Non-Linear Response of High Rise Building to Pulse Type Strong Ground Motions

Mohsen Tehranizadeh

(Professor of Civil Engineering)
(Amir-Kabir University of Technology, Tehran, IRAN)
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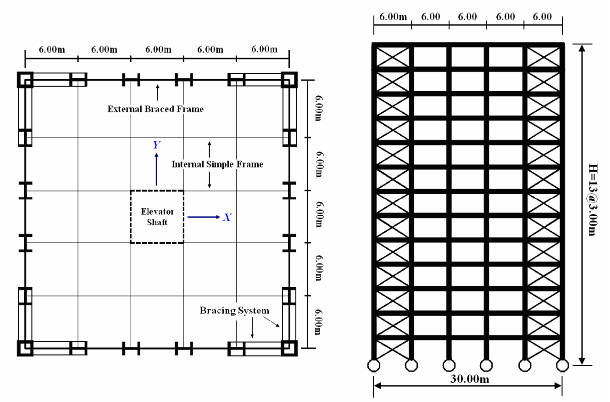
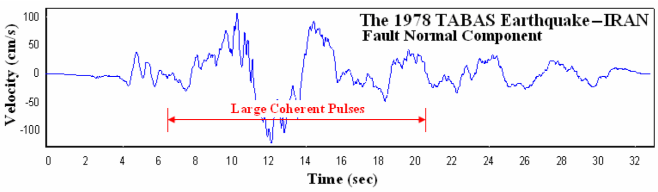
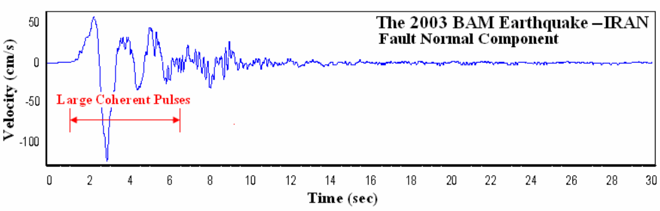
Co-Author: **Afshin Meshkat-Dini**)

Summary: Occurrence of strong ground motions in areas near causative faults is expectative. Studies on recorded near fault strong motions indicate that there are usually some obvious effects in the acceleration, velocity and displacement time histories. Generally, the strong ground motions recorded in near fault zones contain distinct pulses in the velocity time history. These powerful velocity pulses cause that structural system of tall building should face with considerable input energy. It should be noted that these extreme amounts of seismic energy are produced by directivity effects which have been observed in near fault earthquake records. Research results show that the maximum structural demand of a building is function of the ratio of the pulse period to the structure fundamental period. This paper includes the analytical results from non-linear dynamic analyses of two example multi-storey buildings subject to strong ground motions. These example buildings are five and thirteen storey structures which have three dimensional steel framing system. According to the non linear analyses, the structural demands which are calculated subject to near field records are considerably more than those due to far field motions.



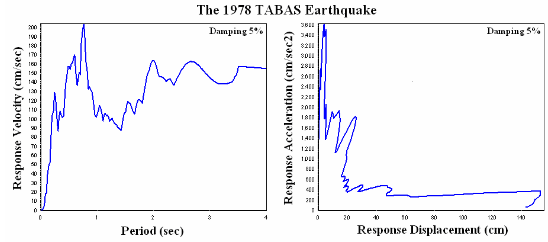




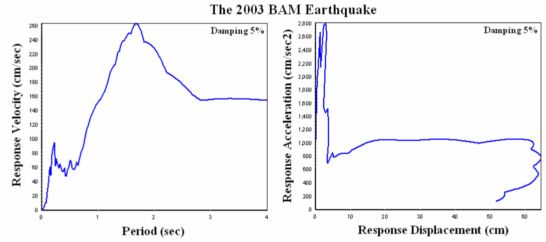
Response characteristics of thirteen storey building to near and far fault records

Ground Motion	PGV (cm/s)		PGV/PGA (sec)		PGD/PGV (sec)		Max. of Relative Drift (TR Dir. - cm)	Max. of Base Shear (TR Dir. - ton)
	TR	UP	TR	UP	TR	UP		
Tabas E. 1978 (Ferdous- 94.4 km)	8.6	7.6	0.08	0.14	1.12	0.89	0.7	385
Tabas E. 1978 (Tabas - 3.00km)	121.3	45. 5	0.14	0.06	0.78	0.37	6.1	1885
Bam E. 2003 (Bam-less than 1 km)	123.7	39. 6	0.15	0.04	0.30	0.21	7.4	1940
Landers E. 1992 (Indiana - 55.7 km)	15.2	6.6	0.14	0.16	0.64	0.60	1.1	380
Landers E. 1992 (Lucerne - 1.1 km)	97.6	45. 9	0.14	0.05	0.72	0.48	5.5	1284
Chi Chi E. 1999 (CHY004-51.0 km)	15.8	6.5	0.16	0.16	0.97	0.82	1.0	530

The 1978 TABAS Earthquake



The 2003 BAM Earthquake



Conclusion: Near field recorded ground motions which are characterized by forward directivity effects display coherent pulses in velocity time history. These powerful velocity pulses may be in the shape of one-sided or two-sided waveforms and contain considerable seismic energy which is released in a small time domain. Therefore, the structural system of medium-rise to tall buildings especially those which have TN/TP ratio close to one, must be able to dissipate extreme amounts of seismic energy in relatively few cycles of inelastic forced vibrations. It is usually observed that the existence of forward directivity effects in near fault earthquake records displays larger values for PGV and PGV/PGA ratios as well as relatively lower PGD/PGV ratios. These conditions are not always met for far-field records.