A Technical Note: A Direct Method for Obtaining the Plate Buckling Coefficient for Double-Coped Beams

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The AISC LRFD 3rd Edition *Manual of Steel Construction* (AISC, 2001), hereafter referred to as the AISC Manual, presents a procedure for deep and unequal depth top and bottom coped beams which extends the procedure of the AISC LRFD 2nd Edition *Manual of Steel Construction* (AISC, 1994), which was limited to shallow ($d_c \leq 0.2d$), approximately equal depth top and bottom copes. This new procedure involves an interpolation of values from a table to determine the plate buckling coefficient. It is the purpose of this note to present a formula for the plate buckling coefficient which eliminates this interpolation.

FORMULATION

The AISC Manual (AISC, 2001) gives a procedure on page 9-9 for buckling of deep ($d_c > 0.2d$) and unequal depth ($d_{c\ top} \neq d_{c\ btm}$) copes (see the list of symbols in the appendix) as follows.

The design buckling stress ϕF_{cr} is

$$\phi F_{cr} = 0.9 F_y Q$$

where

$Q = 1$ for $\lambda \leq 0.7$

$= 1.34 - 0.486\lambda$ for $0.7 < \lambda < 1.41$

$= 1.30/\lambda^2$ for $\lambda > 1.41$

and

$$\lambda = \frac{1}{167}\sqrt{\frac{F_y}{k}}\left[\frac{h_o}{2t_w}\right] \qquad (1)$$

In Equation 1, k, the plate buckling coefficient, must be found by interpolation in Table 1, using the column labeled AISC. These values were scaled from a curve produced by Gerard and Becker (1957), who also gave a formula for k as,

Table 1
Comparison of *k* values

$2c/h_o$	AISC	Eq. 2
0.25	16	16.4
0.3	13	11.5
0.4	10	6.68
0.5	6	4.43
0.6	4.5	3.20
0.75	2.5	2.20
1	1.3	1.43
1.5	0.8	0.870
2	0.6	0.676
3	0.5	0.537
4	0.425	0.488
∞	0.425	0.425

$$k = \frac{6}{\pi^2}\left[(1-\nu) + \frac{(\pi bm/a)^2}{6}\right] \qquad (2)$$

where

$b = h_o/2$

$a = c$

$m = 1.0$ for a plate simply supported along both loaded edges with one unloaded edge and free along the other unloaded edge

The values for k from Equation 2 are also shown in Table 1, which shows good agreement between the scaled values and the computed values. Equation 2 can therefore be used to replace the interpolation required in the current AISC procedure.

A further simplification of the AISC Manual procedure can be achieved by substituting Equation 2 into Equation 1, which gives

$$\lambda = \frac{h_o\sqrt{F_y}}{t_w\sqrt{47{,}500 + 112{,}000\left(\frac{h_o}{2c}\right)^2}} \qquad (3)$$

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APPENDIX

Symbols

a = length of plate parallel to the compressive force, denoted as c

b = width of plate perpendicular to the compressive force, denoted as $h_o/2$

d_c = depth of cope

h_o = reduced beam depth

$d_{c\ top}$ = depth of top cope

$d_{c\ btm}$ = depth of bottom cope

k = plate buckling coefficient, dependent on aspect ratio and boundary conditions of plate

m = number of half sine waves in buckled plate at minimum compressive stress (m=1 for a plate simply supported along both loaded edges with one unloaded edge and free along the other unloaded edge)

t_w = thickness of plate

E = modulus of elasticity (29,000 ksi for steel)

F_{cr} = critical buckling stress

F_y = yield stress

υ = Poisson's ratio (0.3 for steel)

REFERENCES

AISC (2001), *Load and Resistance Factor Design Manual of Steel Construction*, 3rd Edition, American Institute of Steel Construction, Chicago, p. 9-9.

AISC (1994), *Load and Resistance Factor Design Specification for Structural Steel Buildings*, 2nd Edition, American Institute of Steel Construction, Chicago, pp. 8-228, 229.

Gerard, G. and Becker, H. (1957), *Handbook of Structural Stability Part 1—Buckling of Flat Plates*, NACA TN 3781.