A SIMPLIFIED PROCEDURE FOR OBTAINING

SITE DEPENDENT DESIGN SPECTRA

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SUMMARY

A simplified procedure for obtaining the site dependent spectra is described. Some comparisons with the response spectra of actual earthquakes and the Newmark's spectra and the Regulatory Guide 1.60 spectra are also presented.

PROCEDURE FOR CONSTRUCTION OF SITE DEPENDENT SPECTRA

In [1] based on several bounds developed on the magnitude of the response spectra in various frequency ranges and evaluation of several parameters, site dependent spectra for a site with given site period and peak ground acceleration are established. Here, a simplified procedure for construction of the site dependent spectra as developed in [1] is presented.

A site dependent smooth spectra as shown in Fig. 1 is completely specified if the coordinates of seven points ABCDEFG are known.

Suppose T_V is the predominant site period and a is the peak ground acceleration. The natural periods of various control points in seconds are given by

$$T_A = T_v,\ T_B = 4/T_v,\ T_C = T_v/3,\ T_D = 3T_B = 12/T_v,\ T_E = 30,$$
$$T_F = T_v/10,\ T_G = 0.03. \tag{1}$$

The amplitudes of the response spectra at various control points are then given by

$$S_v(\xi,\ T_A) = (\frac{aT_v}{2\pi})N(1 - e^{-100\xi})^{\frac{1}{2}}, \tag{2}$$

$$S_v(\xi,\ T_B) = (\frac{2a}{\pi T_v})N(1 - e^{-100\xi})^{\frac{1}{2}}, \tag{3}$$

$$S_v(\xi,\ T_C) = (\frac{aT_v}{2\pi})\ \frac{N}{3}\ ,\ S_v(\xi,\ T_D) = (\frac{aT_v}{2\pi})\ \frac{N}{3}\ , \tag{4}$$

where ξ is the damping coefficient, and the parameter N is defined by

$$N = (1 + 2\xi)(\frac{0.2}{\xi})^{\frac{1}{2}} \qquad \text{for} \quad \xi > 0.005. \tag{5}$$

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It is clear that when the amplitudes of the response spectra of points A, B, C and D are known, the rest of the spectral curve can be completed trivially. The line DE is a constant displacement line, and the line CF is a constant acceleration line. Point G has an acceleration response equal to that of the ground.

In Fig. 1, the smooth site dependent response spectra are plotted for a ground acceleration of 0.3g and a site period of T_V = .66 sec for several values of damping coefficients. It may be noted that for damping larger than 2% critical, points A,C and F are along the same straight line; similarly points B, D and E are along a straight line.

Figure 2 shows the site dependent spectra for peak ground acceleration of 0.3g, damping coefficient of 0.5% and predominant site periods of 1.5, 1 and 0.5 seconds. The natural period 1.5 second corresponds to a relatively soft site, and 0.5, second corresponds to a relatively rigid site. From figure 2, it is observed that for high period range, the spectra corresponding to a soft site have higher amplitudes as compared to the response spectra of a rigid site. The situation is reversed in the low period range where the response spectra of a rigid site become larger than that of the soft site. These observations are in full agreement with the results of Seed et al [2].

COMPARSIONS WITH OTHER SPECTRA

In Fig. 3 and Fig. 4 site dependent smooth spectra are superimposed on the plots of spectra for actual earthquake records. These plots are taken directly from the Cal-Tech report [3], the predominant site periods are estimated directly from these plots, and the present proposed smooth site dependent spectra are constructed. It should be noted here that the minimum damping coefficient for the proposed method is 0.5%, while for the Cal-Tech plots this value is zero. In those figures, relatively good agreements are observed between the predicted spectra and the actual spectra.

In Fig. 2 smooth site dependent spectra are compared with the Newmark and the Regulatory Guide 1.60 spectra for damping coefficients of 0.5%. In that figure the site periods are taken to be 0.5, 1 and 1.5 seconds corresponding to relatively rigid, intermediate and relatively flexible site periods. It is observed that in certain period ranges the Newmark and the Regulatory Guide 1.60 are too conservative while in other period ranges they under estimates the spectra. From Fig. 2, it is observed that for flexible sites and small damping coefficients, both the Newmark and the regulatory spectra underestimate the response spectra for all natural periods.

FURTHER REMARKS

A simiplified procedure for the construction of smooth site dependent spectra based on the knowledge of the peak ground acceleration and the predominant site period is presented here. Some comparisons with actual spectra are also made and good agreements are observed. Furthermore, the smooth site dependent spectra for some relatively rigid, intermediate and relatively flexible sites are constructed and compared with the Newmark and R.G. 1.60 spectra and the possible deficiencies of these site independent design response spectra are pointed out.

ACKNOWLEDGMENTS

The financial support of the Atomic Energy Organization of Iran is also gratefully acknowledged.

