CLOSURE

Improved Shear Strength of Webs Designed in Accordance with the LRFD Specification

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The writer welcomes the comments of Professor Ellifritt on the paper, and the interest he has shown. Many contemporary advanced limit states codes (or LRFD codes) now permit a rational analysis to be undertaken in lieu of prescribed approximate formulae, and although it would probably be inappropriate to place design curves of the nature of those in the paper into design standards, a designer can nonetheless make recourse to such figures as presented, for example, in the present paper.

As stated by Professor Ellifritt, it is the prime objective to reduce the number of stiffeners, and there is no doubt that this can be achieved by using more accurate (and less conservative) k_v values. It is true that the example presented was not the best illustration of the savings. Although the web is rather "stocky" with an h / t_w of only 90, the example illustrates that use of the LRFD formulae predict that the web is not stocky in the sense that it is governed by the intersection of yielding and buckling. On the other hand, the proposed method shows that the web is in fact stocky, in the sense that it will yield before any buckling effects are present. The corollary is that in theory stiffeners spaced as close as at 60-in. centers do not mobilize the full yield capacity of the beam in accordance with the LRFD Specification, while in fact the proposed method will allow a larger stiffener spacing while maintaining the full yielding capacity of the girder in shear. Assuming a span to depth ratio of 10, the maximum factored distributed load is 10.5 k/ft and of course the shear capacity exceeds that caused by this load. At the ends of such a beam, the shear is at a maximum and the moment zero, and vice versa at midspan. However there are regions of the beam where the interaction of shear and bending are important, and this would be of more significance in a beam loaded with a concentrated load rather than with a uniformly distributed load.

If one wants to be more realistic and place the stiffeners in the same cross-section at 100-in. centers, then it can be shown that $k = 10.1$ from the rational approach and that

$$(h / t_w)\sqrt{F_{yw} / k} = 170 < 187$$

so again the web yields before buckling. On the other hand, the LRFD Specification predicts $k = 5.65$, so that

$$(h / t_w)\sqrt{F_{yw} / k} = 227 > 187$$

and the web is in the "interaction" zone. The LRFD value of $\phi_v V_n$ is then 230 kips which is only 82 percent of the design capacity calculated rationally. With a concentrated load, the interaction of shear and bending where these actions are high would certainly demonstrate the advantage of the proposed method over the LRFD method in the spacing of stiffeners.

In conclusion, although the design example presented does not properly illustrate the advantages of the proposed k values over those predicted in the LRFD Specification, it is clear that enhancing the local buckling coefficient will lead to economies in the number of stiffeners required on a plate girder. The writer does not disagree with Professor Ellifritt that the example given is not wholly convincing of this. Finally, although it was pointed out that the denominator in Equation 8 should not be squared, the numerical example is consistent with the denominator not being squared.

NOTES