PAPER 179:

HIGH-RISE BUILDING RESPONSE: DAMPING AND PERIOD NONLINEARITIES

by

G. C. Hart, M. Lew, and R. Di Julio, Jr.

DISCUSSION by: Sigmund A. Freeman[I]

The authors have presented some results obtained from recordings of building response to the San Fernando Earthquake. Having worked on an investigation of two of these buildings I would like to make the following comments.

The authors state that "intuitively it seems unacceptable that the variation in building periods can be completely explained by a degradation in structural stiffness."

In our investigation of two identical reinforced concrete frame structures (8244 Orion, 1640 Marengo) we were able to conciliate with a time-history analysis of the records the lengthening of the fundamental response periods during the elapsed time of the strong motion of the earthquake. We correlated period lengthening with the stiffness degradation of the structure. For small amplitudes of motion nonstructural elements accounted for a significant portion of the building stiffness. As the amplitude of motion increased the participation of nonstructural elements was decreased as damage to the nonstructural elements occurred. Continued motion caused strains beyond the elastic limit of some elements so that degradation of structural stiffness occurred. Comparison of pre- and post-earthquake ambient data as well as earthquake and aftershock data confirm the permanent stiffness degradation of the structures (1)(2). Results of the investigation of two reinforced concrete test structures (3) (4) also confirmed degradation of structural stiffness during exposure to strong earthquake-like motion. Our investigations have also indicated that some structures respond at substantially shorter periods during ambient motion than at higher amplitudes of motion (3)(4)(5).

I would therefore suggest that the changes in period observed by the authors are primarily due to a combination of nonstructural element (e.g., partitions) degradation and structural element degradation. In the case of reinforced concrete structures the structural degradation occurs in the order of virgin uncracked concrete sections to "cracked" concrete sections to yielded sections. In the case of structural steel structures, stiffness degradation occurs in items such as floor slab participation, "non-moment resisting" frame participation, and nonstructural elements.

[I]Associate, John A. Blume & Associates, Engineers, 130 Jessie Street, San Francisco, California 94105

REFERENCES

(1) Freeman, S. A., "Comparisons of Results of Dynamic Seismic Analyses of Two Identical Structures Located on Two Different Sites, Based on Site Seismograms from the San Fernando Earthquake," Proceedings 41st Annual Convention, Structural Engineers Association of California, October 1972.

(2) Freeman, S. A., and K. K. Honda, Response of Two Seven-Story Structures to the San Fernando Earthquake of February 9, 1971, JAB-99-98, John A. Blume & Associates Research Division, (to be published).

(3) Freeman, Sigmund A., Concrete Test Structures: Second Progress Report on Structural Response, JAB-99-50, John A. Blume & Associates Research Division, July 1971.

(4) Raggett, Jon D., Influence of Nonstructural Partitions on the Dynamic Response Characteristics of Structures, JAB-99-94, John A. Blume & Associates Research Division, July 1972.

(5) Blume, John A., "Response of High-Rise Buildings to Ground Motion from Underground Nuclear Detonations," Bulletin of the Seismological Society of America, v. 59:6, December 1969.