CODE

21.2.2.1 For deformed reinforcement, ε_{ty} shall be f_y/E_s. For Grade 420 deformed reinforcement, it shall be permitted to take ε_{ty} equal to 0.002.

21.2.2.2 For all prestressed reinforcement, ε_{ty} shall be taken as 0.002.

COMMENTARY

exclusive of strains due to prestress, creep, shrinkage, and temperature. The net tensile strain in the extreme tension reinforcement is determined from a linear strain distribution at nominal strength, shown in Fig. R21.2.2a for a nonprestressed member.

Members subjected to only axial compression are considered to be compression-controlled and members subjected to only axial tension are considered to be tension-controlled.

If the net tensile strain in the extreme tension reinforcement is sufficiently large ($\geq \varepsilon_{ty} + \mathbf{0.003}$), the section is defined as tension-controlled, for which warning of failure by excessive deflection and cracking may be expected. The limit $\geq \varepsilon_{ty} + \mathbf{0.003}$ provides sufficient ductility for most applications. Before the 2019 Code, the tension-controlled limit on ε_t was defined as 0.005 established primarily on the basis of Grade 420 nonprestressed reinforcement and prestressed reinforcement, with some consideration given to higher grades of nonprestressed reinforcement (Mast 1992). Beginning with the 2019 Code, to accommodate nonprestressed reinforcement of higher grades, the tension-controlled limit on ε_t in Table 21.2.2 is defined as $\varepsilon_{ty} + \mathbf{0.003}$. This expression is consistent with the recommendations of Mast (1992) for the general case of reinforcement other than Grade 420 and test data show that the expression leads to elements with adequate ductility.

One condition where greater ductile behavior is required is in design for redistribution of moments in continuous members and frames, which is addressed in 6.6.5. Because redistribution of moment depends on the ductility available in the hinge regions, redistribution of moment is limited to sections that have a net tensile strain of at least 0.0075.

If the net tensile strain in the extreme tension reinforcement is small ($\leq \varepsilon_{ty}$), a brittle compression failure condition is expected, with little warning of impending failure. Before ACI 318M-14, the compression-controlled strain limit was defined as 0.002 for Grade 420 reinforcement and all prestressed reinforcement, but it was not explicitly defined for other types of reinforcement. The compression-controlled strain limit ε_{ty} is defined in 21.2.2.1 and 21.2.2.2 for deformed and prestressed reinforcement, respectively.

Beams and slabs are usually tension-controlled, whereas columns may be compression-controlled. Some members, such as those with small axial forces and large bending moments, experience net tensile strain in the extreme tension reinforcement between the limits of ε_{ty} and ($\varepsilon_{ty} + \mathbf{0.003}$). These sections are in a transition region between compression-controlled and tension-controlled.

This section specifies the appropriate strength reduction factors for tension-controlled and compression-controlled sections, and for intermediate cases in the transition region. Beginning with the 2019 Code, the expression ($\varepsilon_{ty} + \mathbf{0.003}$) defines the limit on ε_t for tension-controlled behavior in Table 21.2.2. For sections subjected to combined axial force and moment, design strengths are determined by multiplying both P_n and M_n by the appropriate single value of ϕ.