Enlargement of Site Specific Response Spectrum

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Abstract **- In the present project an attempt has been made to generate response spectrum using site specific soil parameters for a site in seismic zone III i.e. at Coimbatore and the generated response spectrum can be used to calculate the earthquake forces for construction of a new building and for dynamic analysis of existing building. Ground motion data are obtained with reference to the earthquakes at Koyna dam region in Maharashtra which has a magnitude of 6.5 in Richter scale. Response spectrum has been developed by considering a mass-spring element with single degree of freedom using E-TABS software. Finally comparisons have been made between the generated response spectrum and the one provided in the Indian Standard Code IS 1893:2002.**

Keywords— Response Spectrum, E-TABS, Ground Motion Data, Response Spectrum Generated,

1. INTRODUCTION

Seismic design of buildings depends on peak ground acceleration values and shape of Response Spectra curves as depicted by relevant Building codes. Underestimation of peak ground acceleration or wrong evaluation of response spectra may lead to grave consequences during the earthquakes. These two values depend upon earthquake magnitude and distance, as well on the regional propagation path properties and local geological conditions. At the present, there is no doubt that instead of standard design parameters, it is necessary to construct site-specific ones reflecting the influence from different magnitude events at different distances that may occur with certain probability during the lifetime of the construction, as well as the variety of local site conditions. The influence of local geologic and soil conditions on the intensity of ground shaking and earthquake damage has been known for many years and has been shown by many earthquakes. The places situated in areas where earthquake are frequent and severe, if there exists any lapse in estimating the peak ground acceleration and response spectra, it can be catastrophic and may lead to large scale destruction and property loss. In India, the places present in earthquake prone regions should have the design for the structures being made carefully in order to resist the forces that will be acting on the structure due to the local geologic and soil condition. The response of ground shaking is different for different types of soil. The magnitude in unconsolidated sediment is higher than in bedrock for same frequency. Thus the intensity of an earthquake is dependent on the types of soil irrespective of magnitude. The influence of soil deposits on seismic ground motion is enormous in terms of site amplification and thus structural damage and ground failures.

2. DEVELOPMENT OF SOIL PROFILE AT SITE

The soil samples were taken at 5 different places in the Coimbature as per
IS: 1892-1979 — Code of Practice for Subsurface Investigation for Foundations. Shown in table 1.

Table 1: Test Result

S.NO	Test	Result
1	Sieve analysis test	Well graded sand
2	Atterburg's limits: Liquid limit test	• for clay = 53 % • for white coarse gravel =65 %
3	Plastic limit test	1.For clay = 29% for white coarse gravel = 35.36 %
4	Core cutter test	White coarse gravel = 1.52 gm/cc • clay = 1.4 gm/cc
5	Standard penetration test	No. of blows (N) obtained = 65. **Classified as hard or rocky.**

3. DEVELOPMENT OF RESPONSE SPECTRUM PROCEDURE

a) Take the ground motion data of an earthquake. This ground acceleration data is available from the accelerogram, which is earthquake-measuring instrument. This ground motion ordinates are defined at suitable interval. Generally it is at 0.02 sec.
b) For the damping value of 5% take the different value of natural period Tn of a single degree of freedom system (SDF).
c) Compute the deformation response u(t) of this SDF system due to the ground motion ug(t) by using ETABS software.
d) Determine umax, the peak value of u(t).
e) The spectral ordinates are SD = umax, PSV = (2 π /Tn) SD and PSA = (2π/Tn)2 SD. here SD is spectral displacement, PSV is pseudo spectral velocity and PSA is pseudo spectral acceleration.
f) Repeat above steps except first for a different range of Tn.
g) Draw the results graphically to produce the response spectra.

3.1. DEVELOPMENT OF SIGNATURE CURVE

The ground motion data collected from the Koyna dam earthquake data is given in table 2 and the corresponding signature curve i.e. Time period (sec) Vs acceleration plot is generated.
shown in fig 1.

