INVESTIGATION OF THE SEISMIC RESPONSE OF A LIGHTLY-DAMPED TORSIONALLY-COUPLED BUILDING

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ABSTRACT

The earthquake behavior of lightly-damped, torsionally-coupled moment resisting steel space frames is investigated by analyzing the recorded three-dimensional response of a "regular" thirteen story steel frame building located in San Jose, California, and by performing several elastic and inelastic computer analyses of this and similar structures. Several earthquakes have been recorded in the case study building. Of these, three earthquakes are considered in this report: the 1984 Morgan Hill, the 1986 Mt. Lewis and the 1989 Loma Prieta events. During these events the building responded severely, though no structural damage was observed. The recorded responses of the structure were unusual; characterized by long duration, narrow banded periodic motions, with strong amplitude modulation; by large displacements and torsional motions; by large amplification of the input ground motions; and by slow decay of the building's dynamic responses.

Three-dimensional linear and nonlinear numerical models of the complete structure are developed to simulate the recorded responses and to study the effects of changes in various parameters. The dynamic analyses consider unidirectional as well as bi-directional input motions with and without torsional input excitations. A "best fit" model employing standard analysis and design procedures is identified. The parameters affecting the correctness of the response are determined. The effects of such factors as inelastic behavior, amount of equivalent viscous damping, additional plan eccentricities, and input motion characteristics on the overall response of the structure are studied. Typical design code recommendations for this type of structure are also evaluated as part of this investigation.

The investigation concludes that lightly-damped regular space frame structures like the one studied are highly susceptible to strong lateral-torsional and modal coupling because of the closeness of their predominant periods and the possible severe effects of "small" accidental eccentricities. It is shown that even small input motions can produce large responses, if the predominant periods of the structure match those of the site. These various effects together with the large flexibility often found in steel moment resisting frames can create structures that exhibit unusually severe seismic responses.

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