

# State of the Art

By Lena Singer

With a multitude of steel framing systems to choose from, it's never been easier to design with structural steel. Here's what steel industry experts want you to know about the "state of the art" in steel today.

The following article features comments related to various structural steel products from individuals in the structural steel industry. Comments represent the views of the quoted individuals and do not necessarily represent the views of AISC.

## Steel Joists vs. Rolled Beams: What to Consider

Type of occupancy, required plan layout, and fire protection requirements are usually critical issues in determining whether to specify rolled beams or joists. "I think in general, rolled beams or joists have certain advantages and disadvantages depending on their application," said **Perry Green**, Technical Director of the Steel Joist Institute.

However, Green said that as spans increase, joists generally become a more economical choice.

"If you're looking at cost in pounds of steel, in general a joist would cost less than a rolled beam for spans greater than 30'," Green said. "It reduces the overall structural weight, which reduces foundation size, and reduces seismic load."

As a result, joists are commonly used for roof framing, where loads are relatively light, the rhythmic layout of the framing is appropriate, close member spacing is not detrimental, and fire-rating of the roof system is not a requirement.

Joists may also save on labor costs due to the possibility of using panelized construction, which simplifies the erection process, added Green. "If the decking is already installed, it makes it a lot safer, too," he said. "A joist or panel is set down on a joist girder or other structural support rather than bolted or welded to a web or girder flange like a rolled beam. If you were using a fill beam going into a girder, it would have to be bolted in as a shear connection immediately."

Depending on the use of the building, though, the lower weight of joists can sometimes prove to be detrimental. "Joist capacities are often rated in terms of a few hundred pounds per foot, while rolled steel beams often have capacities of several thousand pounds per foot," explained **Kurt Gustafson**, S.E., AISC Director of Technical Assistance. "To accommodate this capacity difference, joist

systems are usually required to be spaced at much closer intervals than steel beams to accommodate the same load, resulting in many more pieces for the joist system. At times it may become unreasonable to accommodate a very closely spaced system."

Green said that because joists are typically designed for uniformly distributed gravity loads, concentrated loads might require KCS joists or a special joists, which can be more expensive.

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"If the designer knew exactly where the concentrated loads were going to be, the pattern of the web could be designed to pick up the additional loads—but that's also an additional expense," Green explained.

Likewise, if floor-to-floor heights are important, beams are usually a better choice. "A wide-flange [beam] may not be as deep as a joist," Green said, "so it can reduce overall building height, with less of a story height for wind." Sometimes, though, the open spaces in the joists can be utilized for smaller ductwork.

Fire-rating requirements are also an important consideration. When passive fire protection is required, the preferred method is often a spray-applied application of fireproofing

fibers. Fire-rated ceiling assemblies are also a possibility, but are generally more difficult and costly to achieve a rated assembly. Because of the configuration of many small chord and web members, in addition to the relatively close spacing, spray-applied application of fire protection to steel joists is often difficult and costly, Gustafson explained. "A costly membrane protection system is often the resulting choice if joist systems are used," he said. "Steel beam systems, with closed sections and relatively fewer pieces at greater spacing will almost always use a spray applied fireproofing, usually resulting in a more economical installation."

Layout of the plan may also be an important factor in the selection of one system over the other. Steel joist systems are not as accommodating as beam systems in providing for non-typical conditions such as large shaft openings, multiple carrying beam configurations, or non-typical column spacing. Joists are best used in a rhythmic pattern layout that can accommodate close spacing of members with only small vertical penetration requirements and are subjected to relatively light loads, according to Gustafson.

Another difference between joist and beam systems is the method of design. Joist systems are load specified (where the manufacturer does the design of the components). The design thus becomes a split-responsibility function, necessitating close coordination between the manufacturer's designer and the EOR for the project. This is especially critical when non-uniform load conditions are a part of the layout. The design professional representing the project owner typically designs steel beam systems. However, this is not as much an economic consideration as it is a suitability consideration for the specific application, Gustafson explained. ★

## HSS Readily Available in 2005

**H**ollow structural sections (HSS) are more available now than in recent past, according to **Tom Muth**, Vice President of Marketing and Sales for Copperweld, one of the nation's largest producers of HSS. "The worst availability problems occurred in the second and third quarters of 2004 when inventories were at their lowest levels in 10 years. Since the fourth quarter last year, inventories have returned to near-normal levels." Muth doesn't expect HSS availability to be an issue in 2005.

