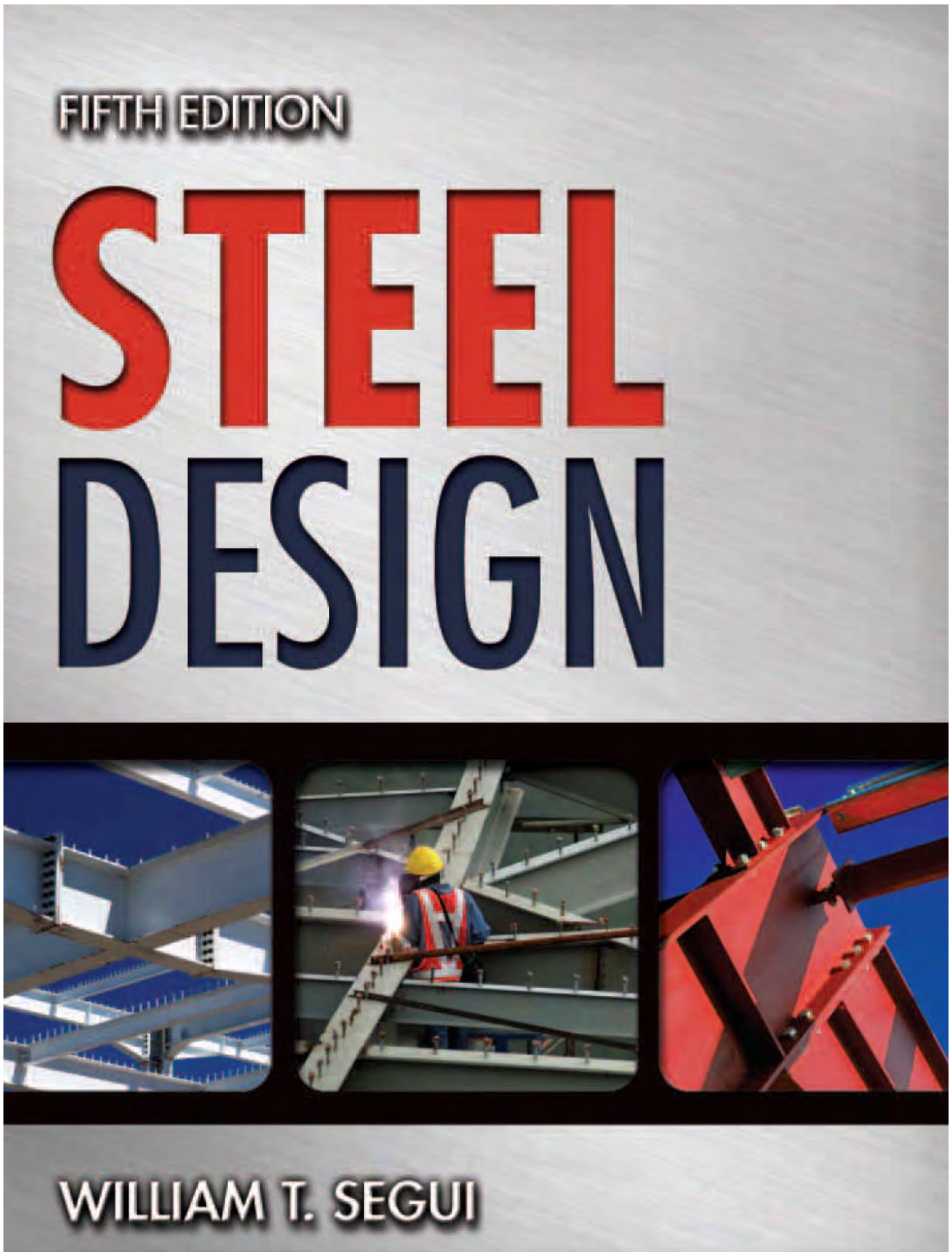
An Instructor's Solutions Manual to Accompany

STEEL DESIGN, 5th Edition

WILLIAM T. SEGUI



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INSTRUCTOR'S SOLUTIONS MANUAL

TO ACCOMPANY

STEEL DESIGN

FIFTH EDITION

William T. Segui

Contents

PREFACE

This instructor's manual contains solutions to the problems in Chapters 1–10 of *Steel Design, 5th Edition*. Solutions are given for all problems in the Answers to Selected Problems section of the textbook, as well as most of the others.

In general, intermediate results to be used in subsequent calculations were recorded to four significant figures, and final results were rounded to three significant figures. Students following these guidelines should be able to reproduce the numerical results given. However, the precision of the results could depend on the grouping of the computations and on whether intermediate values are retained in the calculator between steps.

In many cases, there will be more than one acceptable solution to a design problem; therefore, the solutions given for design problems should be used only as a guide in grading homework.

