Paper No. 1475. (quote when citing this article)
Eleventh World Conference on Earthquake Engineering
ISBN: 0 08 042822 3

THE SOFT SOIL SITE RESPONSES TO THE MANJIL, IRAN (1990) EARTHQUAKE

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ABSTRACT

The responses of the soft soil sites are studied during the Manjil, Iran earthquake of the 20 June 1990, (Mw7.3) in view point of site amplfication and studing the changes in the site dynamic periods. The silty-clayey sites are compared with the sites of deep cohisionless soil sites (in the shoreline of the Caspain sea). The 1-D SHAKE analysis is used and the H/V analysis is applied for the comparison. The results show the smoothing of the response spectra on the soft sites, where the amplification functions show amplification periods up to the 4 second. In the other hand one may see the spreading of the frequency domain of the amplification for the soft sites.

KEYWORDS

Site Effects, Manjil, Iran, Soft Soil, Amplification, Nonlinearity, Peak Ground Acceleration, Predominant Period.

INTRODUCTION

The site effect studies on the Manjil Earthquake in northwest of Iran (20 June 1990; Mw 7.3, Ms7.7, mb6.8;Fig.1) is carried out in the recent years (Zaré 1994, 1995a, 1995b, 1995c). In these studies the nonlinear site responses are taken to considerations in the near field and on the soft soils. This paper presents the soil behavior in the silty-clayey soil sites, and these sites are compared to the site responses on the deep cohisionless soil sites in the Caspian sea shoreline. Since there are not obtained any record on the rock basement or the rock outcrops, the registered time-histories on the soil surface (free field accelerometers) are deconvoluted in orther to obtain the motion on the rock surface. The 1-D SHAKE analysis is applied, and the results are compared with the H/V analysis, where the response spectra of the motions on the horizontal components are divided by those of the vertical components. The result of the study on the soft soil sites are dominant for the special spectral shapes (spread spectral shape, long period amplification periods).

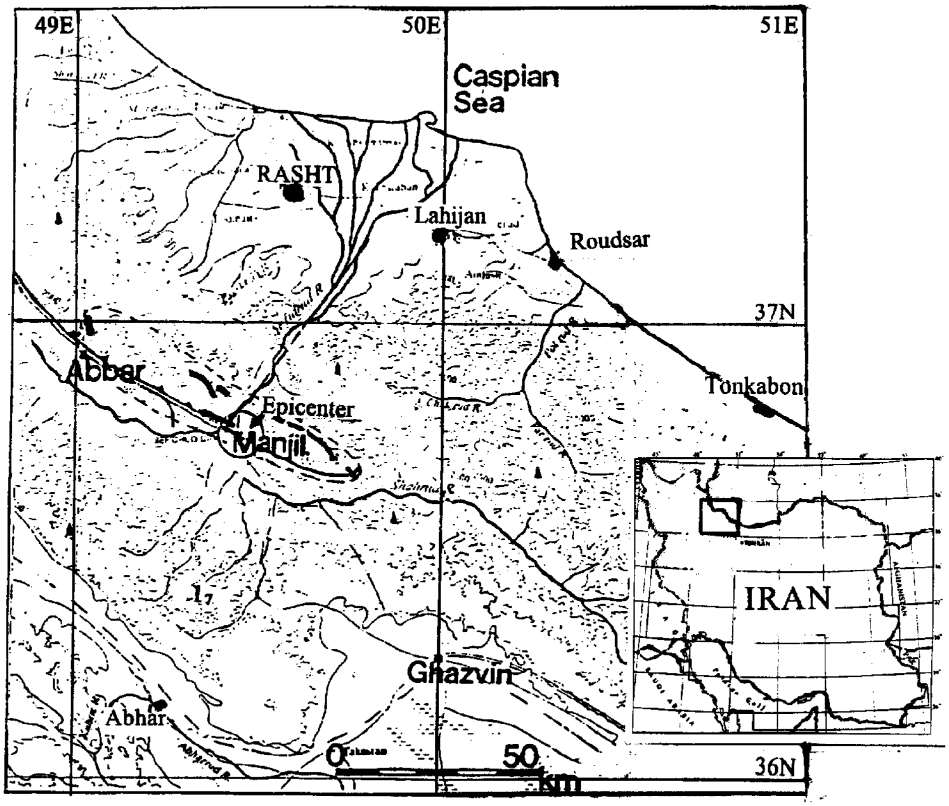


Fig.1 The studied region. The earthquake origin zone is specified with the dashed lines. The earthauke surface fault ruptures are marked with thick lines. The specified thrust which passes nearby Abbar and Manjil is the "Harzevil fault zone" which is reactivated during the Manjil earthquake.

