Steel Interchange

Steel Interchange is an open forum for *Modern Steel Construction* readers to exchange useful and practical professional ideas and information on all phases of steel building and bridge construction. Opinions and suggestions are welcome on any subject covered in this magazine. If you have a question or problem that your fellow readers might help you to solve, please forward it to *Modern Steel Construction*. At the same time, feel free to respond to any of the questions that you have read here. Please send them to:

Steel Interchange
Modern Steel Construction
One East Wacker Dr., Suite 3100
Chicago, IL 60601-2001

Answers and/or questions should be typewritten and double-spaced. Submittals that have been prepared by word-processing are appreciated on computer diskette (either as a Wordperfect file or in ASCII format).

The opinions expressed in *Steel Interchange* do not necessarily represent an official position of the American Institute of Steel Construction, Inc. and have not been reviewed. It is recognized that the design of structures is within the scope and expertise of a competent licensed structural engineer, architect or other licensed professional for the application of principles to a particular structure.

Information on ordering AISC publications mentioned in this article can be obtained by calling AISC at 312/670-2400 ext. 433.

The following responses from previous Steel Interchange columns have been received:

When was the Vierendeel truss first utilized, why was it named, and for what contributions to structural engineering was he/she recognized?

The Vierendeel truss appears to have been developed in the early 1800's but was not commonly known until early in this century. During the 1800's, there was wide experimentation in the design of bridges, mostly for railroad expansion. Engineers of the day developed new structural configurations and used relatively new materials (such as cast iron) in their designs in order to increase spans and improve structural safety and economy. The first use of what is known today as a Vierendeel truss appears to have been in the cast-iron bowstring design of the Bergues Bridge proposed in 1829 by Guillaume Henri Dufour, the French engineer. The design called for a cast-iron, plate-girder arch with a timber deck suspended from the arch. The characteristic Vierendeel geometry was achieved by providing rectangular openings in the web of the arch sections as they were cast. This concept appears to have evolved from the previously successful use of block-shaped iron cages called voussoirs (after their masonry counterparts) in arched bridges. Later, the pierced-plate design was used for a bridge in Ghent by two Belgians named Marcellis and Duval in about 1844. Arthur Vierendeel, also a Belgian, popularized the form at the start of this century. Today, the term Vierendeel truss has lost its historical origin and is used to describe a specific structural geometry without regard for materials selection and construction method. A similar generalization has occurred with other common truss configurations attributed to Fink, Howe, Pratt, and Warren. Additional information regarding the work of Vierendeel can be found in the following references:

Elton, J. (1982), *Bridges, Docks and Harbours with Related Works*, London, Catalogue 45, B. Weinreb Architectural Books Ltd.

Peters, T. F. (1987), *Transitions in Engineering*, Boston, Birkhauser Verlag.

Vierendeel, A. (1903), *La Construction architectural en fonte*, fer et acier, Louvain.

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When asked to design a temporary bracing system for steel beams and columns during the erection phase of construction, what loads are used and what factors of safety are employed for the bracing and its connections?

A 96-member committee of ASCE, under the writer's chairmanship, has been developing the ASCE Guide/Standard for Design Loads on Structures During Construction. Along with dead and live loads, the document deals with environmental loads at short-term exposures and construction loads due to various activities. It specifies maximums as well as point-of-time values of construction loads in various combinations. It is the first ever comprehensive document to specify design loads, load factors and load combinations for structures during their construction phases and for temporary structures in construction. A preliminary working draft was issued for comments in February, 1993. The document is expected to be ready for balloting by the ASCE standards committee later this year, and issued as an ASCE Guide or Standard in 1995.

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When designing using the ASD manual, what is the allowable weak axis bending stress on channel?

In the AISC, Manual of Steel Construction, ASD, 9th Edition, the basic allowable bending stress on any laterally stable or adequately braced member is $F_b = 0.6(Q)F_y$ where "Q" is a local buckling reduction factor given in Appendix B. This is true for both major and minor axis bending. AISC classifies sections into three basic categories. "Compact", "Non-compact" and "Slender-Element" (Section B5). The bending allowable depends on which of the three categories the section falls into, as well as the lateral stability of the section. The slenderness of the individual elements that comprise the shape, as measured by width to thickness ratios, determines into which of the three categories the shape falls, (Section B5, Table B5.1). Broadly speaking the three categories may be thought of as follows:

"Compact sections" are those in which the section's elements are proportioned such that the full plastic moment, $M_p = F_y(Z_x)$, may be reached prior to local buckling.

"Non-Compact sections" are those sections whose elements are proportioned such that the full yield moment, $M_y = F_y(S_x)$, may be reached prior to local buckling.

"Slender Element sections" are those sections whose elements are subject to local buckling at a moment below the yield moment.

A reduction in the allowable bending stress is required for sections which are unstable, either laterally or torsionally, between their brace points. This is reflected in the Section F1.3, equations F1-6, F1-7, and F1-8. Since channels bent about their minor axis and loaded through their shear center are not subject to lateral-torsional buckling, equations F1-6, F1-7, and F1-8 are not applicable to them.

For "Compact sections" with shape factors, Z_y/S_y, greater than 1.10 AISC allows for a 10 percent increase in bending allowable, ($F_b = 0.66F_y$). Since the shape factor for most channels bent about their minor axis is in excess of 1.5, and the flanges of channels tend to be short and thick, nearly all "C" and "MC" channels will qualify as compact sections. Therefore, my recommendation is that channels bent about their minor axis should be designed with the following allowable stresses:

"Compact" channels bent about their minor axis and with shape factors in excess of 1.10, may be conservatively designed with an allowable bending stress of $F_{by} = 0.66F_y$.

"Non-compact" channels bent about their minor axis should be designed for $F_{by} = 0.6F_y$.

"Slender-Element" Channels bent about their minor axis should be designed for $F_{by} = 0.6(Q)F_y$.

Although justification exists for the use of $F_{by} = 0.75F_y$ for compact channels bent about their minor axis, as is done with wide flange sections, it is my recommendation that the more conservative compact section value of $F_{by} = 0.66F_y$ be used. Since channels are not doubly symmetric, the shape factor for channels bent about their minor axis tends to be more variable than for minor axis wide flange beams. The above is also consistent with allowable bending stresses for compact, non-compact, and slender elements given in the *Specification for Allowable Stress Design of Single-Angle Members*, Part 5 of the Manual.

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New Questions

Listed below are questions that we would like the readers to answer or discuss. If you have an answer or suggestion please send it to the Steel Interchange Editor, Modern Steel Construction, One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001.

Questions and responses will be printed in future editions of Steel Interchange. Also, if you have a question or problem that readers might help solve, send these to the Steel Interchange Editor.

Are there special design rules and specifications for steel structures that will be in a "low" temperature area? Is the AISC *Specification for Structural Steel Buildings* appropriate for all temperatures?

What fatigue category should be used for a steel beam-to-column moment connection when the beam flanges have full-penetration welds to the column?

In a structure that has tubular columns, should weep holes be added at the bottom of the columns in order to drain any water in the column?