"The rise in HSS prices in 2004 was steeper than the rise in wide-flange prices because tubing increases were driven by steep increases in hot-rolled coil," continued Muth. Tubing producers use hot-rolled coil to form HSS.

The price news isn't all bad, however. HSS is typically sold on a per-foot basis, according to **Bill Wolfe**, Executive Director of the Steel Tube Institute of North America (STI), with larger shapes costing more per pound than smaller ones.

"The gap in prices between small and large sections has narrowed over the past ten years," said Muth. Industry economies have reduced the "spread" in prices between larger and smaller HSS.

And, while the price per pound of HSS is higher than the price per pound for wide-flange shapes, there are other economies that

need to be factored-in when making such a comparison, according to Muth. For example, HSS shapes are generally lighter (as much as 40% lighter, according to Wolfe) than their wide-flange counterparts. Weight savings reduce handling, transportation, and erection

**"Since fourth quarter last year, HSS inventories have returned to near-normal levels."**

costs—and reduce foundation costs (lighter members) and painting costs (less surface area).

The popularity of exposed structural steel has increased awareness of another less obvious benefit of HSS members: with less surface area and a closed cross section, HSS members accumulate less dirt—and have less surface area to maintain.

However, HSS connections are often more complex and expensive than wide-flange connections. According to **Brett Manning**, chief engineer for the Herrick Corporation, standard practice in some U.S. regions calls for stiffeners in HSS-to-HSS connections, which adds to fabrication costs.

When using HSS, economical design can

balance material costs, according to Manning.

"If you're going to use HSS, optimize the connection design to minimize the shop and field labor, and help offset the material cost," he said.

He suggested that engineers refer to the AISC *Hollow Structural Sections Connections Manual* to optimize connections (available online at [www.aisc.org/publications](http://www.aisc.org/publications)).

"The guide simplifies connections to make HSS more useful," Manning said. "It gives engineers the tools to design the most economical connection and provides background information."

"If engineers use the tools available to optimize connections, HSS will close the gap on being competitive," he concluded.

The 2005 AISC *Specification for Structural Steel Buildings* (available April 2005) also contains a new chapter, "Design of HSS and Box Member Connections," which covers HSS truss-type welded connections.

"It should be no more difficult to connect HSS than any other open section," said **Jefrey Packer**, Ph.D., Professor of Civil Engineering at the University of Toronto.

The only likely exception, according to Packer, is a round tubing connection in a truss-type application because round-to-round welded connections require end profiling of the tube members. ★

## Hot Rolled Material Status Report

**O**ne of the pernicious myths that emerged during the recent round of steel price hikes was that structural steel was in short supply. For most wide-flange sections, that was never true and steel remains easily available, explained **Mike Engestrom**, Technical Marketing Director for Nucor-Yamato Steel Co. "At the current time, rolled shapes are typically available in four weeks or less."

**Lourenco Goncalves**, President and CEO of Metals USA, one of the nation's leading service centers, anticipates a strong year for wide-flange sections.

"Wide-flange beams were one of our most important items for the entire year of 2004," Goncalves said. "I believe that wide-flange will have another good year in 2005."

According to Goncalves, Metals USA has strong inventory of wide-flange sections and carries all sections usually marketable in the United States.

A major service center on the East Coast

reported that wide-flange beams are readily available both at the mill level and the service center level, and prices are extremely competitive, with large W-sections up to 40" in stock.

Goncalves anticipates a strong market for plate in the year ahead, as well. "Currently, Metals USA is in a position to supply plates to the marketplace," Goncalves reported.

"We are doing well in all types and sizes," he continued. "Especially in very heavy plate, we are very well-positioned."

The East Coast service center reported that there is no plate inventory at the mill level. The center is buying on a month-to-month basis from the mills with certain restrictions. Prices for plate remain firm.

According to **Joseph Anderson**, Vice President of Sales and Marketing for PDM Steel Service Centers, Inc., availability of plate less than 3" is plentiful. Prices for plate under 3" have been firm, but are softening. For plate above 3", availability is very limited and prices are on a job-by-job basis, Anderson said.

In regards to larger sections, Anderson reported that any section over 426 lb/ft is hard to come by. However, sections 40" deep and less are readily available.

An alternative to very large built-up members for columns are rolled W40 and W44 shapes weighing more than 500 lb/ft, available from Arcelor International America, which also produces a range of shapes W14 and larger.

According to **Greg DePhillis**, Vice President and General Manager of Structural Shapes for Arcelor International America, these W40 and W44 sections are available through Arcelor in Gr.65, which is highly weldable and could cut other costs. "You save a lot in pre-heating," he said. "It saves a lot in time and gas, particularly in field welding."

