Designing Cold-Formed Steel Mid-Rise Structures

Innovations for Cost-Effective and Attractive Projects

By: Don Allen, P.E.

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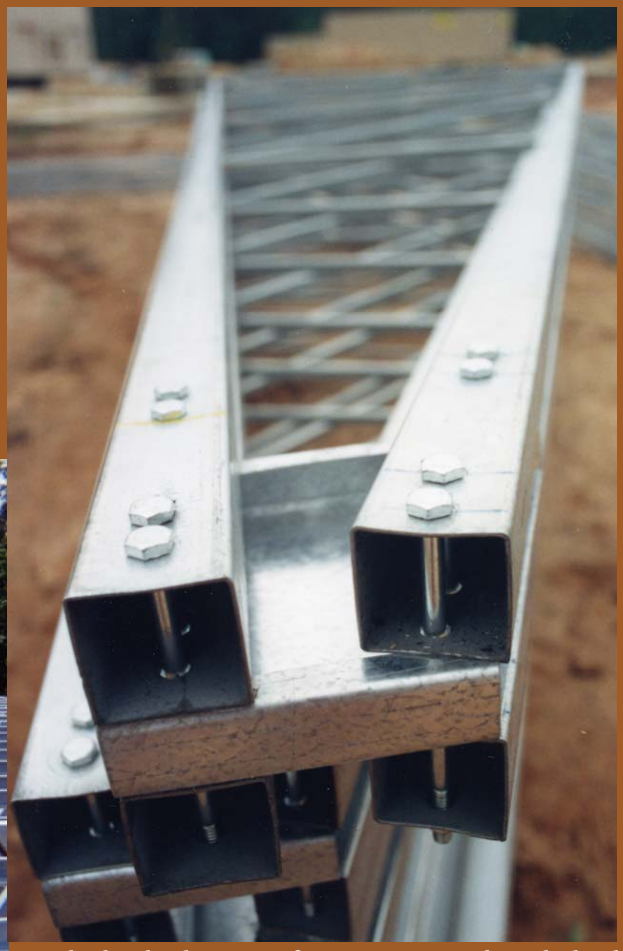

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Innovations in construction techniques and design aids are making metal stud construction a cost-effective material of choice for low-rise and mid-rise structures. Engineers and architects are getting competitive price information from framers and contractors, and are starting to specify more projects with cold-formed steel than ever before. There are several reasons for this. First, the steel industry is becoming more responsive to the needs of the designer and framer, and is making it easier to specify and install the materials. Second, the building codes and standards have more information on steel framing, and it is becoming more accepted as a mainstream product.

Third, there are more design aids, tables, software products, and details available to make the job of the structural engineer and architect easier. Several of the design procedures in the American Iron and Steel Institute (AISI) Specification and the new *North American Specification for the Design of Cold-Formed Steel Structural Members* (NASPEC) can result in lengthy and repetitive hand calculations. Using some of the new design aids and software helps shortcut the time needed, and are invaluable to the experienced designer.

When designing these types of structures, what are some of the innovations that the designer can use to help his or her customer have a cost-effective and attractive project that is easily constructed and energy efficient?

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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 551e for permanent truss bracing, and 551d 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

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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 fastenerless connections are not covered in the code, the manufacturers have test data and software to assist the designer and engineer of record.

For engineers that still want to design truss components using c-shaped stud and rafter material, the software and design tools are much more user friendly and affordable than those available in the late 90's. One software product provides a special "hip generator", which will create and design all of the stepdown trusses, girder trusses, jack trusses, and other components required for an entire hip system, with just a few keystrokes and mouse clicks. Several packages provide "whole building " systems, that will incorporate design of the roof, floors, and walls, all in steel.

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

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(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; I have seen one installation 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.

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

Truss bracing is an important element of both proprietary and c-shaped truss systems.

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.

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 a structural stud systems, if missing or installed improperly. Methods for punchout through the 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. Note that these systems are designed for members up to 6-incehs 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.

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 hollowcore 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 of North America. To most engineers, designing cold-formed steel involves looking up tabulated values, and designing some connections and shearwalls. Using some of these resources may broaden the designer's toolkit when providing solutions to the design problems of owners and architects.■

Proper attachment of the truss system to the structure is essential, especially in areas of high uplift loading.

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