SPECTRAL CHARACTERISTICS OF EARTHQUAKE RECORDS REGISTERED IN SOUTHERN IRAN

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SYNOPSIS

The departures of calculated spectra from the corresponding design spectra obtained from amplification factor approach of Ref. [1] are compared for records registered in Southern Iran and similar records registered in the Western United States. The similarity of records is established on the basis of the shape of the ground velocity diagram. Comparisons indicate that the use of amplification factors obtained from an extensive study of the records of one region to establish design spectra for another region can be associated with a maximum error of the order of 25 percent on design forces in the period range of interest.

INTRODUCTION

The amplification factor approach set forth in Ref [1] provides a viable approach to establishing design response spectra. This approach has been formulated for earthquake applications primarily from an examination of the records registered in the West Coast of the United States. It is of some interest to examine the applicability of the same set of amplification factors to records registered at sites far away from the Western United States. In this paper the records recently obtained in the Zagros range of Iran are considered for examination in order to show the implication of these records from a design point of view. The examination also provides a means for commenting on the amplification factors which have been proposed in Ref [1] . To allow for the fact that records of smaller earthquakes are being studied, we concentrate on the examination of departures of calculated spectra from their corresponding design spectra obtained using amplification factors of Ref. [1] . To complete the examination, we compare the departures thus calculated to departures of spectra of records registered in the Western United States.

RECORDS CONSIDERED

Since the turn of century several large shocks have occurred in Iran with some magnitudes more than 7 on the Richter scale. The last destructive earthquake occurred in Ghir (Southern part of Zagros range, April 10, 1972 M= 6.3) which killed more than 5000 people. Unfortunately no strong motion records are available from these shocks. Since, 1973, the Plan and Budget Organization of Iran has begun establishing a net of strong motion accelerographs which now has instruments at 200 locations and it is planned to expand the net in the future. Records obtained thus far from these instruments belong to shocks in general with magnitude less than 4. In the magnitude 5 to 6 range we have two records from the southern part of the Zagros range, which are considered in this study. In Fig. (1) are shown diagrams of the ground acceleration, velocity, and displacement as a function of time for one horizontal component of the record registered in Bandar-Abbas in March 7, 1975.

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From the consideration of ground velocity diagram which contains a large number of positive and negative velocity pulses in succession, this record is judged to be comparable, except for amplitudes, to the motions such as those recorded in El Centro and Taft, California in 1940 and 1952, respectively. On this basis the departure of spectra of records summarized in Table 1 are studied in this paper.

TABLE 1 RECORDS CONSIDERED

Record & Date	Magnitude (Richter)	Epicentral Dist. Km	Depth Km	Horizontal Components	Maximum Values of Ground Motion			Designation in paper
					$\ddot{y}$, cm/sec^2	$\dot{y}$, cm/sec	y, cm	
Bandar-Abbas March 7, 1975	5.8	20	27	N18W	119.	10.2	6.4	1
				N72E	85.6	10	6.5	2
Haji-Abad Oct. 8, 1975	5.3	30	51	N19W	68.2	3.6	1.8	3
				N71E	64.	6.5	4.2	4
El Centro May 18, 1940	7	48	24	NS	324	32.8	21.6	5
				EW	215	32.5	19.8	6
Taft July 21, 1952	7.7	64	24	S69 E	177	15.5	9.2	7
				N21 E	167	15.5	5.7	8

It is noted that the El Centro and Taft records are registered on firm alluvium with the depth of alluvium deposit at El Centro being of the order of 1200 meters and that at Taft being of the order of 10 meters. The site of Iranian records in Table 1 are also on firm alluvium of definitely more than 100 meters depth.
Elastic Response Spectra for several values of damping for the motion of Fig (1) are shown in Fig (2). The general trapezoidal shape of these spectra confirm the fact that except for amplitudes these spectra are similar to those of El Centro and Taft sites, therefore the comparison of departures of these spectra from their design spectra with the same information for the United States records is valid. It is also added that the amplification factors proposed for the construction of design spectra are intended for records with velocity diagrams consisting of a succession of velocity pulses; in fact the application of the same amplification factors to records with limited number of velocity pulses produces very obvious overestimation, as is the case for the Parkfield record of June 27, 1966 which is not shown here because of space limitations.

