THE EFFECTIVE FLEXURAL STIFFNESS, $(EI)_{eff}$, FOR CALCULATION OF THE CRITICAL BUCKLING LOAD, P_c, OF INDIVIDUAL COLUMNS

In consideration of slenderness effects in an individual column design by Moment Magnification Method, ACI 318-14 utilizes the effective flexural stiffness, $(EI)_{eff}$, of a column section to calculate the critical buckling load, P_c. Three sets of equations are given in ACI 318-14, 6.6.4.4.4 to calculate $(EI)_{eff}$ values as follows:

$$(EI)_{eff} = \frac{0.4E_cI_g}{1+\beta_{dns}} \qquad \text{[ACI 318, Eq. 6.6.4.4.4a]}$$

$$(EI)_{eff} = \frac{0.2E_cI_g + E_sI_{se}}{1+\beta_{dns}} \qquad \text{[ACI 318, Eq. 6.6.4.4.4b]}$$

$$(EI)_{eff} = \frac{E_cI}{1+\beta_{dns}} \qquad \text{[ACI 318, Eq. 6.6.4.4.4c]}$$

The moment of inertia of the section, I, in Eq. 6.6.4.4.4c is calculated per the formula in ACI 318, Table 6.6.3.1.1(b) for an individual column. It is incorrect to use I values from ACI 318, Table 6.6.3.1.1(a) in ACI 318, Eq. 6.6.4.4.4c as I values in ACI 318, Table 6.6.3.1.1(a) are intended to represent an overall average of moment of inertia values of EI for each member type which are used to compute frame deflections.

$$0.35I_g \le I \le 0.875I_g$$

$$\text{where} \quad I = \left(0.80 + 25\frac{A_{st}}{A_g}\right) \times \left(1 - \frac{M_u}{P_uh} - 0.5\frac{P_u}{P_o}\right) \times I_g$$

spColumn Program utilizes Eq. (6.6.4.4.4b) for the calculation of the effective flexural stiffness, $(EI)_{eff}$, of column section. The other two equations, namely, Eq. (6.6.4.4.4a), and Eq. (6.6.4.4.4c) are also permitted by the ACI 318.

Discussion on ACI 318 Design Values for $(EI)_{eff}$ for Individual Columns

ACI 318 states that Eq. (6.6.4.4.4a) is a simplified form of Eq. (6.6.4.4.4b) and therefore, is less 'accurate'. If the reinforcing steel is not yet chosen, I_{se} cannot be computed and Eq. (6.6.4.4.4a) is the only option to compute an initial value for $(EI)_{eff}$. On the other hand, ACI 318 states that Eq. (6.6.4.4.4c) provides improved accuracy in $(EI)_{eff}$ calculation. However, a more complex formula of moment of inertia, I, is required. In that formula, P_u, and M_u values from each load combination must be considered. Alternatively, enveloped values of P_u, and M_u can be used conservatively to compute the lowest value of I.

Conclusions

The designer may utilize any of the options for $(EI)_{eff}$ for individual columns in ACI 318, section 6.6.4.4.4 given the available input data at the given design stage and desired level of accuracy. spColumn Program utilizes Eq. (6.6.4.4.4b) which is more accurate than Eq. (6.6.4.4.4a) and less accurate than Eq. (6.6.4.4.4c).

References

[1] Building Code Requirements for Structural Concrete (ACI 318-14) and Commentary (ACI 318R-14), American Concrete Institute, 2014
[2] Wight J.K., Reinforced Concrete, Mechanics and Design, Seventh Edition, Pearson Education Inc., 2016
[3] Darwin D., Dolan C.W., Nilson A.H., Design of Concrete Structures, McGraw-Hill Education, 2016