THE STUDIED SITES

The strong ground motions in the Manjil earthquake of 20 June 1990 (Fig.1), were recorded in 22 sites, from Ardebil in northwest to Tehran in southeast, within about 210 kilometers distance from the zone of the energy release. The soft soil sites which are studied are Abhar, Lahijan, Roudsar and Tonekabon (Table-1);

Table-1: Studied sites on the soft soil deposits, where the Manjil earthquake is recorded ;

Site	Distance from Zone of Energy Release (km)	Peak Horz. Acceleration (cm/sec.sec)	Predominant Period (sec)	Intensity I(MSK)	Site Geology	Site Type
Lahijan	61	166	0.3	VI+	Clay	4
Abhar	69	196	0.4	VI+	Clayey -silt	4
Roudsar	70	88	0.4	VI+	Silty Sand	3
Tonkabon	105	88	0.5	VI+	Silty Sand	3

The site types are seclected as suggested by BHRC (1988) and in the UBC (1991). The obtained time-histories in the mentioned sites (Table-1) are deconvoluted (SHAKE analysis; Schnable et al 1972) in a research on the site effects and strong motions in the Manjil earthquake (Zaré1994). The site specifications are studied based on the geotechnical borring logs and the soil profils are examined in each site during the field observations. The Abhar accelerogram was located on a Clayey -silty site with a depth of about 50 m, where the ground water level is settled at this depth. Lahijan site is placed in the Caspian shoreline, on a high plactic clayey site with about 30m depth that is located on a silty sandy layer up to the 70-90m depth , where the ground water table is situated in 5m depth. The site of Roudsar and Tonkabon are on the sandy to silty-clayey sand layers on the Caspian shorline. The amont of clay and silt was observed more for the Tonkabon site. The ground water table is located in about 2 to 5m in these two sites. There are the base rock below these surface soil layers.

The response spectra for the studied sites are shown in the Fig.2. It is observable that the spectra on the Abhar site is spreaded over the longer periods(Fig.2a) , and in Lahijan the response spectra is absolutely smoothed on the surface layer(Fig.2b). In the deep cohisionless sites of Tonkabon and Roudsar, there are also obvious the peaks in the longer peiords (Fig2 c&d). Comparing the spectra for the clayey, silty-clayey sites to those on sandy layers , the similarity of the response spectra is apparant.

The amplification functions are shown for these sites in Fig.3. The clayey - silty sites are shown together (Fig.3a) and the sites on the sandy layers are indicated separately (Fig.3b). The soft soil sites are accompanied with the vast periodic domain of the amplifications (Fig.3a). This vast area is obvious for the Abhar spectra in the higher frequencies, while the amplifications took place in Lahijan in lower frequencies (longer periods).

APPLICATION OF H/V METHOD

The acceleration response spectra on the horizontal components are divided to the response spectra on the vertical ones for the soft soil sites (Fig.4) . This is fundamentally shown by Nakamura (1989) for the microtremors, to find the natural site periods. In this study, this method is examined for the strong motions. The predominance of P waves on the vertical component of the motion and the S waves on the horizontal component provide the basis for this analysis. It is expected that the spectra on the horizontal component comprise the soil nonlinearity, and through dividing it by the vertical spectra, this effect will be able to be determined . The spectra on the vertical and horizontal components are indicated for Abhar (Fig.4a), and Lahijan (Fig.4c) and the H/V spectral ratios are presented in Fig.4b&d. The intresting result is the existance of longer amplification periods which were not determinable with the classic SHAKE analysis (deconvolution method). The amplfication periods on 2.4 sec for Abhar and 3.2 & 4 sec for Lahijan are found through the H/V analysis.