COMPARISON OF CALCULATED AND DESIGN SPECTRA

Undamped elastic response spectra calculated for records listed in Table 1 are compared with their corresponding design spectra in Figs (3) and (4) . Figure (3) gives comparisons for records registered in Iran and Fig. (4) shows similar information for the records from the Western United States which are listed in the Table 1. The design spectra for each record is obtained by multiplying maximum values of ground acceleration, velocity, and displacement of each record by amplificatinn factors respectively of 6.4 , 4, and 2.5 which are taken from Fef [1]

Since we focus our attention on the trend of departures of calculated spectra from corresponding design spectra, using more improved amplification factors, Ref [2] , would also lead to similar information which is presented herein.

Using amplification factors and procedure of Ref [1] , five sections are defined in the period range of interest which are numbered 1 through 5 in this discussion and are so indicated in Fig (3) . In Sect. 1 response spectra approach the ground acceleration itself and this Sect. is not of interest to consider departures of amplified values.

In Sect. 2 of spectrum for some of Iranian records the design spectrum over-estimates the calculated spectra; however, Iranian records are also found in Fig(3) for which the design spectrum in Sect. 2 provides a good approximation to the calculated spectra. Because of existence of a good fit in some cases and over-estimation in others, the use of amplification factor of Ref. [1] in this Sect. are appropriate at this time for purposes of design. In the same Sect. 2 for the American records, both good fits and under-estimations are seen which suggest some refinement of design spectrum for the records of this region in Sect. 2 may be necessary.

In Sect. 5 of spectrum which corresponds to the long-period structures the departures of calculated spectra from their respective design spectra have a similar behaviour for records of both Iran and U. S. ; under-estimations occur at periods longer than 5 seconds which are not of interest in many design.

In Sect. 3 and 4 the calculated spectra depart from the design values positively and negatively for all records from Iran and U. S. which are considered herein. Evidently, for purposes of establishing design spectra positive departures are of interest. To analyze the nature of departures of records for Iran and the United States a departure index is defined as follows:

$$\delta = \frac{\frac{1}{n}\sum_{i=1}^{n} r_i - \text{design value}}{\text{design value}} \qquad (1)$$

in which i extends over all the peaks in spectrum which exceed the design spectrum in the Sect. of interest and r_i is the peak value of response spectrum at the period which it occurs. Equation 1 defines a pseudo coefficient of variation. The values of δ thus calculated from the spectra of Figs. (3) and (4) are listed in Table 2.

TABLE 2- VALUES OF δ IN EQ. 1
For Records of IRAN and U. S.

Record Iran	Sect of Spectrum 3	Sect of Spectrum 4	Record U. S.	Sect of Specturm 3	Sect of Specturm 4
1	0. 55	0. 24	5	0. 40	0. 25
2	0. 41	1. 10	6	0. 18	0. 26
3	0. 45	0. 89	7	0. 50	0. 40
4	0. 95	1. 08	8	0. 42	0. 42
average	0. 59	0. 80	average	0. 38	0. 33

The average value of δ for each Sect. of the spectrum and for four records of Iran and the United States are also given in Table 2. To interpert the results, since amplification factors used are derived from the data in the United States, the quantity Q in Eq. (2) gives an indication of under or over estimation which would be implied by using these amplification factors to establish design spectrum in Iran.

$$Q = \frac{(1+\delta_{Ave})\ \text{U.S.}}{(1+\delta_{Ave})\ \text{IRAN}} \qquad (2)$$

The values of Q for Sects. 3 and 4 of spectrum are 0.87 and 0.74 repeatively. Since these Q values are not drastically different from unity, the results obtained indicate that the amplification factors established on the basis of an extensive study of records in a region may be used without serious error to establish design spectra for records of generally similar character in another region of the world.

