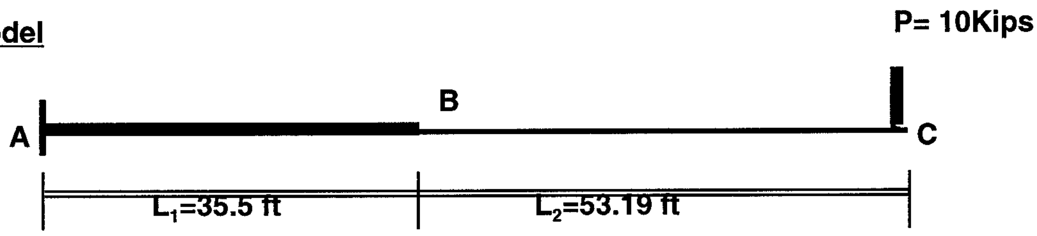
Westinghouse Design Certification Review of AP1000
Structural Review
Sample Hand Calculation of a Shear Wall Deflection
Comparison Hand Calculation with ANSYS Results Provided by Westinghouse

Model



Deflection at point C,

$$\delta_C = \delta_1 + \delta_2 + \delta_3 = \delta_1 + \theta_B L_2 + \delta_3 \cdots\cdots (1)$$

$$\delta_1 = \frac{PL_2^3}{3EI_2} + \frac{KPL_2}{A_2G} \cdots\cdots (2)$$

$$\theta_B = \frac{M_B L_1}{EI_1} + \frac{PL_1^2}{2EI_1} = \frac{PL_2L_1}{EI_1} + \frac{PL_1^2}{2EI_1} \cdots\cdots (3)$$

$$\delta_2 = \theta_B L_2 = \frac{PL_1L_2^2}{EI_1} + \frac{PL_1^2L_2}{2EI_1} \cdots\cdots (4)$$

$$\delta_3 = \frac{PL_2L_1^2}{2EI_1} + \frac{PL_1^3}{3EI_1} + \frac{KPL_1}{A_1G} \cdots\cdots (5)$$

$$\therefore \delta_C = \frac{KP}{G}\left(\frac{L_1}{A_1} + \frac{L_2}{A_2}\right) + \frac{P}{E}\left(\frac{L_2^3}{3I_2} + \frac{L_1^2L_2}{I_1} + \frac{L_1^3}{3I_1} + \frac{L_1L_2^2}{I_1}\right) \cdots\cdots (6)$$

Now,

$$\mathbf{P = 10kips, E = 57\sqrt{4000} \times 144 = 5.19 \times 10^5 ksf, G = \frac{E}{2(1+\mu)} = 2 \times 10^5 ksf,}$$

$$\mathbf{L_2 = 53.19ft, L_1 = 35.5ft, A_1 = 3 \times 37.1 = 111.3ft^2, A_2 = 2 \times 37.1 = 74.2ft^2,}$$

$$\mathbf{K = 1.2}$$

$$\mathbf{I_{g1} = \frac{1}{12} \times 3 \times 37.1^3 = 1.277 \times 10^4 ft^4, I_{g2} = \frac{1}{12} \times 2 \times 37.1^3 = 8.51 \times 10^3 ft^4}$$

Attachment 3

Using Equation (6),

$$\delta_C = \frac{1.2\times 10}{2\times 10^5}\left(\frac{35.5}{111.3}+\frac{53.19}{74.2}\right)+\frac{10}{5.19\times 10^5}\left(\frac{53.19^3}{3\times 8.51\times 10^3}+\frac{35.5^2\times 53.19}{1.277\times 10^4}+\frac{35.5^3}{3\times 1.277\times 10^4}+\frac{35.5\times 53.19^2}{1.277\times 10^4}\right)$$

$$\therefore \delta_C = 6.214825\times 10^{-5}+\frac{1}{5.19\times 10^4}(5.894393921+5.249232381+1.167811929+7.864976633)$$

$$\therefore \delta_C = 6.214825\times 10^{-5}+\frac{20.176}{5.19\times 10^4}\text{ft}$$

$$\therefore \delta_C = 6.214825\times 10^{-5}+3.88755585\times 10^{-4} = 4.50903835\times 10^{-4}\text{ft}$$

ANSYS result, δ_C=2.06X10^{-4} ft

Using M. Sozen's recommendation (J.P. Moehle, P. Monteiro, H.T. Tang, and M.A. Sozen, "Effects of Cracking and Age on Stiffness of Reinforced Concrete Walls Resisting In-Plane Shear," Proceedings of the Fourth Symposium on Nuclear Power Plant Structures, Equipment, and Piping, North Carolina State University, Raleigh, N.C., December 1992, pp. 3.1-3.13): Apply cracked moment of inertia for the flexural part only.

$$\text{Cr.Moment}, M_{cr} = \frac{I_g}{c}(f_r + f_\phi), f_r = 6\times\sqrt{f'_c} = 6\times\sqrt{4000}\times 144\div 1000 = 54.6\text{ksf}\approx 65\text{ksf}$$

$$\therefore M_{cr} = 65\frac{I_g}{c}\cdots\cdots(7)$$

$$\text{Also}, \frac{M_{cr}}{EI_{cr}} = \frac{1}{R} = \frac{\varepsilon_{cr}}{c}, M_{cr} = \frac{0.0002EI_{cr}}{c}\cdots\cdots(8)$$

$$\text{From(7)and(8)}, 65\frac{I_g}{c} = \frac{0.0002EI_{cr}}{c}, \therefore I_{cr} = I_g\times\frac{65}{0.0002E}$$

$$\therefore I_{cr} = I_g\frac{65}{2\times 10^{-4}\times 5.19\times 10^4} = 0.6262I_g,$$

$$\therefore \delta_{C_{cr}} = 6.214825\times 10^{-5}+\frac{1}{.6262}\times 3.88755585\times 10^{-4} = 6.82965\times 10^{-4}\text{ft}$$

$$\frac{\delta_{C_{cr}}}{\delta_{ANSYS}} = \frac{6.82965}{2.06} = 3.32$$

This is a substantial discrepancy that needs to be carefully examined.