

NONLINEAR STRUCTURAL ANALYSIS

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Introduction to nonlinear structural analysis; Overview, Sources of nonlinearities, types of structural analysis (1st order elastic, 1st order inelastic, 2nd order elastic, and 2nd order inelastic), overview of solution strategies for nonlinear structures; Principles of computational plasticity; overview, yield criterion, flow rule, hardening rule, loading/unloading criterion. Some commonly used uniaxial material models; elastic material, elastic-perfectly plastic material, bilinear steel material with kinematic and isotropic hardening, Ramberg-Osgood steel material model, Giuffre-Menegotto-Pinto model with isotropic strain hardening, Kent-Scott-Park concrete material model, Visco-elastic material model, Bouc-Wen model; Member section analysis; fiber section discretization; moment-curvature response; force-deformation response; Material nonlinear beam-column element formulation; lumped plasticity models (beam with hinges formulation), distributed nonlinearity models; displacement-based nonlinear beam-column element; force-based nonlinear beam-column element. Geometrically nonlinear analysis; simplified 2nd order P- Δ analysis, co-rotational formulations of truss and beam elements. Solution strategies for nonlinear system of equations; incremental single-step methods; Euler method, second-order Runge-Kutta methods, incremental-iterative methods, load control, displacement control, work control, arc-length control; Nonlinear structural dynamic analysis; semi-discrete equations, of motion, explicit time integration, implicit time integration, dissipative integration algorithms, stability and accuracy. Application to hybrid simulation; overview, sub-structuring in hybrid simulation; application to modeling analytical substructures, solution of time discretized equations of motion.