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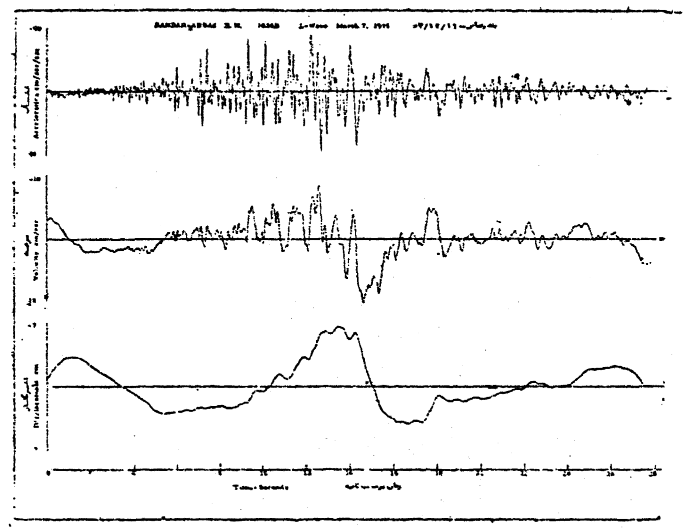
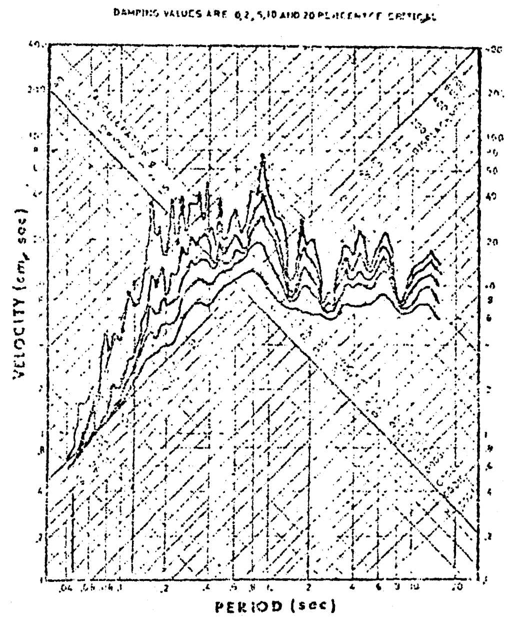
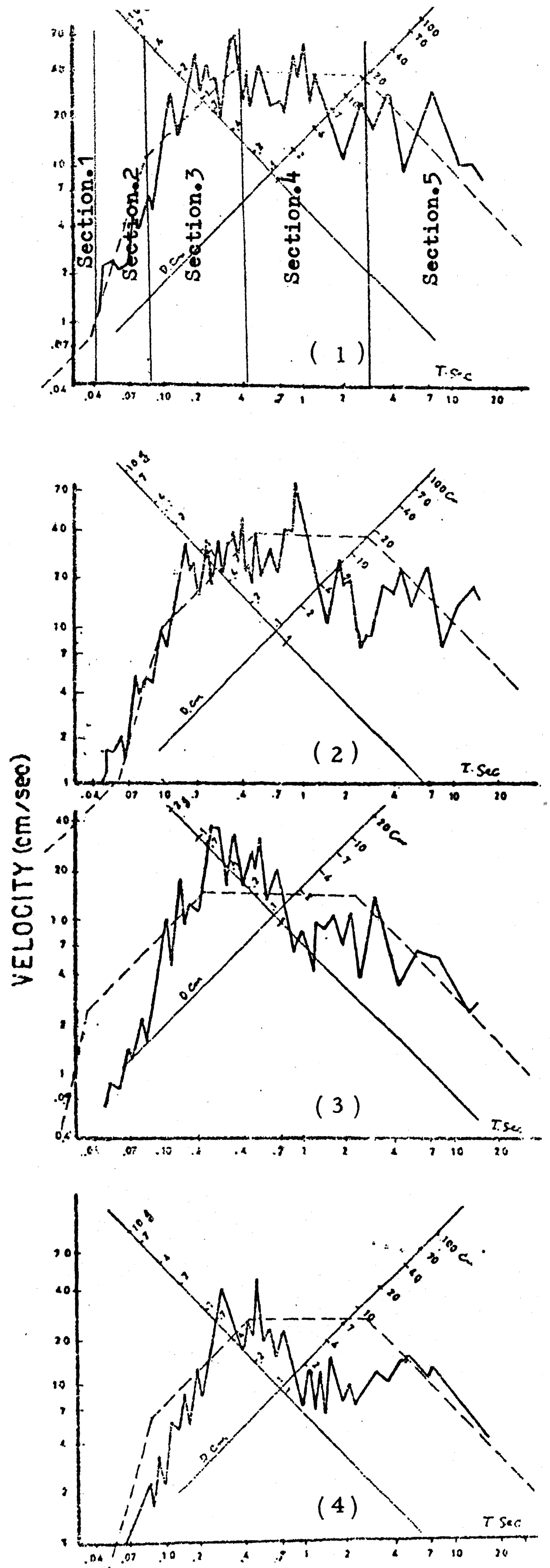