I would appreciate learning of any errors in the textbook or solutions manual that you may discover. You can contact me at wsegui@memphis.edu. A list of errors and corrections in the textbook will be maintained at http://www.ce.memphis.edu/segui/errata.html.

William T. Segui
August 15, 2011

CHAPTER 1 - INTRODUCTION

1.5-1

(a) $P = 20(67) = 1340 \text{ lb}$

$$f = \frac{P}{A} = \frac{1340}{19.7} = 68.02 \text{ psi} \qquad \underline{f = 68.0 \text{ psi}}$$

(b) Since $E = \frac{f}{\epsilon}$,

$$\epsilon = \frac{f}{E} = \frac{68.02}{29{,}000{,}000} = 2.35 \times 10^{-6} \qquad \underline{\epsilon = 2.35 \times 10^{-6}}$$

1.5-2

(a) $L = 9/\sin 45° = 12.73 \text{ ft}$

$$\Delta L = \epsilon L = 8.9 \times 10^{-4} \times 12.73 \times 12 = 0.136 \text{ in.} \qquad \underline{\Delta L = 0.136 \text{ in.}}$$

(b) $f = \epsilon E = 8.9 \times 10^{-4} \times 29{,}000 = 25.81 \text{ ksi}$

$$P = fA = 25.81(1.31) = 33.8 \text{ kips} \qquad \underline{P = 33.8 \text{ kips}}$$

1.5-3

(a) $A = \frac{\pi d^2}{4} = \frac{\pi(0.5)^2}{4} = 0.1963 \text{ in.}^2$

$$f = \frac{P}{A} = \frac{5000}{0.1963} = 25{,}470 \text{ psi}$$

$$\epsilon = \frac{\Delta L}{L} = \frac{6.792 \times 10^{-3}}{8} = 8.49 \times 10^{-4}$$

$$E = \frac{f}{\epsilon} = \frac{25{,}470}{8.49 \times 10^{-4}} = 3.0 \times 10^{7} \text{ psi} \qquad \underline{E = 30{,}000 \text{ ksi}}$$

(b) $F_u = \frac{P_u}{A} = \frac{14{,}700}{0.1963} = 74{,}900 \text{ psi} \qquad \underline{F_u = 74.9 \text{ ksi}}$

4.8-4

(a) $P_u = 1.2D + 1.6L = 1.2(30) + 1.6(70) = 148$ kips

Try a C15 × 33.9

AISC E4(b) must be used, because this shape is nonslender and is neither a double-angle shape nor a tee shape. Check flexural buckling strength about the *y* axis (this is the axis of no symmetry for a channel):

$$\frac{K_y L}{r_y} = \frac{0.65(10 \times 12)}{0.901} = 86.57 < 200 \qquad \text{(OK)}$$

$$F_e = \frac{\pi^2 E}{(KL/r)^2} = \frac{\pi^2(29000)}{(86.57)^2} = 38.19 \text{ ksi}$$

$$4.71\sqrt{\frac{E}{F_y}} = 4.71\sqrt{\frac{29000}{50}} = 113.4 > 86.57$$

$$\therefore\ F_{cry} = 0.658^{(F_y/F_e)}F_y = 0.658^{(50/38.19)}(50) = 28.91 \text{ ksi}$$

$$P_n = F_{cr}A_g = 28.91(10.0) = 289.1\text{kips}$$

$$\phi_c P_n = 0.90(289.1) = 260.2 \text{ kips}$$

This shape may be too conservative. Try a C12 ×30.

$$\frac{K_y L}{r_y} = \frac{0.65(10 \times 12)}{0.762} = 102.4 < 200 \qquad \text{(OK)}$$

$$F_e = \frac{\pi^2 E}{(KL/r)^2} = \frac{\pi^2(29000)}{(102.4)^2} = 27.30 \text{ ksi}$$

$$4.71\sqrt{\frac{E}{F_y}} = 4.71\sqrt{\frac{29000}{50}} = 113.4 > 102.4$$

$$\therefore\ F_{cry} = 0.658^{(F_y/F_e)}F_y = 0.658^{(50/27.30)}(50) = 23.23 \text{ ksi}$$

$$P_n = F_{cr}A_g = 23.23(8.81) = 204.7\text{kips}$$

$$\phi_c P_n = 0.90(204.7) = 184.2 \text{ kips}$$

Flexural-torsional buckling strength about the *x* axis (this is the axis of symmetry for a channel):

For $L_b = 10$ ft, $L_p < L_b < L_r$, so

$$M_n = C_b\left[M_p - (M_p - 0.7F_yS_x)\left(\frac{L_b - L_p}{L_r - L_p}\right)\right] \leq M_p \qquad \text{(inelastic LTB)}$$

$C_b = 1.14$ (see Fig. 5.15 in textbook).

