DEPARTMENT OF CIVIL ENGINEERING AND GEOLOGICAL SCIENCES

Spring 2009 Seminar Series

CHALLENGES AND INNOVATION IN CIVIL AND ENVIRONMENTAL ENGINEERING

Validating Performance of Self-Centering Steel Frame Systems using Hybrid Simulations

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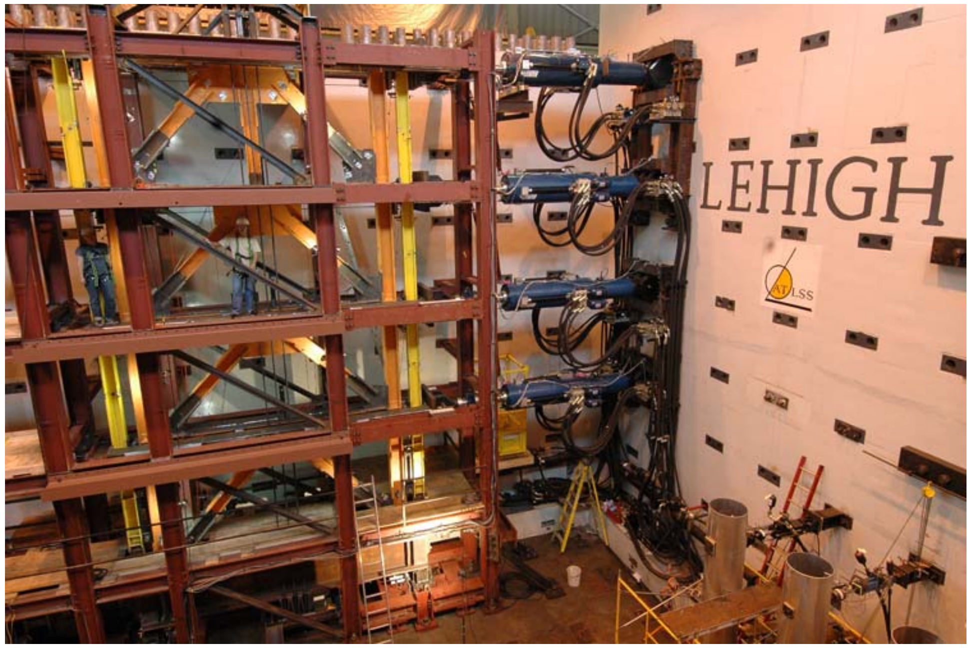
Wednesday, September 23, 2009
129 DeBartolo Hall
4:30pm – 5:30pm



Innovative earthquake-resistant self-centering (SC) steel frame systems are being developed to be damage-free and without residual drift under the design basis earthquake (DBE). This presentation summarizes hybrid earthquake simulations on large-scale 4-story SC steel frames at the Lehigh NEES equipment site that are being used to validate performance-based design procedures for these SC steel frame systems.

Unlike conventional earthquake-resistant steel frame systems that develop significant inelastic deformations under the DBE, resulting in significant damage and residual drift, SC steel frame systems have a low probability of structural damage under the DBE as a result of several features: the lateral force-drift behavior softens without inelastic deformation of the structural members, and, therefore, without the resulting structural damage and residual drift; the softening behavior results from gap opening at selected post-tensioned connections; the ductility capacity of the lateral force-drift behavior can be quite large and is not controlled by material ductility capacity; and energy dissipation under seismic loading is not from damage to structural members, but from energy dissipation (ED) elements that are specified in the design process and can be replaced if damaged.

Both self-centering moment resisting frames (SC-MRFs) and self-centering concentrically-braced frames (SC-CBFs) are being developed. The seismic behavior of the SC-MRF is characterized by gap opening and closing at beam-column interfaces, where the beams are post-tensioned to the columns by high strength post-tensioning strands oriented horizontally. The SC-MRF was designed for the following seismic performance objectives: no structural damage, leading to immediate occupancy under the DBE, and collapse prevention under the Maximum Considered Earthquake (MCE). A 7-bay-by-7-bay, 4-story building located on stiff soil in Los Angeles is the basis for a 2-bay, 4-story 0.6-scale SC-MRF laboratory test specimen. Earthquake simulations on this test specimen using the hybrid simulation method show that the seismic performance objectives are satisfied; no significant structural damage develops during numerous DBE simulations, and minimal damage develops during MCE simulations

The seismic behavior of the SC-CBF is characterized by uplift of the "tension" column of the fame after the initial precompression of the column is overcome from overturning effects. The initial column precompression is provided by post-tensioning (PT) bars oriented vertically and gravity loads. After column decompression and uplift, the lateral displacement of the frame is dominated by rigid body rotation of the frame about the base of the "compression" column (i.e., rocking). The PT bars elongate from the uplift of the frame, leading to an increase in PT force, which provides a positive lateral stiffness. The SC-CBF was also designed for no structural damage under the DBE, and collapse prevention under the MCE. A 6-bay-by-6-bay, 4-story building located on stiff soil in Los Angeles is the basis for a 2-bay, 4-story 0.6-scale SC-CBF laboratory test specimen. Earthquake simulations on this test specimen using the hybrid simulation method are in progress.

A reception and an opportunity to meet the speaker will take place at 4:00pm in the CE/GEOS office conference room, Fitzpatrick 156, before the seminar