Near Fault Effects on the Instability of Simple Systems

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Whereas the special characteristics of near fault records have been recognized for some time, and their effects on elastic and inelastic spectra has been the subject of numerous studies [1,2], quantitative information on the interaction between the impulsive nature of the motion and the factors that determine instability of ductile systems during inelastic response is currently limited. An opportunity to investigate near fault effects on instability using a realistic data set opened up recently thanks to the large number of near fault records obtained during the 9/28/04 Parkfield event. Dynamic instability is a phenomenon whereby the seismic response of a structure changes from vibration to unbounded drift in a single direction [3]. Since the consequence of dynamic instability is complete collapse, characterization of this limit state is of paramount importance for the formulation of performance based seismic design guidelines.

The salient feature of the instability phenomenon is the fact that it is abrupt. The key issue in design, therefore, is not that of assessing amplifications to account for P-delta effects but rather quantifying the instability limit so that the designer can ensure that the structure has an adequate safety margin against this failure mode. In this paper the study on the near fault effect on collapse potential is examined by inspecting how normalized collapse response spectra vary for near fault and far fault records. In the foregoing the collapse spectrum is defined as the minimum strength per unit mass for which the response is stable as a function of period (or frequency) for constant stability coefficient when second order effects are considered. The stability coefficient, in turn, is a dimensionless characterization of the gravity load that equals unity when the intensity is equal to that for which static buckling ensues. Normalization of the collapse spectra is done using the elastic spectrum so what is actually obtained is the reciprocal of the limit that stability imposes on the maximum reduction that can be applied to elastic spectra to take advantage of inelastic response.

An item also examined in the paper is the adequacy of simplified descriptions of the motion in the near field from the perspective of instability. It is found, as one anticipates from theoretical considerations; that these motions have a collapse potential that is notably smaller than a representative ensemble of real motions recorded at short distances from the fault.

References:

[1] MacRae, G.A., Morrow, D.V. and Roeder, C.W., (2001), "Near fault ground motion on simple structures", Journal of Structural Engineering, ASCE, Vol.127, No.9, pp.996-1004.

[2] Mavroeidis G.P., Dong, G. and Papageorgiou A.S., (2004). "Near-fault ground motions, and the response of elastic and inelastic single-degree-of-freedom (SDOF) systems", Earthquake Engineering and Structural Dynamics Vol.33 pp.1023-1049.

[3] Bernal, D. (1992a),"Instability of Buildings Subjected to Earthquakes", Journal of Structural Engineering, ASCE, Vol. 18, No.8, pp. 2239-2260.

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