**Georges Axmann**, Technical Marketing Manager for Arcelor International America, said these shapes are available with normal lead times of approximately 10 weeks, though small quantities are available in inventory. ★

## Castellated Beams Offer Weight Advantage

According to **Billy Milligan**, Vice President of SMI Steel Products, the economy between a castellated beam and a conventional wide-flange beam is dependent on span and loading conditions. Generally, castellated beams will provide economic benefit on spans over 38' in a typical office building structure.

"If you look at the various building types, some lend themselves to short-span applications and some to long-span applications," Milligan said. "We are seeing the construction industry (building owners/AE firms) change from traditional spans of 30' to 40' and push the envelope of 45' to 60' of clear span. This is where the castellated beam provides the most economy."

According to Milligan, a series of studies conducted by SMI show that as the price of wide-flange raw material increases, castellated beams become economical at shorter spans. In terms of office spans and loading criteria, castellated beams become more economical over the 38' to 40' range.

"The castellated beam is saving steel weight, which translates into dollars," he said. "With the volatility of scrap prices today, the

savings in cost for castellated beams over traditional wide-flange are very significant," he said.

"It takes approximately two man hours to convert a beam from raw wide-flange to castellated," Milligan explained. "You have to save enough material to pay for those man hours, and for spans larger than 40' the weight savings are significant."

At spans shorter than 30', the material weight savings are generally not enough to overcome the labor required, according to Milligan. Spans between 30' and 38' should be analyzed on a project-by-project basis, as they are dependent on the specific project's loading and serviceability requirements, he said.

"As material prices increase, the cost savings increase," he said. "In general, the weight savings are about 40%." This translates into a cost savings of about 10% for short spans and 25% for larger spans, according to Milligan.

This cost savings can make a particular difference in construction of parking structures.

"Parking garage spans are generally in the 60' span range," Milligan said. "With wide-flange, you're looking at a W30x90 or W27x84 minimum. With castellated members, you can

use a CB30x50 member (50 lb) for the same span and the same load carrying capabilities—that's almost 50% weight savings at that span," he concluded.

Castellated beams can save on the overall cost of the finished building itself, however.

"We're on the borderline of being economical on structural costs alone," Milligan said.

"Depending on the structure design, it does have utility value."

Milligan said he has seen cases where installing HVAC systems through castellated beams lowered floor-to-floor heights by 1' per floor. This will reduce building façade, resulting in cost savings for the overall building costs, he said.

"By getting the floor-to-floor heights down in the 11'-6" range, we are better prepared to compete with concrete structures on an even playing field," Milligan said. "Approximately 50% of our work each year is a direct replacement of structures that were originally designed in concrete. This translates not only into castellated beam fabrication, but also more market share for the fabricators of the remainder of the structure in girder beams, columns, and miscellaneous steel." ★

## Extended Connections vs. Coped Beams

The decision between an extended shear plate connection and a coped beam is a balance between the cost of eliminating the beam cope versus the cost of additional bolts that may be required in the design of an extended connection, according to **M. Thomas Ferrell**, President of Ferrell Engineering, Inc.

Filler beams represent the largest quantity of members on most projects. According to Ferrell, using extended shear plate connections for these members can lead to a significant reduction in the cost of the overall project. "Both the shop labor required for coping the beams, along with material handling costs, may be eliminated when using extended shear plate connections," he said.

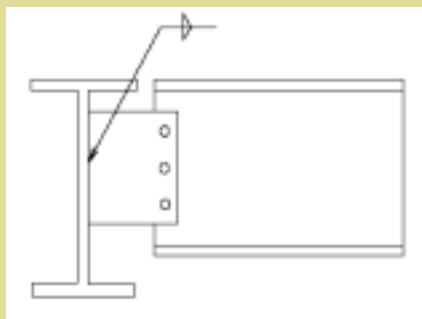
However, additional costs potentially associated with extended shear plate connections may make coped beams the economical choice, according to Ferrell.

"It's not just the cost of the bolts alone, it's the cost of additional bolts—plus the field installation of these bolts—that must be

compared to the cost of coping the beam," he said.

Whether bolts are required to be slip-critical or snug-tight is another factor that can increase the cost of the extended shear plate connection, he explained.

Added shop costs for the plate material and punching for the additional bolts for the extended shear plate connection, however, is minimal. ★



Typical extended plate connection.