$M_p = F_yZ_x = 50(8.30) = 415.0$ in.-kips $= 34.58$ ft-kips

$$M_n = 1.14\left[415 - (415 - 0.7 \times 50 \times 7.31)\left(\frac{10 - 3.243}{11.22 - 3.243}\right)\right]$$

$= 319.4$ in.-kips $= 26.62$ ft-kips $< M_p$

For the y axis, since the shape is compact, there is no flange local buckling and

$M_{ny} = M_{py} = F_yZ_y = 50(2.32) = 116.0$ in.-kips $= 9.667$ ft-kips

Check the upper limit:

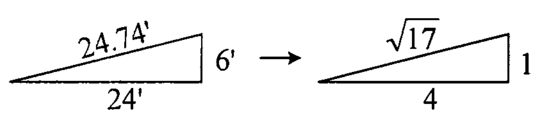
$$\frac{Z_y}{S_y} = \frac{2.32}{1.50} = 1.55 < 1.6 \qquad \therefore\ M_{ny} = M_{py} = 9.667 \text{ ft-kips}$$

(a) LRFD solution

$\phi_bM_{nx} = 0.90(26.62) = 23.96$ ft-kips, $\quad \phi_bM_{ny} = 0.90(9.667) = 8.700$ ft-kips

Roof load: Combination 3 controls.

$w_u = 1.2D + 1.6S = 1.2(40/2) + 1.6(40/2) = 56.0$ psf



Tributary width $= \dfrac{\sqrt{17}}{4}(6) = 6.185$ ft

Purlin load $= 56.0(6.185) = 346.4$ lb/ft

Component normal to roof $= w_{ux} = \dfrac{4}{\sqrt{17}}(346.4) = 336.1$ lb/ft

Component parallel to roof $= w_{uy} = \dfrac{1}{\sqrt{17}}(346.4) = 84.01$ lb/ft

$$Y2 = t - \frac{a}{2} = 4 - \frac{0.962}{2} = 3.519 \text{ in.}$$

Taking moments about the bottom of the steel, we get

Component	A	y	Ay	$\bar{I}$	d	$\bar{I} + Ad^2$
Concrete	4.71	15.519	73.094	0.00	-4.760	106.69
W12 x 16	4.71	6.00	28.26	103	-4.760	209.7
Sum	9.42		101.4			316.4

$$\bar{y} = \frac{\sum Ay}{\sum A} = \frac{101.4}{9.42} = 10.76 \text{ in.,} \qquad I_{LB} = 316.4 \text{ in.}^4$$

$$\Delta_{part} = \frac{5w_{part}L^4}{384EI_{LB}} = \frac{5(0.090/12)(25 \times 12)^4}{384(29000)(316.4)} = 8.621 \times 10^{-2} \text{ in.}$$

$$\Delta_L = \frac{5w_L L^4}{384EI_{LB}} = \frac{5(0.750/12)(25 \times 12)^4}{384(29000)(316.4)} = 0.7184 \text{ in.}$$

$$\Delta = \Delta_D + \Delta_{part} + \Delta_L = 0.9298 + 0.08621 + 0.7184$$

$$= 1.73 \text{ in.} \qquad \underline{\Delta = 1.73 \text{ in.}}$$

(b) Maximum permissible $\Delta_L = \dfrac{L}{360} = \dfrac{25 \times 12}{360} = 0.833 \text{ in.} > 0.718 \text{ in.}$ OK.

9.6-4

(a) From Problem 9.4-1, a W21 × 57 is used, with $t = 6$ in., $s = 9$ ft, $L = 40$ ft, $q_{const} = 20$ psf, $q_L = 250$ psf, A992 steel and 4 ksi concrete.

Before concrete cures:

$$\text{Slab: } \frac{6}{12}(150)(9) = 675.0 \text{ lb/ft}$$

$$w_D = 675 + 57 = 732 \text{ lb/ft}, \qquad w_{const} = 20(9) = 180 \text{ lb/ft}, \qquad I_s = 1170 \text{ in.}^4$$

$$\Delta_D = \frac{5w_D L^4}{384EI_s} = \frac{5(0.732/12)(40 \times 12)^4}{384(29000)(1170)} = 1.243 \text{ in.}$$

$$\Delta_{const} = \frac{5w_{const}L^4}{384EI_s} = \frac{5(0.180/12)(40 \times 12)^4}{384(29000)(1170)} = 0.3056 \text{ in.}$$

$$\Delta = \Delta_D + \Delta_{const} = 1.243 + 0.3056 = 1.549 \text{ in.} \qquad \underline{\Delta = 1.55 \text{ in.}}$$