A COMPARATIVE STUDY OF STRONG-MOTION RECORDS FROM LARGE EARTHQUAKES IN CALIFORNIA AND TAIWAN

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ABSTRACT

We have used large numbers of digitized strong-motion records from three large earthquakes in California and Taiwan for a comparative study of the local magnitude (ML) and site-dependent response spectral shapes. The date, mb and MS magnitudes, seismic moment MO, and the total number of horizontal acceleration records used for each of the earthquakes are as follows:

Earthquake	Hualien, Taiwan	Loma Prieta, CA	Landers, CA
Date	November 14, 1986	October 17, 1989	June 28, 1992
mb	6.3	6.5	6.2
MS	7.8	7.1	7.6
MO (dyne-cm)	9.4 (x10**26)	2.3 (x10**26)	10.6 (x10**26)
No. of records	156	120	44
UBC S1 records	12	48	6
UBC S2 records	54	42	28
UBC S3 records	14 (Taipei Basin)	30	10 (LA Basin)
	76 (SMART-1)		
ML (/UBC S1)	6.40 +/- 0.14	6.96 +/- 0.21	6.19 +/- 0.07
ML (/UBC S2)	6.90 +/- 0.21	7.03 +/- 0.20	6.92 +/- 0.18
ML (/UBC S3)	7.26 +/- 0.07 (TB)	7.45 +/- 0.16	7.17 +/- 0.08
	7.32 +/- 0.07 (SM)		

In total there are 156 records available for the 1986 Hualien earthquake, 120 records for the 1989 Loma Prieta earthquake, and 44 records for the 1992 Landers earthquake. For the present study, we first calculated from each acceleration record the 5%-damped response spectrum and then normalized the result by the peak ground acceleration(PGA) to obtain the response spectral shape for the record. In the meantime, we also obtained the peak amplitude of the simulated Wood-Anderson seismogram (WAA) to determine the ML magnitude from each

horizontal acceleration record.

Next, we classified the pair of observed horizontal response spectral shapes at each recording site using, as references, the three site-dependent design spectral shapes given in the Uniform Building Code (UBC) which are referred to as the UBC S1, UBC S2,and UBC S3 spectral shapes, respectively,in the following discussion. The number of records in each spectral shape classification are tabulated in the preceding table. Figures 1, 2 and 3 show the geographical distributions of the different types of records for the three earthquakes, respectively. We then calculated the mean ML value and the mean response spectral shape of each classification of records for the earthquakes. The results are summarized below.

For the Hualien earthquake, 12,54, and 90 records are found to have UBC S1 , UBC S2, and UBC S3 types of response spectral shapes, respectively. The 12 UBC S1 type records were from sites on relatively hard rocks in the Central Mountains consisting of Mesozoic to late Paleozoic schists, known as Tananao Schist. The 90 UBC S3 type records were from sites on relatively soft alluvium in the Taipei Basin and the SMART-1 array in the Lanyang Plain. The remaining 54 UBC S2 type records are from sites on soft rocks or stiff alluvium in the Coastal Range and the Longitudinal Valley in Eastern Taiwan, and in the Foothill region and Coastal Plain in Western Taiwan.

For the Loma Prieta earthquake, 48,42 and 30 records are found to have the UBC S1, UBC S2, and UBC S3 types of response spectral shapes, respectively. Except for the 14 UBC S3 records from sites on the relatively soft bay mud deposits around the San Francisco Bay, the rest were from sites on recent alluvium, old alluvium or the Franciscan complex. In this case, the observed response spectral shapes are not readily correlatable with local site geology.

For the Landers earthquake, 6, 28 and 10 records are found to have the UBC S1, UBC S2, and UBC S3 types of response spectral shapes, respectively. The 6 UBC S1 type records were from sites on relatively hard rocks of weathered granite or thin alluvium over granite in the Mojave Desert area. The 10 UBC S3 type records were from the Los Angeles Basin area which is underlain by a thick section of sedimentary rocks. The remaining 28 UBC S2 type records were from site son alluvium or deep alluvium overwide areas around the earthquake fault rupture.

