ABSTRACT

Laughery, Lucas Alan. Ph.D., Purdue University, August 2016. Response of High-Strength Steel Reinforced Concrete Frames to Simulated Earthquakes. Major Professor: Santiago Pujol.

In reinforced concrete (RC) structures expected to resist earthquake demands, substituting smaller amounts of high-strength steel for conventional steel reinforcement can help reduce reinforcement congestion and placement costs while keeping strength unchanged.

Reducing the amount of longitudinal steel while maintaining member dimensions produces a member with similar initial stiffness but lower post-cracking stiffness. Increasing the strength of the steel can help keep member strength constant within the same cross-section. The topic of this investigation is whether two frames containing members with the same initial stiffness and nominal strength but different post-cracking stiffness reach comparable peak drift during a given ground motion. This is a question about drift demand, not drift capacity. The impact of changes in steel strength on drift capacity has been examined by others and is not the subject of this study.

Four nominally identical reinforced concrete frames were tested on a unidirectional earthquake simulator. In two frames, conventional reinforcing steel was used in the columns at a reinforcement ratio of 1.8%. In the other two frames, high-strength reinforcing steel was used in the columns at a reinforcement ratio of 0.8%. Each frame was subjected to one of two series (or sequences) of five ground motions. The first four motions were of either increasing intensity (series 1) or decreasing intensity (series 2). The last motion was the strongest motion allowed by the simulator.

Comparisons of frames with different post-cracking stiffness, and comparisons of similar frames subjected to different ground motion sequences supported the hypothesis that the dominant factor driving peak drift is initial period calculated using gross cross-sectional properties.

To examine further the idea that initial period drives peak drift in RC structures subjected to earthquake demands, a dataset was compiled using results from more than 160 dynamic tests of RC structures and the measured responses of 3 instrumented RC buildings. This dataset was used to evaluate an expression proposed by Sozen (2003) indicating that peak drift is a directly proportional to the product of peak ground velocity and initial period (calculated from gross cross-sectional properties). Comparisons of measured-to-estimated peak drift revealed that, for ground motions with PGV/PGA > 0.03 sec, the studied expression produced reasonable and safe estimates of peak drift. Ground motions outside this range have been used in laboratory tests but are unlikely to occur in the field.

ABSTRACT

All the evidence examined suggests that peak drift caused by earthquake demands is proportional to initial period. It follows that replacing conventional steel reinforcing bars with fewer or smaller bars of higher grade is unlikely to result in consistent increases in drift demand.