Steel Moment-Resisting Frame Responses in Simulated Strong Ground Motions: or How I Learned to Stop Worrying and Love the Big One

Thesis by

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Abstract

This thesis studies the response of steel moment-resisting frame buildings in simulated strong ground motions. I collect 37 simulations of crustal earthquakes in California. These ground motions are applied to nonlinear finite element models of four types of steel moment frame buildings: six- or twenty-stories with either a stiffer, higher-strength design or a more flexible, lower-strength design. I also consider the presence of fracture-prone welds in each design. Since these buildings experience large deformations in strong ground motions, the building states considered in this thesis are collapse, total structural loss (must be demolished), and if repairable, the peak inter-story drift. This thesis maps these building responses on the simulation domains which cover many sites in the San Francisco and Los Angeles regions. The building responses can also be understood as functions of ground motion intensity measures, such as pseudo-spectral acceleration (PSA), peak ground displacement (PGD), and peak ground velocity (PGV). This thesis develops building response prediction equations to describe probabilistically the state of a steel moment frame given a ground motion. The presence of fracture-prone welds increases the probability of collapse by a factor of 2–8. The probability of collapse of the more flexible design is 1–4 times that of the stiffer design. The six-story buildings are slightly less likely to collapse than the twenty-story buildings assuming sound welds, but the twenty-story buildings are 2–4 times more likely to collapse than the six-story buildings if both have fracture-prone welds. A vector intensity measure of PGD and PGV predicts collapse better than PSA. Models based on the vector of PGD and PGV predict total structural loss equally well as models using PSA. PSA alone best predicts the peak inter-story drift, assuming that the building is repairable. As "rules of thumb," the twenty-story

steel moment frames with sound welds collapse in ground motions with long-period PGD greater than 1 m and long-period PGV greater than 2 m/s, and they are a total structural loss for long-period PGD greater than 0.6 m and long-period PGV greater than 1 m/s.

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