CODE

A.7.3.4 All actions not designated as deformation controlled, ordinary force-controlled, or noncritical force-controlled shall be classified as critical-force controlled.

A.8—Effective stiffness

A.8.1 Member stiffness shall include effects of deformations due to flexure, shear, axial elongation or shortening, and reinforcement slip along its development length.

A.8.2 If cracking is anticipated as a result of combined effects of applied forces, displacements, and volume change effects associated with shrinkage, temperature, or creep, effects of concrete cracking on effective member stiffness shall be modeled.

A.8.3 If yielding of reinforcement or nonlinear response of concrete is anticipated as a result of combined effects of applied forces, displacements, and volume change effects associated with shrinkage, temperature, or creep, the structural model shall be capable of representing member stiffness for loading near the onset of inelastic response, as well as behavior past the onset of inelastic response.

COMMENTARY

RA.8—Effective stiffness

RA.8.1 Software for nonlinear analysis generally is capable of directly modeling deformations due to flexure, shear, and axial elongation or shortening. Additional deformation may occur due to slip of longitudinal reinforcement from adjacent anchorages. Such effects commonly occur where beams frame into beam-column joints or walls, where columns frame into beam-column joints or foundations, and where walls frame into foundations. If such effects are considered important to the performance of the structure, appropriate assumptions should be included in the analytical model, either directly or by adjustment of flexural stiffness.

RA.8.2 Effects of cracking on stiffness reduction can be considered directly by using models that represent stiffness reduction as calculated stress reaches the cracking stress or indirectly by reducing the effective stiffness relative to the gross-section stiffness. Where the latter approach is used, the degree of stiffness reduction should be consistent with the degree of cracking anticipated under earthquake loading. Structural walls that are lightly cracked, including basement walls, have traditionally been modeled using effective flexural stiffness in the range 0.5 to 1.0 times gross-section stiffness. Diaphragms at major force transfer levels are commonly modeled using effective axial stiffness in the range 0.10 to 0.5 times gross-section stiffness. TBI (2017) and LATBSDC (2017) provide additional effective stiffness recommendations while NIST GCR 17-917-46v1 (NIST 2017a) and NIST GCR 17-917-46v3 (NIST 2017b) provide more detailed guidance on modeling of diaphragms and frame elements.

For stiffness of beams, columns, and structural walls other than basement walls, refer to RA.8.3.

RA.8.3 If calculations indicate nonlinear response under load combinations including earthquake effects, the nonlinear model should be capable of representing an effective secant stiffness from zero loading to a point corresponding to yield-level forces (slope from A to B in Fig. RA.8.3). The model should also be capable of representing stiffness reduction past the yield point. Degradation in element strength or stiffness should be included in the analytical model unless it can be demonstrated that the demand is not sufficiently large as to produce these effects.

A Nonlinear