Fig(1) Diagrams of the ground acceleration, Velocity and displacement as a function of time.
Bandar -Abbas Earthquake of March, 1975- N72E component.

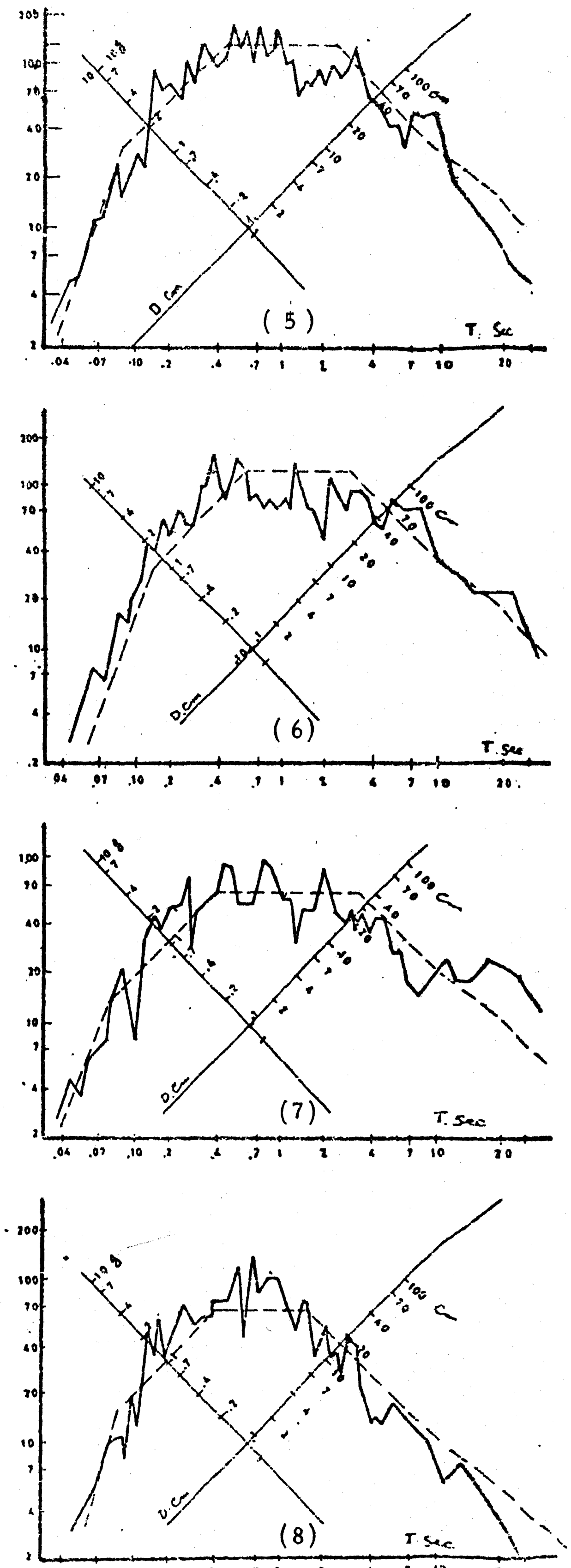


RESPONSE SPECTRUM

Fig(2) . Bandar-Abbas Earthquake of March 1975- N72E Component



Fig(3) comparisons of design spectra with records registered in Southern Iran which are listed in Table 1



Fig(4) comparisons of design spectra with records from Western United States which are listed in Table 1