Selecting Laterally Unsupported Beams of Least Weight

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The Load and Resistance Factor Design Specifications for laterally unsupported beams are far easier for the designer to use than were the previous allowable stress design provisions, for those cases in which C_b, the bending coefficient dependent upon moment gradient, is not equal to 1.0. This is due to the fact that C_b is used in LRFD as a linear multiplier of nominal moment resistance in all of the lateral-torsional buckling formulas, with, of course, the restriction that the final value of nominal moment resistance must not exceed M_p, the plastic bending moment.

Figure C-F1.1 on page 6-158 in the LRFD Manual[1] (reproduced here) is a graphical representation of the last sentence in the paragraph above.

On pages 3-57 to 3-102 of the manual, graphs of the Design Moment (ϕM_n, the factored nominal moment resistance) are plotted for the usual commercial beams having values of $F_y = 36$ ksi and 50 ksi, using $\phi = 0.9$ and $C_b = 1$. These graphs make it possible to select the lightest beam for these conditions when the required flexural strength and unbraced length are known. Example 1 on page 3-55 of the manual illustrates the procedure.

When C_b is not equal to 1.0, replotting all the graphs can be avoided by reducing the required flexural strength M_u by dividing it by C_b, rather than multiplying the moment resistance by C_b. Then the graphs can be entered with this new effective moment and unbraced length. The upper limit on design moment of ϕM_p must still be observed, so any beam selected must be checked to be sure that ϕM_p is greater than the unreduced required flexural strength. If this check were not performed, there would be cases in which points under the dotted line in Fig. C-F1.1, but above the solid line for the given C_b (2.3 in the figure), would erroneously and dangerously be said to represent safe combinations of moment and unbraced length.

Example 2 on pages 3-55 and 3-56 illustrates the procedure described above. Unfortunately, the W21×62 section selected is not really the lightest.

An alternate procedure can be used which is more likely to result in the selection of the lightest section, and no more effort is required. Proceed in this fashion after M_u of 352 kip-ft and $M_{effective}$ of 201 kip-ft are found in Example 2:

(1) With the required $\phi M_p = M_u = 352$ kip-ft, enter the Load Factor Design Selection Table for Shapes Used As Beams on page 3-15. Observe that a W24×55 (in boldface type) is the lightest acceptable section in the absence of lateral-torsional buckling. THIS PROVIDES A LOWER BOUND FOR THE WEIGHT OF THE OPTIMAL BEAM.

(2) Check to see whether the point representing the effective moment (201 kip-ft) and unbraced length (15 ft) is under the curve for a W24×55. On page 3-70, it is, and the section is the lightest.

Of course, instead of using the table in Step (1), the graphs could be entered with design moment of 352 kip-ft and unbraced length of zero. Doing this on page 3-68 also gives W24×55 as the trial section for Step (2).

An ancillary benefit of either version of this alternate procedure is that the selection of the trial section is made either in the table or on the verticle axis of the graphs, rather than in the often cluttered body of the graphs. The customary indicators of optimality in beam selection (boldface type in the table, solid rather than dotted curves in the graphs) serve only as useful guides and must be used with discretion when beams are laterally unsupported and C_b is not equal to 1.

REFERENCES

1. American Institute of Steel Construction, Inc., "Load and Resistance Factor Design (LRFD)," *Manual of Steel Construction,* 1st ed., Chicago: AISC, 1986.

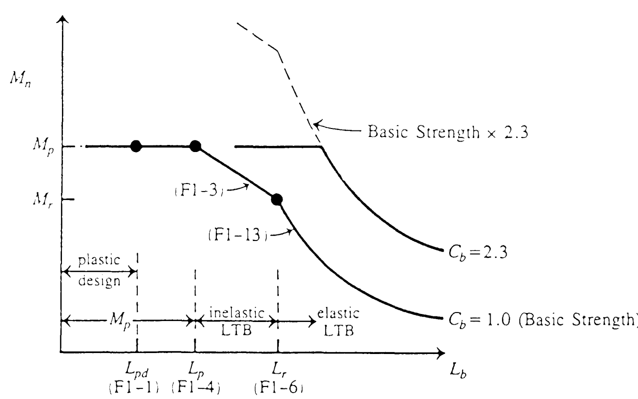

Fig. 1. Nominal moment as a function of unbraced length and moment gradient.

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