they can span over door and window openings without additional headers in the wall below. One of the most expensive and time consuming parts of wall framing is the installation of loadbearing headers over openings; using the rim joist can be a major labor (and material) saver on low rise and mid-rise loadbearing projects. Another way to reduce the labor required on headers is using the “L header.” L header members are simple, L-shaped steel sheets that are attached to the sides and top of a wall over an opening. These headers can be put in place after the wall is built, with no additional coping of jamb studs or cripple studs to accommodate the member depth. The L header not only has a cost advantage over traditional boxed and back-to-back headers, but it is easier to insulate, build, and disassemble or move if required. The disadvantage is that it has a very low capacity for uplift loads, which could be an issue in high wind areas. However, research is underway on different configurations for this type of header to increase the capacity in high-uplift conditions. Currently, the Header Design Standard from the AISI gives design methods and values for using the L-header, as well as the more traditional box and back to back header configurations.

(D) Bracing

Bracing of floor, roof, and wall systems, both laterally and axially loaded is another important part of the framing process that can greatly reduce the capacity of structural stud systems, if missing or installed improperly. Methods for punchout through the bracing, such as the Spazzer Bar®, Bridge Clip®, and Bridge Bar®,

Figure 2: L header members are simple, L-shaped steelsheets that are attached to the sides and top of a wall over an opening. These headers can be put in place after the wall is built, with no additional coping of jamb studs or cripple studs to accommodate the member depth.

Figure 3: Methods for through the punch out bracing, such as the Spazzer Bar®, Bridge Clip®, and Bridge Bar®, are made to provide both torsional and translation restraint for wall studs and shallow rafters under lateral and axial loads.

Figure 4: Truss bracing is an important element of both proprietary and c-shaped truss systems.
are made to provide both torsional and translation restraint for wall studs and shallow rafters under lateral and axial loads. Note that these systems are designed for members up to 6-inches in depth. For 8-inch, 10-inch and deeper joists and studs, a flange attached bracing system is required, such as flat strapping and blocking, or diagonal bracing of members. Note that the Specification permits sheathing braced design; the engineer of record should use his or her best judgment as to whether or not this is appropriate for the specific configuration and loading condition. Refer Figure 3 and 4.

(E) Hybrid Applications

One of the most widely used developments of cold-formed steel framing in mid-rise construction is the hybrid use of steel with other systems. Details are available for steel wall framing with hollow core floor slabs, composite floor systems, and engineered lumber floor joist systems. Steel floor and roof systems have been used successfully with insulated concrete form (ICF) wall systems, as well as masonry construction. Often, the driving factor behind use of steel is not economy of the system, but the height and area requirements and non-combustibility requirements of the governing code.

Conclusions

Using cold-formed steel framing is not new to most structural engineers. However, many of the applications, products and systems mentioned here have not yet gained widespread use in many areas still today. To most engineers, designing cold formed steel involves looking up tabulated values, and designing some connections and shear walls. Using some of these resources may broaden the designer’s toolkit when providing solutions to the design problems of owners and architects.

Reference

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