Story Spring Derivation

Modified Ibarra-Medina-Krawinkler Bilinear material

ASCE 7-10 Equivalent Lateral Force Procedure

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1 Design story stiffness

The deflection of a given story x is given by equation 12.8-15 as:

$$\delta_x = \frac{C_d \delta_{xe}}{I_e} \tag{1}$$

Where δ_{xe} is the calculated elastic deflection. This is taken to be:

$$\delta_{xe} = \frac{V_x}{K_x} + \delta_{(x-1)e} \tag{2}$$

Where V_x is the design story shear (§12.8.3), K_x is the story stiffness, and $\delta_{(x-1)e}$ is the elastic deflection of the story below x. The story drift is the difference between story deflections:

$$\Delta_x = \delta_x - \delta_{x-1} \tag{3}$$

Taking Δ_x to be the allowable story drift, Δ_a, and substituting equations (1) and (2) into (3) obtains:

$$\Delta_a = \frac{C_d}{I_e}\left(\frac{V_x}{K_x} + \delta_{(x-1)e} - \delta_{(x-1)e}\right) \tag{4}$$

K_x is then solved for:

$$K_x = \frac{C_d V_x}{I_e \Delta_a} \tag{5}$$

2 Design story strength

The maximum strength of each story x, V_c, is taken as:

$$V_c = \Omega_o V_x \tag{6}$$

Where Ω_o is the system overstrength factor and V_x is the design story shear.

3 Pre-capping deflection

The design strength, V_c, is connected to the yield strength, V_y, by the parameter C_{yc}:

$$V_y = C_{yc} V_c \tag{7}$$

The deflection at yield and pre-capping deflection can now be calculated. Using linear relations and equation (7), the following equations are developed:

$$\Delta_y = \frac{V_y}{K_x} \tag{8}$$

$$\Delta_p = \frac{V_c - V_y}{a_s K_x} \tag{9}$$

These equations are evaluated for each floor x. a_s and C_{yc} are assumed to be the same for each story.

4 Post-capping and ultimate deflection

The post-capping deflection is currently defined as proportional to Δ_p:

$$\Delta_{pc} = C_{pcp} \Delta_p \tag{10}$$

The ultimate deflection is currently defined as proportional to the sum of the previously calculated deflections:

$$\Delta_u = C_{upc} \left(\Delta_y + \Delta_p + \Delta_{pc} \right) \tag{11}$$