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 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
1 East Wacker Dr.
Suite 3100
Chicago, IL 60601

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).

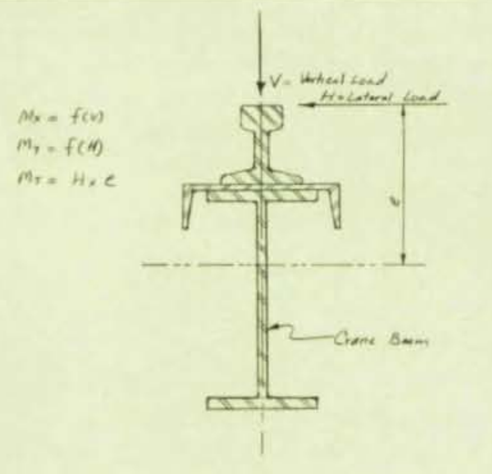
The opinions expressed in *Steel Interchange* do not necessarily represent an official position of the American Institute of Steel Construction, Inc. and have not been reviewed. It is recognized that the design of structures is within the scope and expertise of a competent licensed structural engineer, 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 to questions from previous Steel Interchange columns have been received:

Under what circumstances does the designer have to consider torsion in the design of a beam?

An example of torsion in the design of a beam would be a beam supporting crane runways. According to the AISC Manual, the lateral force on crane runways (20% of the sum of the weights of the lifted



TYPICAL CRANE RUNWAY BEAM
FIGURE 1

load and of the crane trolley) is applied at the top of rail. This horizontal force (see Figure 1) will result in a moment in the weak axis (M_y) and a torsional moment (M_t = He). In absence of the torsional moment, the beam would be checked for combined stresses as follows:

$$f_b = f_{bx} + f_{by}$$
$$= \frac{M_x}{S_x} + \frac{M_y}{S_y}$$

where M_x is the moment in the strong axis caused by gravity loads

To include the effect of torsion, complex calculations can be performed. Or, a simple procedure for handling torsional moment, for a simply-supported beam would be to halve the I_y (or double M_y) since the horizontal load is acting on one flange. Thus the total combined stresses can be calculated as follows, and compared with the allowable bending stress:

Total bending stress

$$= \frac{M_x}{S_x} + \frac{M_y}{S_{y/2}} = \frac{M_x}{S_x} + \frac{2M_y}{S_y}$$

This approximate method can be applied safely to relatively short members because results will be overly conservative in case of long spans.

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How can one take into account blast effects in the design of steel structures?

I am certain that the recent bombing of the World Trade Center in New York has generated a substantial amount of interest in this subject. Obviously, a great deal of local failures occurred in the vicinity of the explosion, but when considered as a whole, the structure performed admirably. One concept that must be grasped, is that the structure will have to absorb a tremendous amount of energy, in a very short period of time. Pressures in the immediate vicinity of the detonation can reach into the thousands of psi, and last for fractions of a millisecond. There are a number of important parameters that must be examined before one can dive headlong into the study of structural response to explosive incidents. For example:

- What type of explosion is being considered? In addition to high explosives, such as TNT or some of the other common energetic materials used by the military, a structure can be subjected to a gas or vapor explosion; dusts, such as coal or grain; or, rupture of a pressure vessel, such as a boiler. Each of these incidents have distinctive "pressure-time" history relationships. which influence the magnitude and duration of the loading and the response of the structure. Although each of these occurrences exhibit a loud "bang", which we experience as an "explosion", accompanied by heat, fireball, smoke, flying debris, etc., they are actually quite different.

- Where does the load originate? Does the explosion come from within the structure, or is it external? If the explosion occurs from within, a residual gas pressure, with a duration substantially longer than the initial pressure pulse, is formed, adding to the total energy the system must absorb. This gas pressure must be vented through the openings in the structure, similar to the air escaping from the neck of an open balloon. For an explosion external to the structure, the gas pressure does not form, making the loading less demanding. What does become a concern is the orientation of the element under investigation with respect to the source of the explosion. If the shock front passes parallel to the element under consideration, the peak pressure is substantially less than if the shock front hits normal to the element.
- What type of support conditions are present in the structure? This will affect how rapidly the system responds to the loading, and hence, how much load the system will experience. What about fragments? Small, shrapnel sized primary fragments generated from the explosives' casings can reach velocities similar to those created by high powered rifles. Light metal panels, curtain walls, even masonry walls, will provide little resistance to these fragments. Large, relatively slow moving secondary fragments can be "chunks" of concrete, masonry, steel columns, bolts, building furnishings, etc., and cause gross structural damage.

The subjects that could be discussed regarding the behavior of steel structures under blast loading can and have filled volumes on the subject. Several good texts exist on the topic, the great majority of them the result of research conducted by the Department of Defense. Of particular note is TM 5-1300, "Structures to Resist the Effects of Accidental Explosions, Vol. 5, Structural Steel Design." This volume, together with its five companion manuals, serves as a basis for the analysis, design, and detailing of structures under blast loading.

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If a pin hole in a lifting lug is flame-cut, should the net section be reduced to compute the capacity of the lug?

The author of the question is concerned with tension failure at the sides of the hole. This is the only one of four possible lug plate failure modes which would be influenced by the method of producing the hole. An electronic or template-guided cut, when made in the shop under controlled conditions using oxy-fuel or plasma, will produce a clean, well-finished cut. A careful ironworker can manually produce a satisfactory hole. The heat affected zone bordering the cut has no mere adverse affect that does that bordering a weld, and should not be a concern in lug design.

However, pin holes are often required to be burned or enlarged in the field under adverse conditions. Such holes are apt to be irregular and have sizeable notches. If the notches are in the sides of the hole where the tension stresses are highest, problems could develop.

It should be remembered that lifting lugs are a fracture critical part of the load path. They are often overloaded and abused. It is prudent to make sure their strength is adequate. A lifting lug accounts for such a small portion of the overall steel weight that it is unwise to skimp on the design.

Further information on lug design and references can be gotten from "Design and Construction of Lifting Beams", Engineering Journal, 4th Quarter 1991 (Vol. 28, No. 4)

David T. Ricker, P.E.
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If a pin hole in a lifting lug is flame-cut, should the net section be reduced to compute the capacity of the lug?

It appears that the difference between machining and flame cutting is a factor. "Design of Machine Elements", M. F. Spotts, 4th Edition, Prentice-Hall, 1971 implies a surface hardening because of the flame cut.

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New Questions

If you have an answer or suggestion for one of the questions listed below, 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 any references on designing composite columns made up of wide-flange shapes encased in concrete to form a round column?

A tubular shape is used to support a sign, the closed shape is very torsionally stiff and the design works. However, an access hole is needed in the column which creates an open shape that is not resistant to torsion. How big an access hole can be used before torsion must be considered?