REFERENCES

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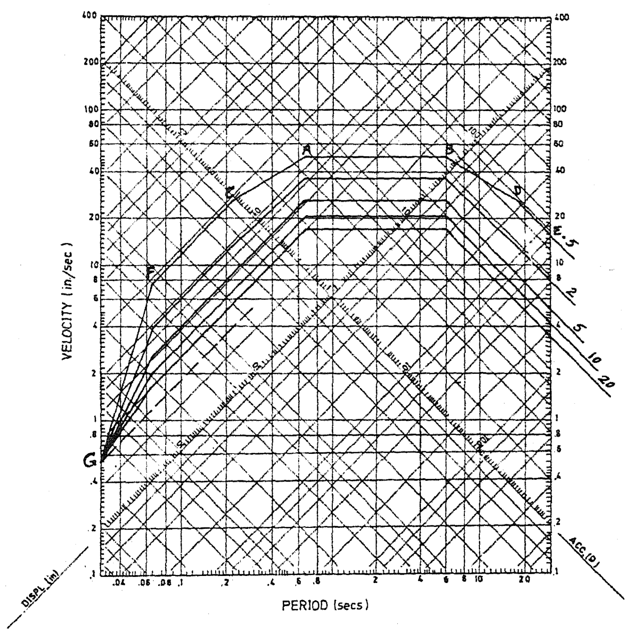

Fig. 1. Smooth spectra for a = 0.3g, T_V = 0.66s and .5,2,5, 10, 20% dampings

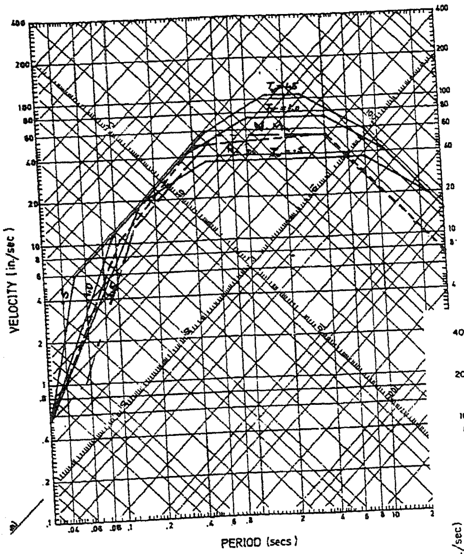

Fig. 2. Comparison with Newmark and Regulatory Guid 1.60 spectra for a=0.3 g,ξ = 0.5% and different values of site periods.

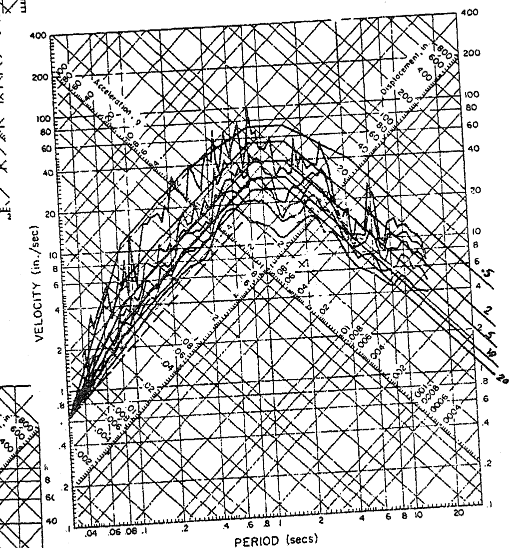

Fig.3. Smooth and actual spectra. Response spectrum, Imperial Valley earthquake, 18 May 1940-2037 PST, IIIA001 40.001.0, El Centro Site Imperial Valley Irrigation District, COMP S00E; damping values are 0,2,5,10 and 20% of critical.

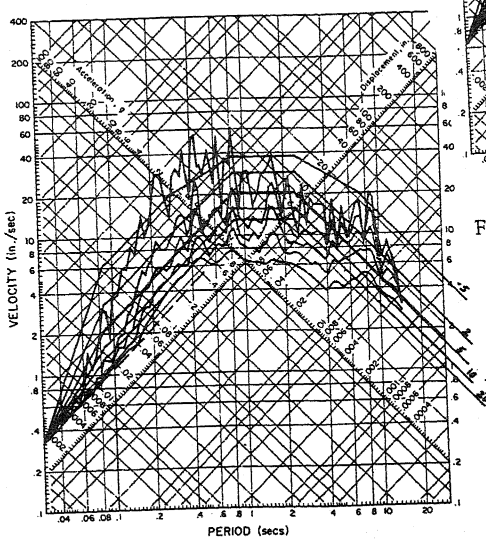

Fig 4. Smooth and actual spectra. Response spectrum, Kern County, California earthquake, 21 July 1952-0453 POT, IIIA004 52.002.0 Taft Lincoln School Tunnel, COMP S69E; damping values are 0,2,5, 10 and 20% of critical.