GROUND MOTION TIME HISTORIES FOR THE VAN NUYS BUILDING

Prepared for the PEER Methodology Testbeds Project
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Introduction

Near fault ground motions contain forward rupture directivity pulses and static ground displacements. These characteristics are described in Somerville (2002), which is posted on this website, and the way in which they are treated in the development of time histories for the Van Nuys building is described below.

Site Conditions

The site condition is classified as NEHRP category S_D based on blow count data. This report describes ground motion time histories for S_D soil conditions.

Uniform Hazard Spectra

Uniform hazard spectra for the site were derived from the USGS probabilistic ground motion maps for rock site conditions (Frankel et al., 1996; 2001). Modification to account for near fault rupture directivity effects, and the use of separate response spectra for the fault normal and fault parallel components of ground motion, is not be required, for the reasons stated below.

Soil spectra were generated from the rock site spectra by multiplying the rock spectra by the ratio of soil to rock spectra for the Abrahamson and Silva (1997) ground motion model. These ratios are for the mode magnitude and distance combinations from the deaggregation of the hazard, listed in Table 2.

Table 1. Equal Hazard Response Spectra for the Van Nuys building

Van Nuys - 50% in 50 years		
Period	**Rock**	**Soil**
0.01	0.248	0.232
0.1	0.422	0.336
0.2	0.554	0.491
0.3	0.522	0.543
0.5	0.375	0.479
0.8	0.24	0.34
1.0	0.188	0.287

1.5	0.125	0.21
2.0	0.100	0.174

Van Nuys - 10% in 50 years		
Period	**Rock**	**Soil**
0.01	0.628	0.490
0.1	1.213	0.819
0.2	1.434	1.099
0.3	1.377	1.276
0.5	1.125	1.339
0.8	0.71	0.98
1.0	0.528	0.806
1.5	0.32	0.53
2.0	0.235	0.420

Van Nuys - 2% in 50 years		
Period	**Rock**	**Soil**
0.01	0.989	0.698
0.1	1.898	1.135
0.2	2.262	1.559
0.3	2.200	1.872
0.5	1.754	1.980
0.8	1.37	1.67
1.0	0.945	1.443
1.5	0.57	0.97
2.0	0.401	0.729

Deaggregation of the Hazard

The deaggregation of the hazard shows that the hazard at the site is dominated by nearby earthquakes. The higher ground motions for the 2% in 50 year probability level than for the 10% in 50 year level will reflect not larger magnitudes, but higher ground motion levels for the same magnitude (larger number of standard deviations above the mean).

Table 2. Deaggregation of Uniform Hazard Spectra, 5% damping, soil, East (Transverse) Sa at 1 seconds, at the Van Nuys building

Hazard Level	Earthquake Source	M mean	R mean
50% in 50 years	Santa Susana, Northridge blind thrust	6.75	20 km
10% in 50 years	Northridge blind thrust, Santa Susana	6.75	10 km
2% in 50 years	Northridge blind thrust, Santa Susana	6.75	5 km

Representation of Near Fault Rupture Directivity Effects in the Ground Motion Recordings

Although the site is located near active faults in map view, none of the faults that dominate the seismic hazard at the site are oriented in such a way that the site will experience strong rupture directivity effects. For example, the fault that caused the 1994 Northridge earthquake is located about 10 below the site, but it dips up to the north-northeast and focuses forward rupture directivity toward the northern part of the San Fernando Valley. Suitable recordings do not include the recordings of the Northridge earthquake from the northern San Fernando Valley and the Santa Clarita basin, because they all contain strong forward rupture directivity effects.

Process of Selecting Ground Motion Recordings

The recordings satisfy the magnitude and distance criteria from the deaggregation, and the recording site criterion of S_D. Additional criteria are that the earthquake have a thrust mechanism, including blind thrust mechanisms (like the 1994 Northridge earthquake), and that the recording not contain strong forward rupture directivity effects. Suitable earthquakes include the 1971 San Fernando, 1986 North Palm Springs, 1997 Whittier Narrows, and 1994 Northridge earthquakes.

