ABSTRACT

Observations from experiments and post-earthquake surveys have shown that drift is the key parameter for identifying potential damage of a structure during ground motions (Sozen, 1981). These observations suggest that drift should govern seismic design and evaluation of structures.

In this study, three methods for estimating drift demands were considered: 1) the method proposed by Sozen (2003) referred to in this study as Velocity of Displacement (VOD), 2) the Coefficient Method and 3) Nonlinear Dynamic Analysis (NDA). The reliability of each method was evaluated by comparing estimates of roof and maximum story drift ratios with measurements from 46 reinforced concrete structures with initial periods shorter than 3 seconds.

Measurements from long-period structures (with periods longer than 3 seconds) were not available. To produce data to evaluate the reliability of the three mentioned methods for long-period structures as well as understand the displacement and base-shear response of such structures, seven scaled Multi-Degree-of-Freedom (MDOF) specimens with an initial period of approximately 1.2 seconds were tested with five scaled base motions of varying intensities. Each motion was scaled in time such that its scaled spectral shape near the initial period of the specimen was similar to the spectral shape of the unscaled motions for periods ranging from approximately 1 to 10 seconds. A total of 118 tests were conducted.

The effect of loading history on drift demands and drift estimates was also evaluated by quantifying changes in drift demands of structures subjected to repeats of the same ground motion. Data from 1) experimental tests of structures subjected to repeated ground motions, and 2) numerical analyses of Single-Degree-of-Freedom (SDOF) oscillators subjected to multiple sequences of ground motions of varying intensities were used.

Based on comparisons of measured and calculated drifts as well as data from the experimental program, the following observations were made:

1. For structures with periods shorter than 3 seconds, all three methods for estimating drift demands produced estimates of both roof and maximum story drifts of similar quality despite large differences in the effort required to use each method.

2. For structures with periods longer than 3 seconds, NDA produced drift estimates close to the mean of measured values while VOD overestimated measured values, on average, by approximately 30%. The Coefficient Method produced estimates that were, on average, smaller than measurements by approximately 60%.

3. For structures (not susceptible to decay in lateral strength) subjected to sequences of ground motions of similar intensities, the relative increase in drift demands was, on average, no more than 20%. Larger increases in drift demands were observed for structures where the first motion (in a pair of repeated motions) was mild enough not to cause cracking and/or yielding, and the second motion was preceded by larger intensity motions that did cause cracking and/or yielding.

4. For test structures with periods longer than 3 seconds, drifts in the nonlinear range of response were generally smaller than linear estimates, and maximum base-shear demands were as much as three times those calculated assuming a linear lateral load distribution.