In the ML determination it was found that the existing distance correction functions for the Central and Southern California areas would systematically under estimate the ML values for sites located close to the sources of both the Loma Prieta and Landers earthquakes. We have to make additional distance corrections in order to remove a linear trend with distance in the ML values. A similar trend with distance was also found in the case of the Hualien earthquake.This observation indicates saturation of ground motion toward the source dependent UBC design spectral shapes, with slight modification in the high-frequency range, are in fact as applicable in Taiwan as in California.

We notice in Figure 5 that a few of the mean response spectral shapes,such as those from sites on the San Francisco Bay mud and in the Taipei Basin and the SMART-1 array areas have dominant spectral peaks which significantly exceed the UBC design spectral shapes. Thus,in addition to select an appropriate type of design spectral shape,it is also important to identify and accommodate for such high spectral peaks which may be present at individual sites in developing the site-specific seismic design spectra.

Even though the above findings have been based on large numbers of strong-motion records from three large earthquakes, it still would be interesting to see how consistent are the observed deviation in the distance correction function, - log A0, for ML determination, and the apparent correlation between ML and response spectral shape for other large earthquakes and even for smaller earthquakes. The CWB free-field strong-motion accelerographs have great potentials for providing significant records before long to address this question more completely.

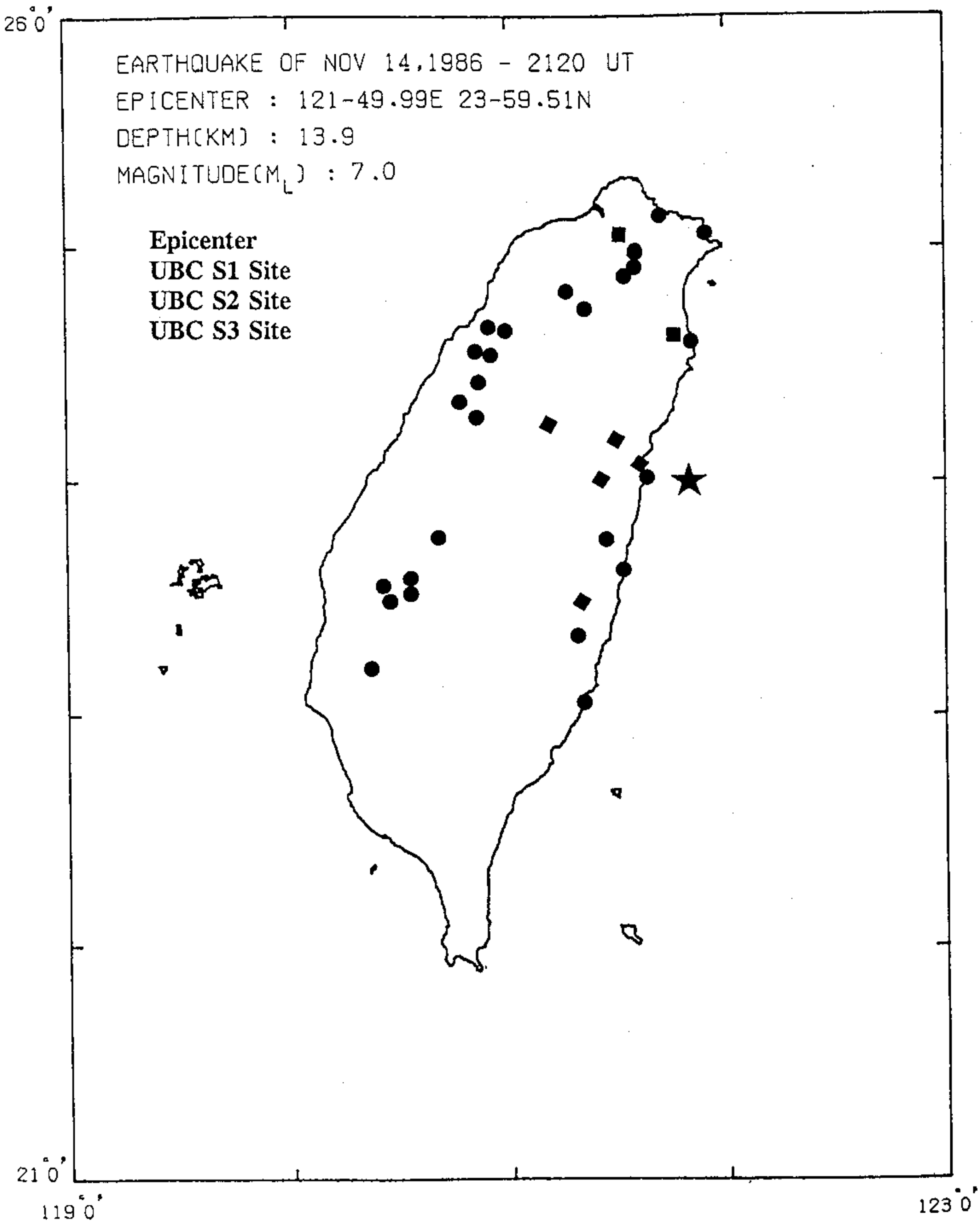

Figure 1. Locations of the epicenter and strong-motion recording sites of the Hualien, Taiwan earthquake of November 14, 1986.

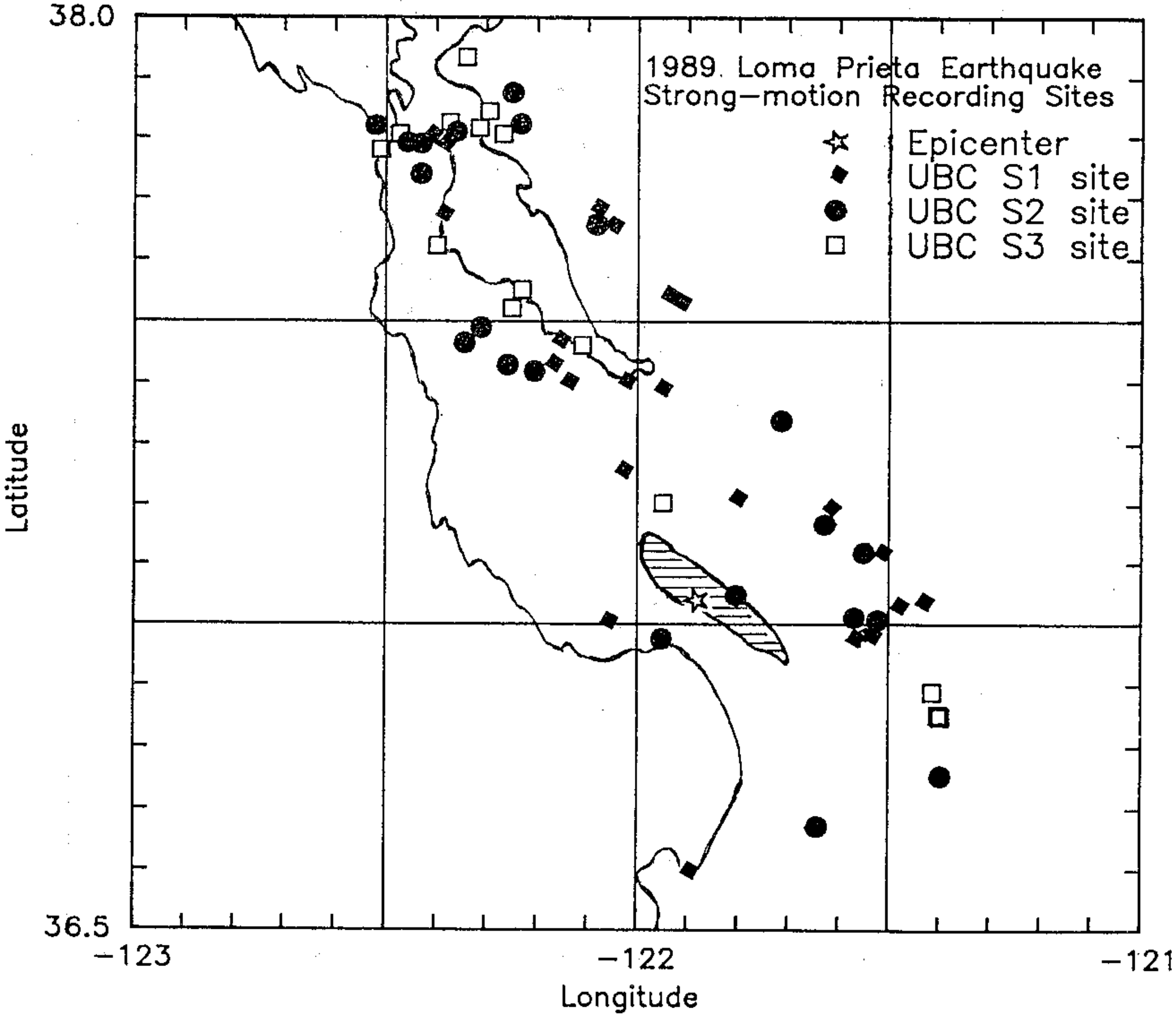

Figure 2. Locations of the epicenter and strong-motion recording sites of the Loma Prieta, California earthquake of October 17, 1989.