THE SOFT SOIL NONLINEAR ITY; RESULTS OF THE MANJIL EARTHQUAKE

The peak acceleration values on the soft soil sites are already compared to these values on the rock outcrops by Zaré (1994, 1995a). Since no time-history is obtained on the rock outcrops or in a down hole array (on the base rock) , the motions are deconvoluted to find the rock outcrop motions in each site. The PGA values which are calculated in this way (on the rock outcrops) are shown against these values on the soft soil sites (Fig.5) . It is clear that the limit for the nonlinearity was about 0.30 - 0.33g in the Manjil earthquake (on the horizontal and the vertical components). It must be mentioned that the results presented in Fig.5 are based

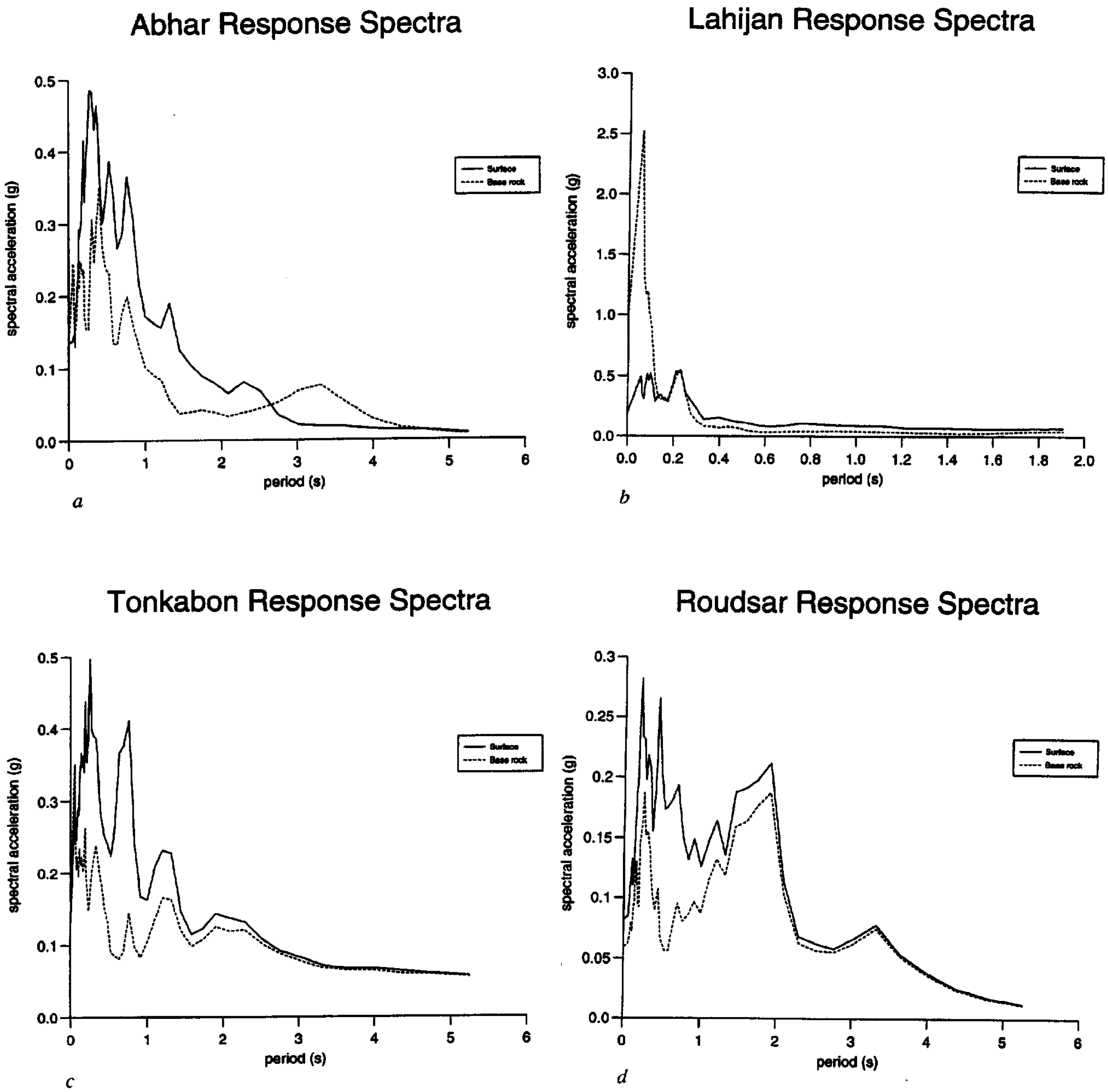
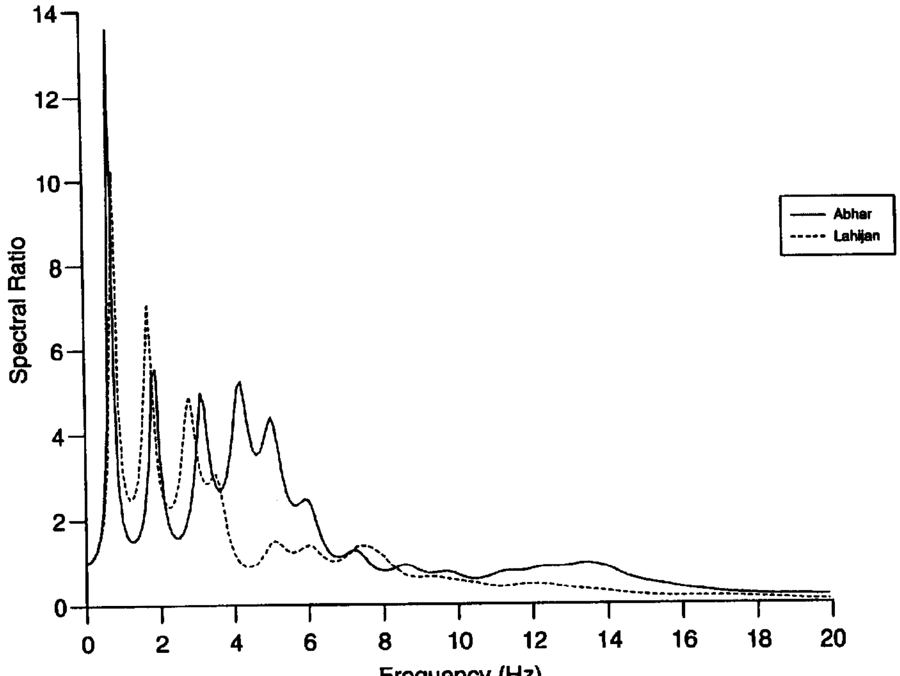
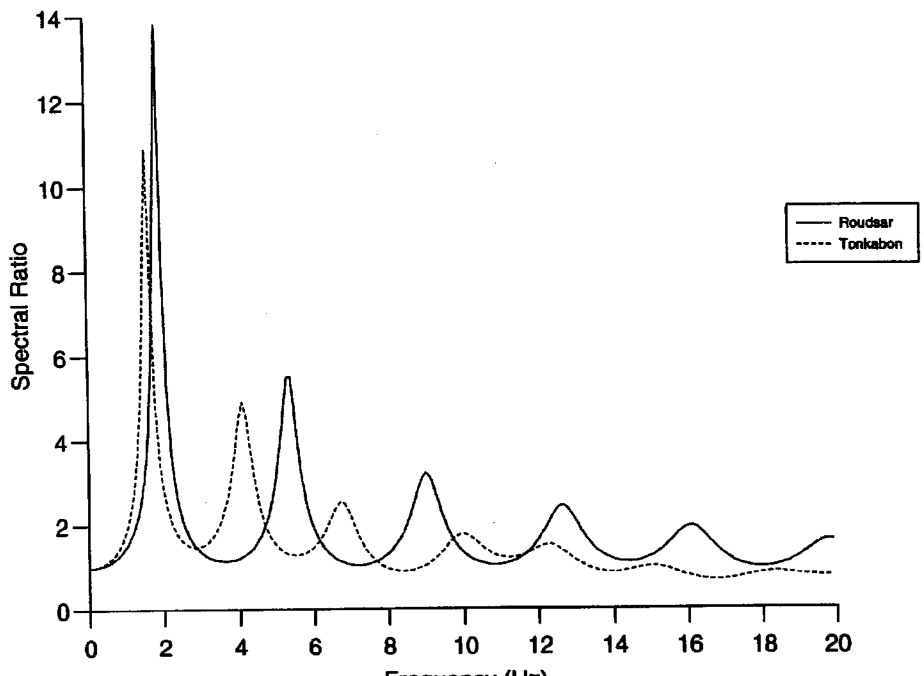


