Chapter X

From Force- to Displacement-based Seismic Design of Concrete Structures and Beyond

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Abstract Earthquakes impart to structures energy and produce displacements, both of which depend on the structure's pre-yielding natural period but not on its strength. The resulting seismic force is normally equal to the structure's lateral resistance. Nevertheless, seismic design is still carried out for empirically specified lateral forces, proportional to the ground motion intensity. Displacement-based seismic design (DBD) requires realistic estimation of seismic deformation demands and of the corresponding deformation capacities. A comprehensive and seamless portfolio of models for the secant-to-yield-point stiffness (which is essential for the calculation of displacements and deformations by linear or nonlinear analysis) and the ultimate deformation under cyclic loading has been developed, covering all types of concrete members, with continuous or lap-spliced bars, ribbed or smooth. The effect of wrapping the member in Fiber Reinforced Polymers is also considered. DBD is now making an entry into European standards, sidelining the earlier, more promising idea of energy-based seismic design, although energy lends itself better than displacements as a basis for seismic design: a) being a scalar, it relates best to the 3D seismic response and damage; b) it has a solid basis: energy balance; c) its evolution during the computed response flags numerical problems. The initial enthusiasm for seismic energy 25 years ago led to a boom in activity on energy demand, but ran out of steam without touching on the more challenging issue of energy capacity of components. This is a fertile field for seismic engineering research.