CODE

24.2.3.4 Modulus of elasticity, E_c, shall be permitted to be calculated in accordance with 19.2.2.

24.2.3.5 For nonprestressed members, unless obtained by a more comprehensive analysis, effective moment of inertia, I_e, shall be calculated in accordance with Table 24.2.3.5 using:

$$M_{cr} = \frac{f_r I_g}{y_t} \quad (24.2.3.5)$$

Table 24.2.3.5—Effective moment of inertia, I_e

Service moment	Effective moment of inertia, I_e, mm^4	
$M_a \leq (2/3)M_{cr}$	I_g	(a)
$M_a > (2/3)M_{cr}$	$\dfrac{I_{cr}}{1-\left(\dfrac{(2/3)M_{cr}}{M_a}\right)^2\left(1-\dfrac{I_{cr}}{I_g}\right)}$	(b)

24.2.3.6 For continuous one-way slabs and beams, I_e shall be permitted to be taken as the average of values obtained from Table 24.2.3.5 for the critical positive and negative moment sections.

24.2.3.7 For prismatic one-way slabs and beams, I_e shall be permitted to be taken as the value obtained from Table 24.2.3.5 at midspan for simple and continuous spans, and at the support for cantilevers.

24.2.3.8 For prestressed Class U slabs and beams as defined in 24.5.2, it shall be permitted to calculate deflections based on I_g.

24.2.3.9 For prestressed Class T and Class C slabs and beams as defined in 24.5.2, deflection calculations shall be based on a cracked transformed section analysis. It shall be permitted to base deflection calculations on a bilinear moment-deflection relationship or I_e in accordance with Eq. (24.2.3.9a)

$$I_e = \left(\frac{M_{cr}}{M_a}\right)^3 I_g + \left[1-\left(\frac{M_{cr}}{M_a}\right)^3\right] I_{cr} \quad (24.2.3.9a)$$

where M_{cr} is calculated as

$$M_{cr} = \frac{(f_r + f_{pe})I_g}{y_t} \quad (24.2.3.9b)$$

COMMENTARY

R24.2.3.5 The effective moment of inertia approximation, developed by Bischoff (2005), has been shown to result in calculated deflections that have sufficient accuracy for a wide range of reinforcement ratios (Bischoff and Scanlon 2007). M_{cr} is multiplied by two-thirds to consider restraint that can reduce the effective cracking moment as well as to account for reduced tensile strength of concrete during construction that can lead to cracking that later affects service deflections (Scanlon and Bischoff 2008).

Before 2019, ACI 318 used a different equation (Branson 1965) to calculate I_e. The previous equation has subsequently been shown to underestimate deflections for members with low reinforcement ratios, which often occur in slabs, and does not consider the effects of restraint. For members with greater than 1 percent reinforcement and a service moment at least twice the cracking moment, there is little difference between deflections calculated using the former and the current Code provisions.

R24.2.3.7 The use of the midspan section properties for continuous prismatic members is considered satisfactory in approximate calculations primarily because the midspan stiffness (including the effect of cracking) has the dominant effect on deflections, as shown by ACI 435.5R, ACI Committee 435 (1978), and Sabnis et al. (1974).

R24.2.3.8 Immediate deflections of Class U prestressed concrete members may be calculated by the usual methods or formulas for elastic deflections using the moment of inertia of the gross (uncracked) concrete section and the modulus of elasticity for concrete specified in 19.2.2.1.

R24.2.3.9 The effective moment of inertia equation in 24.2.3.5 was revised in the 2019 Code. The revision is not applicable to prestressed members. Equation (24.2.3.9a) maintains the provisions of previous editions of the Code for these types of members. The *PCI Design Handbook* (PCI MNL 120) gives information on deflection calculations using a bilinear moment-deflection relationship and using an effective moment of inertia. Mast (1998) gives additional information on deflection of cracked prestressed concrete members.

Shaikh and Branson (1970) shows that the I_e method can be used to calculate deflections of Class C and Class T prestressed members loaded above the cracking load. For this case, the cracking moment should take into account the effect of prestress as provided in Eq. (24.2.3.9).