Fig.2. The response spectra at the (a) Abhar, (b)Lahijan, (c) Tonkabon and (d)Roudsar .
The base rock spectra are developed thruogh the SHAKE analysis (deconvolution method).



a



b

Fig..3 . The Amplification functions for the studied sites (a) Abhar & Lahijan, and (b) Roudsar and Tonkabon.

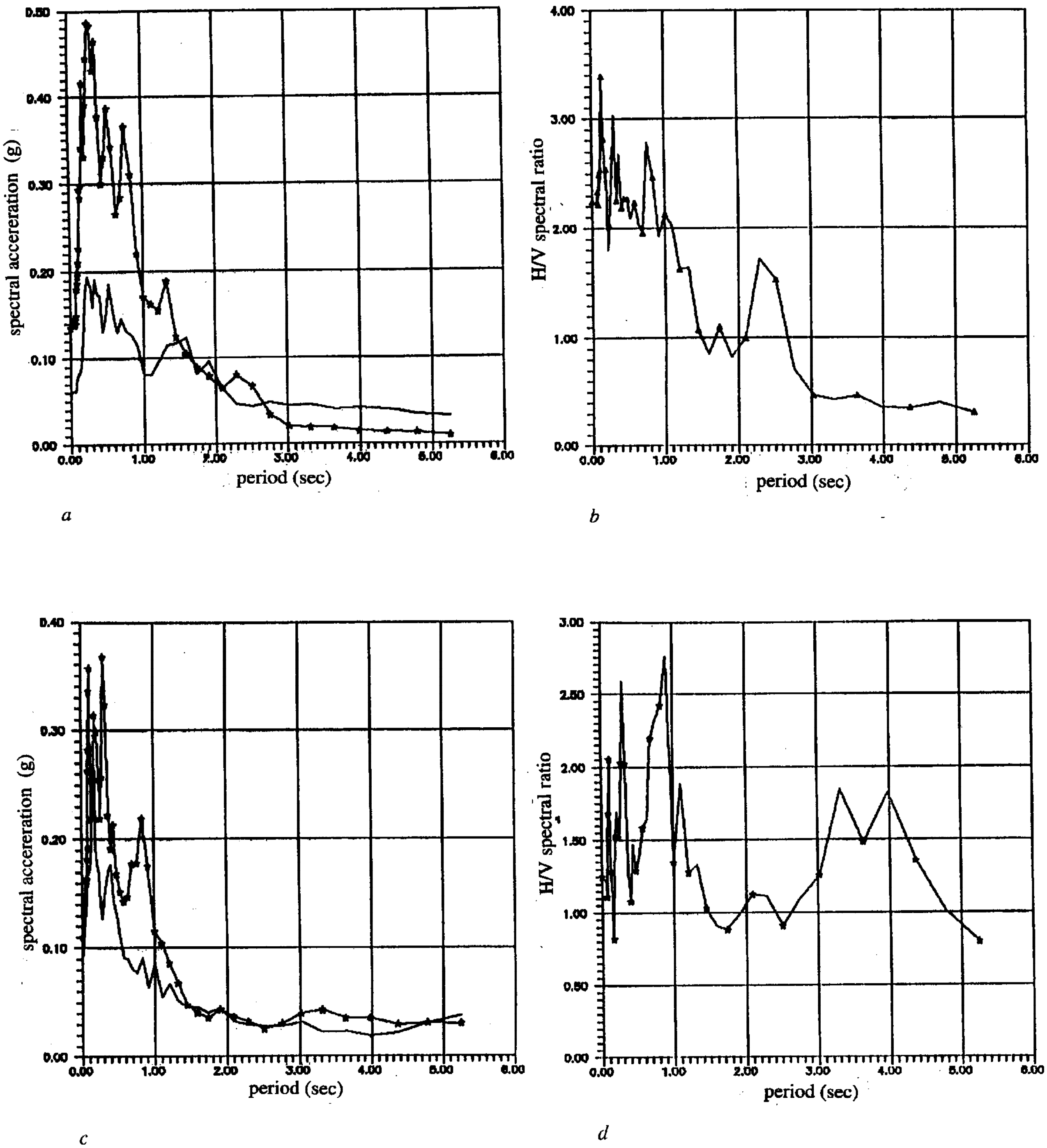


Fig.4. The response spectra and H/V spectral ratio for Abhar (a&b), and Lahijan (c&d). In the response spectra,the marked spectra are the horizontal components and the others are the vertical ones.