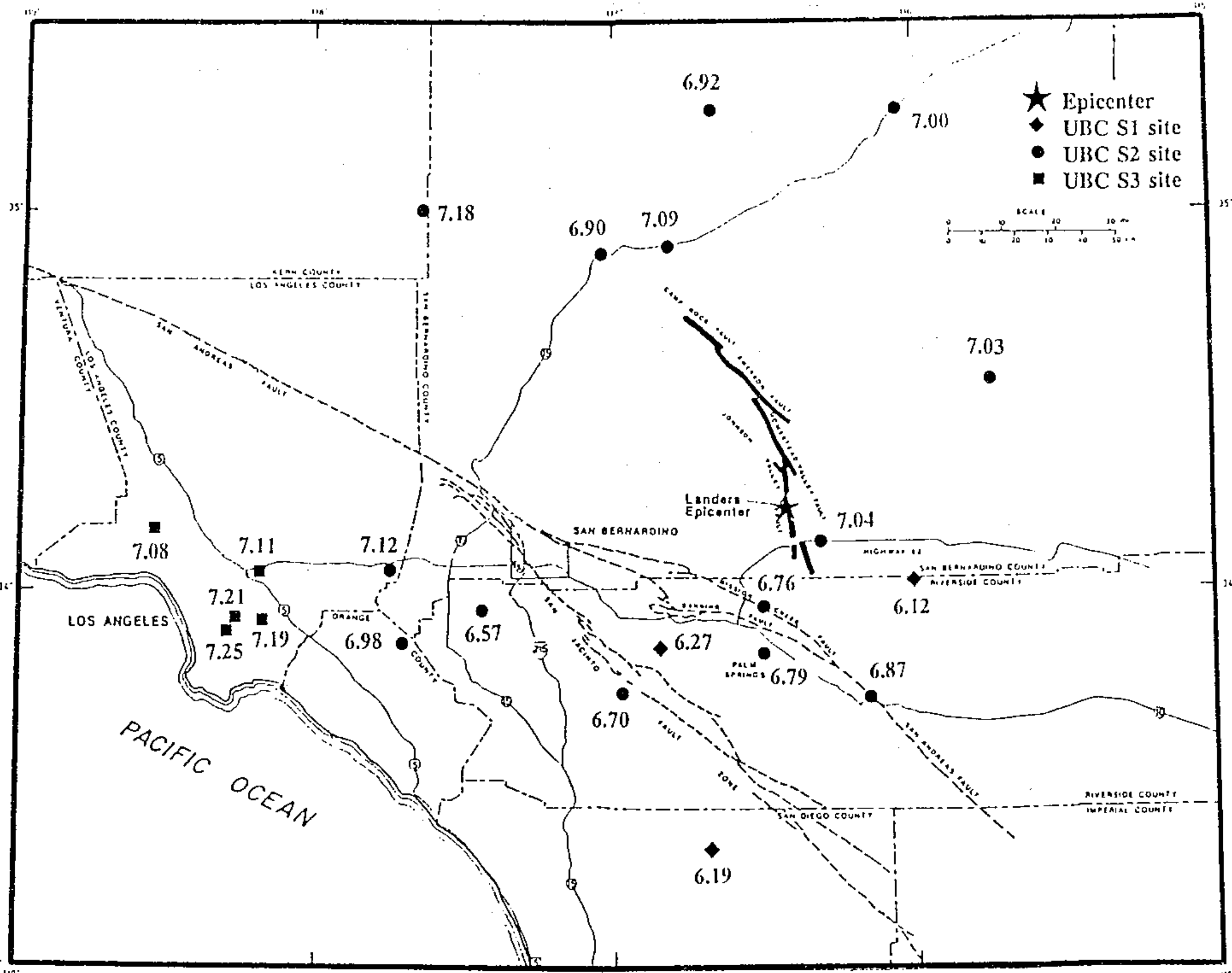

Figure 3. Locations of the epicenter and strong-motion recording sites of the Landers, California earthquake of June 28, 1992.

