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RESEARCH AND IMPLEMENTATION CHALLENGES FOR PERFORMANCE-BASED EARTHQUAKE ENGINEERING

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ABSTRACT: Modern approaches to earthquake resistant design emphasize the convenience of establishing practical criteria and methods based on acceptance rules expressed in terms of specified performance levels. Those criteria and methods should lead to consistent reliability and expected performance levels for wide families of systems; they should be based on life-cycle optimization concepts and they should maintain the implied risks within socially acceptable levels. Their formulation requires counting with accurate criteria and methods for the estimation of the seismic response, reliability and performance of complex nonlinear systems subjected to multi-component and spatially distributed ground motion with uncertainly known intensities, evolutionary amplitudes and frequency content; and they should provide an optimum balance between simplicity and accuracy. Uncertainties arising from the random nature of natural phenomena and material properties should be examined together with those associated with insufficient knowledge or imperfect models used to represent both seismic excitations and structural systems.

An overview is presented of some current trends and some desirable efforts aiming at facing the challenges mentioned above. Special attention is given to the development of seismic vulnerability functions of complex nonlinear structural systems, and to their application to the development of efficient tools for the practice of earthquake engineering design with quantitative reliability and performance targets, specified in probabilistic terms. Assets and limitations of alternative criteria for the derivation of seismic vulnerability functions for multistory buildings, including those based on deformation capacity, incremental dynamic analysis, damage accumulation and stiffness-reduction indexes.

An analysis is made of alternative formats and tools for practical design with specified reliability and expected-performance targets; they include models with different degrees of refinement and, therefore, with different random and epistemic uncertainty levels.

Research and development needs include the following concepts, among others:

- Reliability levels implicit in current seismic design recommendations and codes
- Constitutive functions of structural members and systems: beams, columns, shear walls, infill walls
- Approximate methods, adequate for practical applications, for the probabilistic estimation of the seismic response of complex nonlinear systems, on the basis of the responses predicted with the aid of simple systems modified by response transformation factors
- Sensitivity of response transformation factors to the spatial variability of structural properties: mass, stiffness, strength
- Derivation of acceptable values of control variables in order to attain the target reliability levels.