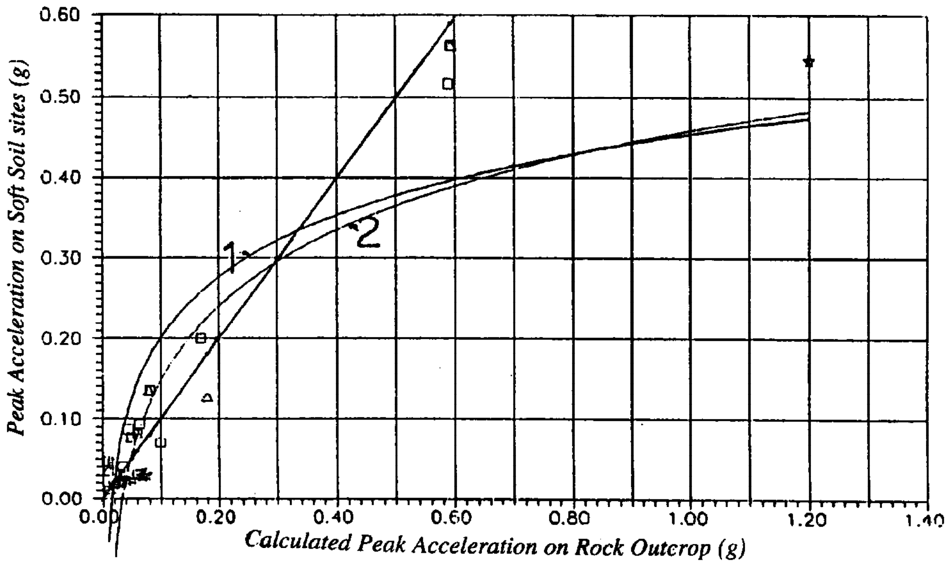


Fig.5. Relationship between the PGA on the soft soil sites and on the Rock outcrops (calculated) during the Manjil earthquake (1; horizontal, 2; vertical components) , (after Zaré 1995a).

on all of the studied site (in 17 studied sites during the Manjil earthquake) and therefore contain also the results obtained for the Ahhar, Lahijan, Roudsar and Tonkabon sites.

CONCLUSIONS AND DISCUSSION

Regarding the developed results herein, the typical behavior of the soft soil sites are predonimantly shown , and compared with the characteristics of dynamic response on the deep cohisionless soil sites. Keeping in mind the simiqrity of the response spectra for the silty-clayey sites and those for the sandy sites, the amplification funtions are dominant for these two grades of sites (soft soil and deep cohisionless soil sites). The forthcoming conclusions are suggested based on the results;

1- The response spectra on the deep cohisionless soil (sandy) sites are similar to the spectra on the soft soil sites (Fig.2).

2- It was previously shown by Zaré (1995a) that the increasing in the intensity of the motion on the soft soil layers is accompanied with the elongation of the priodic domain of the amplifications (which is obvious on the amplifcation functions ; Fig.3) . This problem is proved again for the soft soil sites with the results of the Manjil earthquake.

3- The harmonics on the amplification functions (spectral ratio against frequency; Fig.3b) are specific and apparantly determinable for deep cohisionless soil sites (Fig3b) from those of the soft soil deposits (Fig3a); the distances in the peaks for the amplification spectra on the sandy sites are larger than those of the soft soil sites.

4- The spectra on the Lahijan clayey site is completely spreaded (Fig.2b), the periodic domain of the amplifications is the largest (lowest frequency domain; Fig.3a) where the longest amplification period is observed for this site through the H/V analysis (Fig4d).

5- The results of the H/V analysis shows the longest amplification periods (3.2 & 4sec for Lahijan, and 2.4 sec for Abhar; Fig.s 4b&d), where these results were not obvious with the SHAKE analysis.

REFERENCES

Building and Housing research Center (BHRC), (1988), *Iranian code for seismic resistant design of buildings*, Standard No. 2800, Pub.No.82., 4th edi. 72p.

Nakamura, Y. (1989), A method for dynamic characteristics estimations of subsurface using microtremors on the ground surface, *QR of RTRI,* No.30, pp.25-33.

Schnabel, P.B. et al. (1972), *A computer program for earthquake response analysis of horizontally layered sites*, Rep. EERC 72-12, U.C. Berkeley, 78 p.

Zaré, M. (1994), The study of the site effects on the strong ground motions during earthquakes, A case study on the Manjil 1990 earthquake; *M.Sc. Thesis,* Engineering Geology Dept., Tarbiat-Modarres University, Tehran, 214p.

Zaré, M. (1995a), Nonlinear behavior in the near-field; A case study on the recent Iranian accelerometric dara, *Proc. 2nd Int. Conf. on Seismology and Earthquake Engineering*; Tehran, IIEES Pub.Vol.2, pp.1283-1292.

Zaré, M. (1995b), Selection of earthquake time histories for engineering proposes regarding the site conditions; A case study, *Proc. 2nd Int. Conf. on Seismology and Earthquake Engineering*; Tehran, IIEES Pub.Vol.2, pp.1293-1300.

Zaré, M. (1995c), Site dependent attenuation of strong motions for Iran, *Proc.5th Int. Conf. On Seismic Zonation*; Nice, Ouest Pub.,Vol.2, pp.1227-1236.