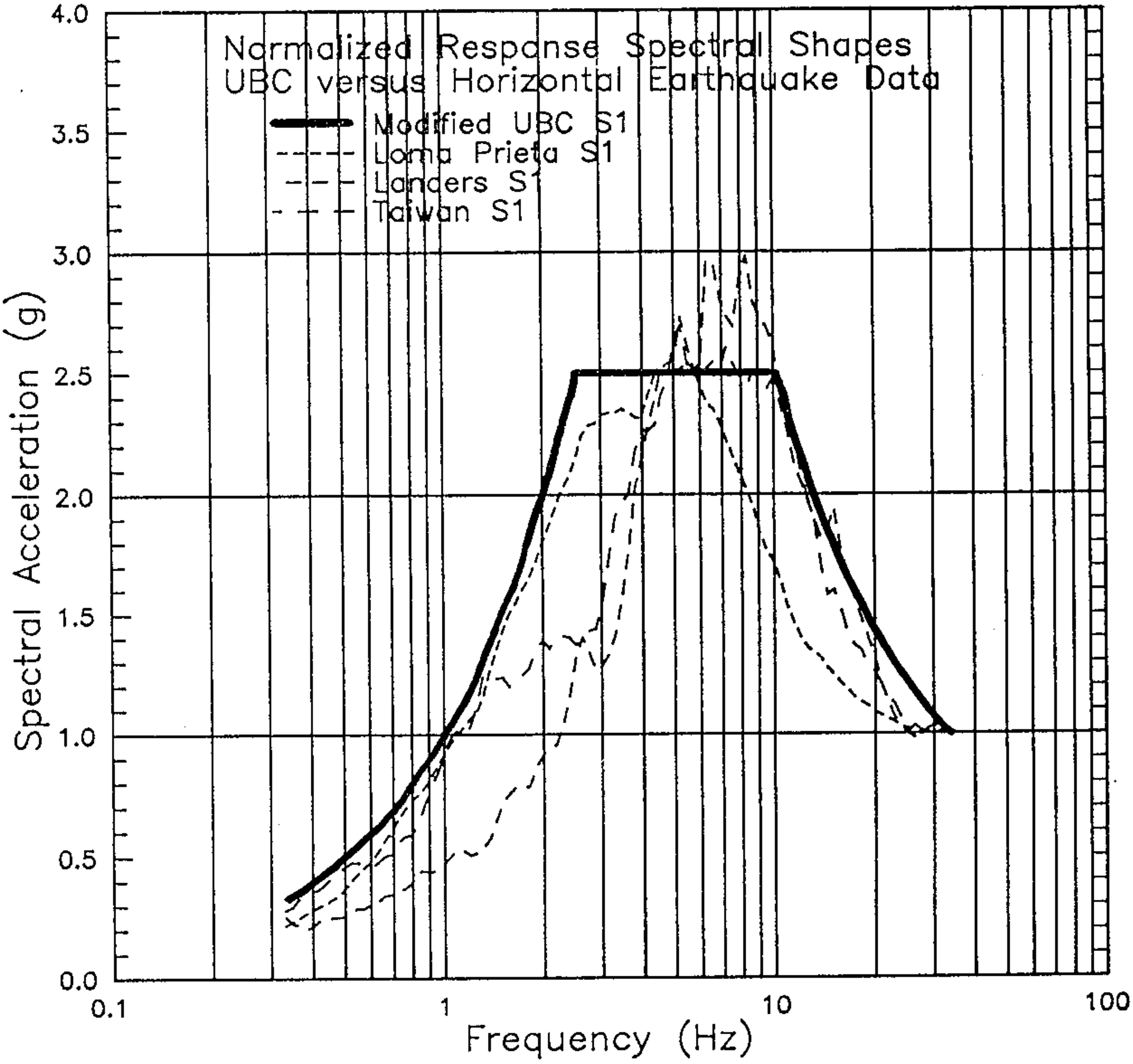

Figure 4. Observed mean horizontal response spectral shapes of the UBC S1 type for the Hualien, Loma Prieta, and Landers earthquakes. Also shown is the modified UBC S1 design spectral shape. All spectral shapes are for 5% damping.