Site Effects in the Ground Motion Recordings

Much better representations of appropriate site effects could be made in the selection of time histories, for example by using recordings from sites with comparable seismic velocity profiles, if there were seismic velocity data (as exists for the ROSRINE sites).

Scaling of the Ground Motion Recordings

For each set of recordings, a scaling factor was found by matching the east component time history to the longitudinal uniform hazard spectrum at a period of 1.5 sec. This scaling factor was then applied to all three components of the recording. This scaling procedure preserves the relative scaling between the three components of the recording.

Process of Selecting Ground Motion Recordings

The recordings listed in Tables 3, 4 and 5 were selected to satisfy to the extent possible the magnitude and distance combinations from the deaggregation listed in Table 2. All of the recordings are from thrust earthquakes in the Los Angeles region. In most cases, the selected recordings are from earthquakes having appropriate magnitudes and distances. Detailed information on the characteristics of the recording sites is not known, and they are classified using broad rock and soil categories.

Time Histories for 50% in 50 years

The time histories used to represent the 50% in 50 year ground motions are listed in Table 3.

Time Histories for 10% in 50 years (under development)

The time histories used to represent the 10% in 50 year ground motions are listed in Table 4.

Time Histories for 2% in 50 years

The time histories used to represent the 2% in 50 year ground motions are listed in Table 5.

Table 3. Time histories representing 50% in 50 years hazard level at the Van Nuys Building

Earthquake	Mw, Strike (^{o}E of N)	Station	Distance	Site	Scale	Reference
Whittier Narrows 1987.10.1	6.0 280	athl	16.6	soil	3.885	Hartzell and Iida (1990)
		nsmv	18.6	soil	4.7	
San Fernando 1971.2.9	6.6 290					Heaton (1982)
Northridge 1994.1.17	6.7 122					

Table 4. Time histories representing 10% in 50 years hazard level at the Van Nuys Building

Earthquake	Mw, Strike (^{o}E of N)	Station	Distance	Site	Scale	Reference
San Fernando 1971.2.9	6.6 290					Heaton (1982)
Northridge 1994.1.17	6.7 122	whox	20.0	soil	1.922	Wald et al. (1996)
		vnsc	12.8	soil	2.961	

Table 5. Time histories representing 2% in 50 years hazard level at the Van Nuys building

Earthquake	Mw, Strike (^{o}E of N)	Station	Distance	Site	Scale	Reference
San Fernando 1971.2.9	6.6 290					Heaton (1982)
Northridge 1994.1.17	6.7 122	vnuy	11.3	soil	1.909	Wald et al. (1996)
		spva	9.2	soil	2.176	

Representation of Static Ground Displacements in the Ground Motion Recordings

An earthquake occurs when elastic strain that has gradually accumulated across a fault is suddenly released in a process of elastic rebound. The elastic energy stored on either side of the fault drives the motion on the fault. The elastic rebound generates dynamic strong ground motion that last for a few seconds to a few minutes. The elastic rebound also generates static deformation of the ground. The static deformation of the ground consists of a discontinuity in displacement on the fault itself, and a gradual decrease in this displacement away from the fault on either side of the fault. Even if the fault does not break the surface, there is static deformation of the ground surface due to subsurface faulting. The characteristics of static near fault ground motion are described by Somerville (2002). Strong ground motions recorded on digital accelerographs in recent earthquakes, including the 1985 Michoacan, Mexico, 1999 Chi-chi, Taiwan and 1999 Kocaeli, Turkey earthquakes, contain both dynamic ground motions and static ground displacements. The static ground displacement is coincident in time with the largest dynamic ground velocities, and occurs over a time interval of several seconds. It is therefore necessary to treat the dynamic and static components of the seismic load as coincident loads.

None of the ground motion time histories provided for the Van Nuys building contain static ground displacements. Such displacements are expected to be small at the Van Nuys building site because the site is not close to large faults.

References

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