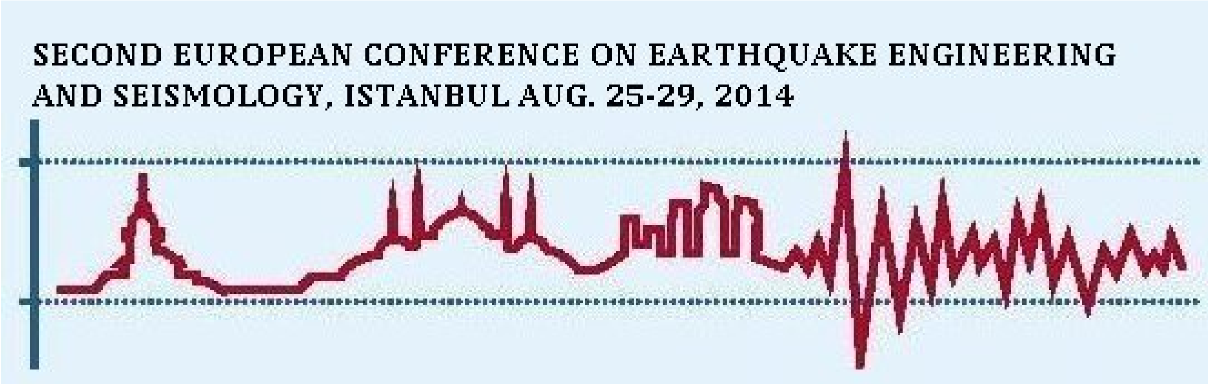

SEISMIC ENERGY DEMAND FOR LIFE SAFETY AND COLLAPSE PREVENTION PERFORMANCE OBJECTIVES IN PERFORMANCE-BASED SEISMIC DESIGN OF STEEL MOMENT FRAMES

Bulent AKBAS[1], Jay SHEN[2]

Traditionally, seismic design of structures are strength-based, i.e. a certain amount of static lateral seismic force, combined with the gravity load, is applied to a structure as the strength demand. The structural members are selected based on the principle that the strength supply from the structure should not be less than the strength demand on it. Nevertheless, the assigned level of the seismic force in the seismic provisions provides only a minimum lateral resistance level, but is not intended to design the structure to be without damage in the design earthquake. A structure thus designed is expected to go through large inelastic deformations when subjected to a strong ground motion. Whether or not the structure collapses depends largely on the structural tolerance to the cyclic inelastic deformations. Performance-based seismic design of structures calls for a rational and rigorous design approach in its conceptual framework and has been widely used for the last two decades. Performance-based design approach accounts for realistic seismic performance of a structure and is considered to be more rational seismic design approach in its structural design stage. The multiple levels of objectives, from functional to collapse prevention, naturally require a hybrid methodology.

Energy-based design approach provides an alternative in earthquake-resistant design. The earthquake effect on the structure can be considered as energy input, a function of the structural properties and characteristics of the earthquake ground motion. The structural capacity is defined by the energy dissipation capacity, the total area enclosed in the force-deformation curves under cyclic loading. Thus, seismic design becomes the balancing of the energy input and the energy capacity of the structure. The cumulative effect of seismic loading of the structure can be rationally represented by the energy transferred into the structure by the given earthquake. Naturally, for design purposes the structural capacity to dissipate the energy demand would be in terms of hysteresis energy, and the design process becomes the balancing of energy demand dissipation throughout the structure.

The purpose of this paper is to present such an energy-based design process in the framework of performance-based earthquake engineering, emphasizing the life safety and collapse prevention objectives. Special steel moment resisting frame is selected as the structural system to demonstrate the rationality, feasibility and further research needs. Three typical steel moment resisting frames with heights equal to 4-, 9-, and 20-stories, representing typical low-, medium-, and high-rise steel buildings are designed based on the seismic design requirement in ASCE 7 (2005) and AISC 341 (2005, 2010). The buildings are designed for a site in downtown Los Angeles, where S_s=2.0g and S_1=1.0g. These buildings are similar to those developed as part of the FEMA-sponsored steel frame research program conducted following the 1994 Northridge earthquake. An ensemble of ground

[1] Prof., Gebze Institute of Technology, Kocaeli, akbasb@gyte.edu.tr
[2] Assoc.Prof., Iowa State University, Iowa, jshen@iastate.edu

motions are selected so that the seismic response of each of the three frames would range from moderate to severe and the seismic energy demand would be evaluated based on the response of the frames. Two sets of ground motions corresponding to 10% and 2% probability of exceedance are used in nonlinear dynamic time history analyses. The scope of the paper includes the following:

(1) Energy response (demand) under strong ground motion corresponding 10% and 2% probability of exceedance in terms of total energy, hysteresis energy and damping energy for different frames represented by their fundamental periods of vibration,
(2) Seismic energy distribution along the height of the frames.

REFERENCES

Shen, J., Sabol, T.A., Akbas, B., and Sutchiewcharn (2010) Seismic Energy Demand on column Splices in Steel Moment Frames, Engineering Journal, fourth quarter, 223-240.