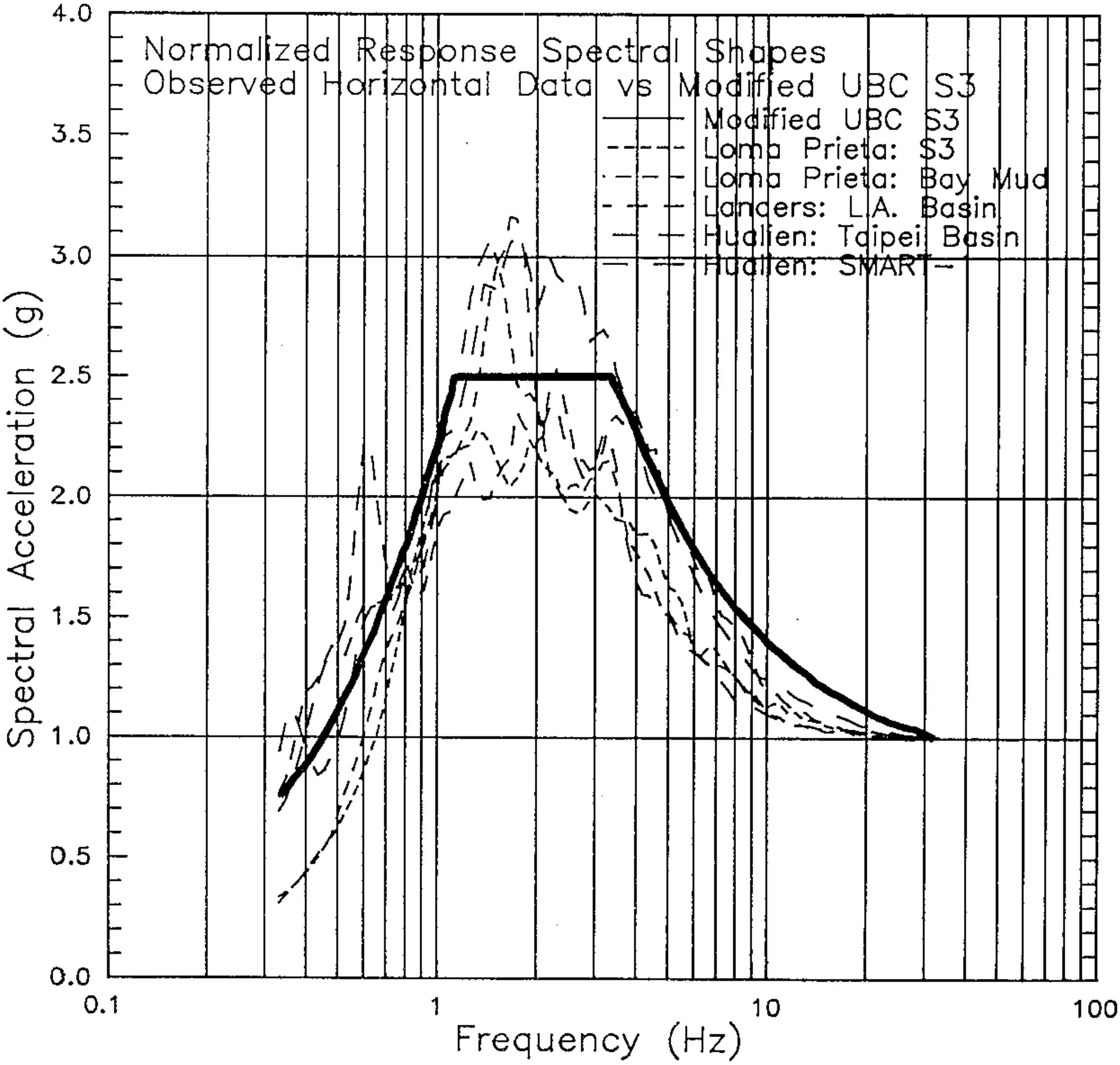

Figure 5. Observed mean horizontal response spectral shapes of the UBC S3 type for the Hualien, Loma Prieta, and Landers earthquakes. Also shown is the modified UBC S3 design spectral shape. All spectral shapes are for 5% damping.