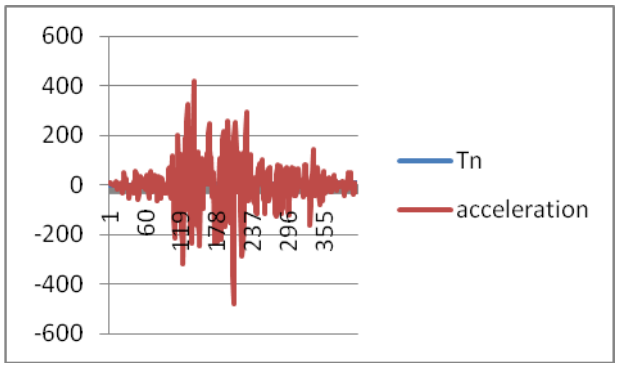

Fig 1: signature curve

3.2. DEVELOPMENT OF DISPLACEMENT SPECTRUM USING E-TABS SOFTWARE

Spring - Mass Element Analysis:

In order to develop the displacement spectra for an SDOF system (single degree of freedom system) we have adopted a spring- mass element analysis method shown in fig 2. By generating a spring mass element in E-tabs software we can obtain the displacement values for different time periods (T_n) and stiffness values.

Fig 2: spring mass element

After creating the spring mass element with a particular stiffness value , a constant mass value and a corresponding damping value, the ground motion data collected is fed into the software using the DEFINE TIME HISTORY FUNCTION > USER FUNCTION option and TIME HISTORY CASES are developed. Then the system is analyzed to get the corresponding displacement value.

3.3. GENERATION OF SITE SPECIFIC RESPONSE SPECTRUM

Each of the deformation, pseudo velocity, and pseudo acceleration response spectra for a given ground notions contains the same information, no more and no less. The three spectra are simply different ways of presenting the same information on structural response. But each of them has their own importance. The deformation spectra provide the peak deformation of a system. The pseudo velocity spectrum is related directly to the peak strain energy stored in the system during the earthquake. The pseudo acceleration spectrum is related directly to the peak value of the equivalent static force and base shear.

Hence the three spectrums displacement, velocity, and acceleration are combined to form a response spectrum so that the shape of the spectrum can be approximated more readily for design purposes with the aid of all three spectral quantities rather than any one of them alone.

The required response spectrum is generated in a four-way logarithmic graph. The four way plot is a compact presentation of the three deformation, pseudo velocity, and pseudo acceleration- response spectra.

3.4. COMPARISION OF GENERATED RESPONSE SPECTRUM WITH THE STANDARD SPECTRUM IN *IS-1893(PART I):2002:*

The Response spectrum generated for the site specific soil parameter is compared with the spectrum provided in IS 1983(PART I): 2002 by calculating the design horizontal seismic coefficient A_h, which is given as:

$$A_h = \frac{ZI}{2R}\left(\frac{S_a}{g}\right)$$

Where,

Z= Zone factor
I = Importance factor
R = Response reduction factor

As per IS 1893(PART I):2002,

Z = 0.16 (for coimbatore)
I = 1.5 (for important buildings)
R = 3.0 (for OMRF)

S_a/g = 2.5 (**Fig 1: signature curve**) Shown in fig 3.
Sa/g = 5.42 (**from generated spectrum**)

Therefore,

For code value of Sa/**g , A_h = 0.1** (inches/ sec^2)
For generated value of Sa/**g , A_h = 0.21** (inches/ sec^2)

Thus we see that the horizontal seismic coefficient value is higher for the generated site specific spectrum.

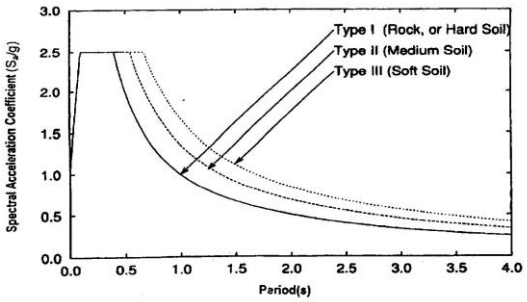

Fig 3. Response spectrum as per IS Code

4. INFERENCE

While comparing the generated response spectrum with that of the spectrum available in IS-1893 Code, the seismic load value obtained for design purpose is higher in the generated spectrum. Hence, we can infer that a higher factor of safety can be imparted against earthquake effects.

This value can be taken for design purpose of highly important building, Irregular structures, and multi-storey buildings for mitigation of earthquake effects.

5. SUGGESTIONS:

- Now-a-days a large number of seismic stations have been setup all over the country so that more number of earthquakes can be recorded.
- Since the ground motion data for Coimbatore earthquake which occurred in February, 1900 is not available, we have referred to the ground motion data of Koyna dam earthquake of magnitude of 6.5.
- In future, if the ground motion data for Coimbatore region is available then site specific response spectrum shall be revised accordingly.
- Also an attempt can be made to develop a response spectrum for the entire Coimbatore region.
- The spectrum shall also be developed for various damping values like 2%, 20%.

6. REFERENCES

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