The Physics of Tall Building Collapse

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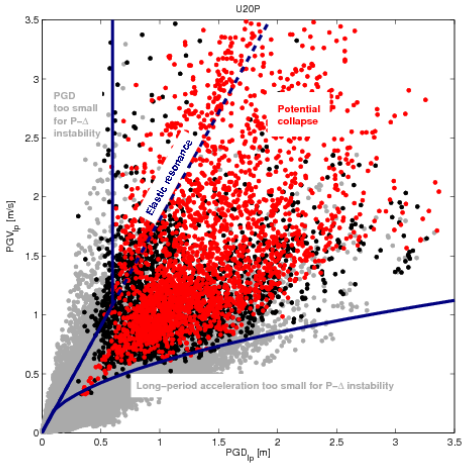
There is a building boom for tall buildings for West Coast Cities; daring architectural designs trumpet that they are designed to withstand the 2,500-yr earthquake shaking. In this talk, I explore whether or not these claims are scientifically based, or are we being used as "useful idiots" to facilitate the ambitions of developers? Cutting through the claims of current high-rise development is surprisingly difficult. Technical reports describing the attributes of real buildings are mostly proprietary and the deliberations of peer-review committees are secret. To help better understand the collapse resistance of typical tall buildings I have worked with my colleagues and students to simulate the response of steel moment-resisting-frame buildings designed to meet building codes that have evolved considerably since the 1950's. We have focused on the problem of building collapse; this occurs when steel columns become tilted enough that gravitational forces cause bending moments (as opposed to axial forces for vertical columns) that exceed the bending yield capacity of steel sections. I will show that the combination of high peak ground velocity (pgv) and high peak displacement (pgd) are much better predictors of collapse than is 5% spectral acceleration, which is currently the focus of the National Probabilistic Seismic Hazard maps (NPSHA). High pgv (>75 cm/s) induces plastic yielding and large pgd (>75 cm) causes column tilts that are gravitationally unstable. I will further show that 70% damped response spectra are another alternate collapse predictor which is also significantly better than 5%-damped response spectra. I also discuss the problem of statistical analysis of pgv, pgd. I argue that pgd is poorly characterized by earthquake magnitude and that its occurrence is described by a heavy-tailed power law with an undefined variance. I argue that current statements that tall buildings are constructed for 2,500-yr shaking are misleading and are designed to lull the public into believing that tall buildings are safe in future large earthquakes. I will show how the evolution of building codes over the past 60 years has affected the intended collapse resistance of tall buildings (surprisingly little). I will also show that pre-Northridge steel buildings are much less collapse resistant due to mistakes in the design of critical beam/column welded connections.



Red is collapse
Black is unrepairable bending
Gray is repairable or undamaged