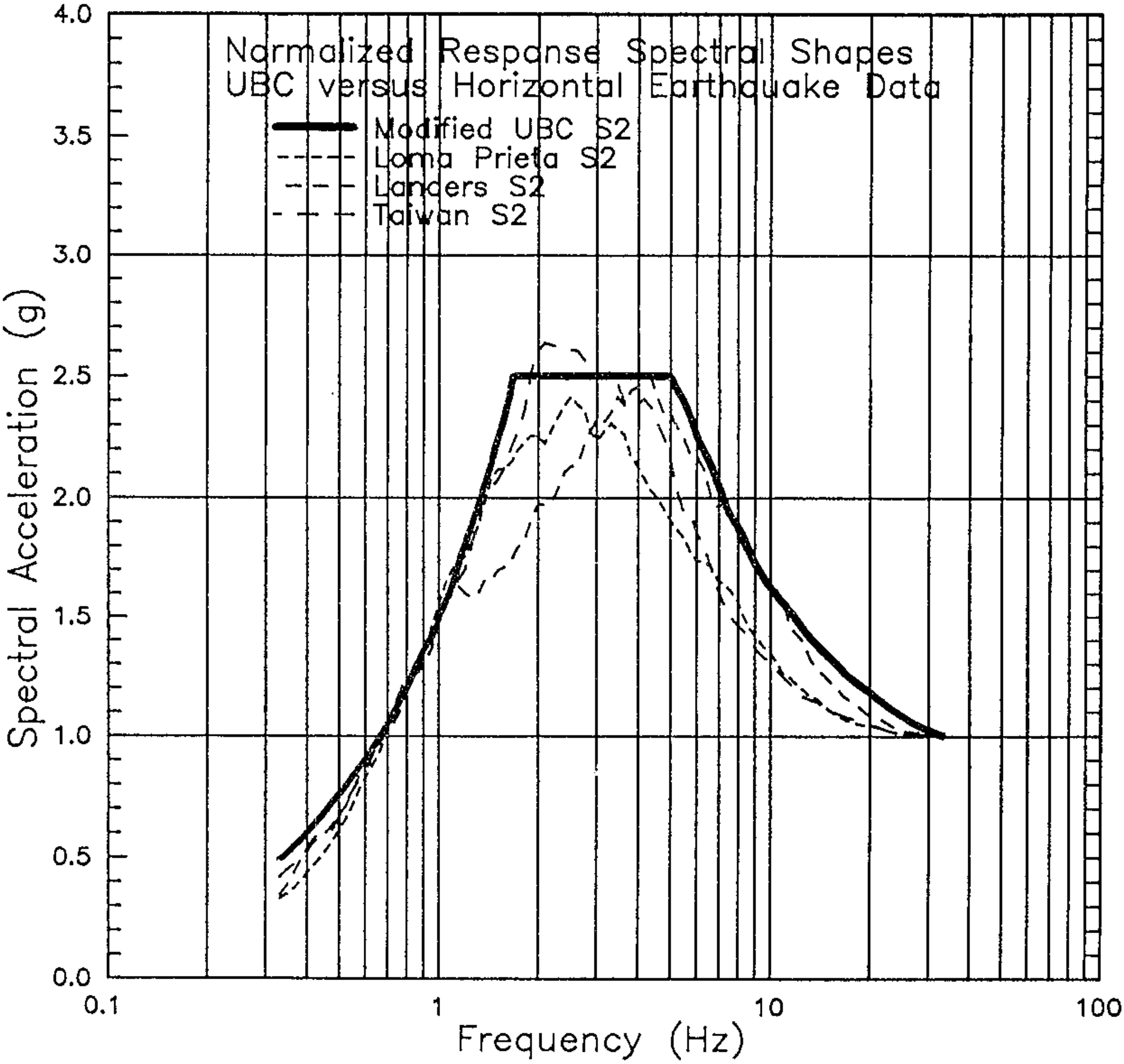

Figure 6. Observed mean horizontal response spectral shapes of the UBC S2 type for the Hualien, Loma Prieta, and Landers earthquakes. Also shown is the modified UBC S2 design spectral shape. All spectral shapes are for 5% damping.