GENERATION OF ARTIFICIAL EARTHQUAKE TIME HISTORY

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Abstract - Ground motion estimation, due to future earthquakes is one of the most challenging problems in earthquake engineering for seismic response analysis of structure. Earthquake acceleration time histories are required to perform dynamic analysis. Earthquake resistant design critically depends on how accurately the ground motion can be determined at a particular site. In the present work Mumbai region is selected for generation of earthquake time history. This city is located in Peninsular India, which has experienced the devastating Koyna (1967, Mw = 6.3), Khillari (1993, Mw = 6.1), Jabalpur (1999, Mw = 5.8) and Bhuj (2001, Mw = 7.7) earthquakes. Seimoartif software is use to generate artificial earthquake time history for different magnitude of earthquake.

Keywords: Simulated ground motions, Phase angles, Spectrum-compatible motions, Envelope function, and Duration time. Seismoartif

I. INTRODUCTION

Earthquake time-histories are the most presentation of earthquake ground motion because they contain a wealth of information about the nature of seismic wave propagation and ground properties. Earthquake time-histories are usually recommended to be used for dynamic analysis and design of building with irregularities as well as evaluation of the response of earth structures in terms of stability, deformation, and liquefaction potential. Strong earthquake time-histories are generated from one of three fundamental types of accelerograms synthetic records obtained from seismological models, real accelerograms recorded in earthquakes, and artificial records, compatible with the design response spectrum. According to the type of structure under analysis, different earthquake loading representation is needed. In most of the codes and for the majority of structures, a pseudo-static analysis is required, for this type of analysis a smooth response spectra characterizes the earthquake actions. , for some Specific design situations dynamic analysis is required or recommended, hence the selection of one or more representative time-histories is needed. The particular motivation for this research is to generate earthquake time history for Mumbai region and these time history can used for analysis of different structure.

1.1 Types of Accelerograms

Following are different types of accelerograms real accelerograms and artificial accelerograms

1.1.1 Real accelerograms

The advantage of using real accelerograms is that they are genuine records of shaking produced by earthquakes. Therefore, they carry all the ground-motion characteristics (amplitude, frequency and energy content, duration and phase characteristics), and reflect all the factors that influence accelerograms (characteristics of the source, path and site). The disadvantages of real accelerograms are that not all soil combinations are covered, and the spectra are generally not smoothed.

1.1.2Artificial Accelerograms

Artificial accelerograms whose response spectra is closely compatible to the design response spectra can be generated in either time or frequency domain .Artificial spectrum-compatible accelerograms can be generated using seismoartif programs. The program seismoartif computes a power spectral density function from a specified smooth response spectrum and uses this function to derive the amplitudes of sinusoidal signals which have random phase angles uniformly distributed between 0 and 2π. The sinusoidal motions are then summed and an iterative procedure can be invoked to improve the match the target response spectrum, by calculating the ratio between the target and actual response ordinates at selected frequencies. The power spectral density function is then adjusted by the square of the ordinate ratio and a new motion is generated. In order to get other characteristics of artificial spectrum compatible record, such as the duration, it is necessary to obtain supplementary information about the expected earthquake motion apart from the response spectrum. Here the iterative scheme is applied in the frequency domain where the phase angles of the desired motion are randomly generated.

II. FORMULATION

The method used for artificial motion generation is the superposition of the sinusoids (Equation 2.1) which have random amplitudes derived from a power spectral density function. The computer uses a "random number generator" subroutine to produce strings of phase angles (or seeds of random number) with a uniform distribution in the range between 0 and 2π. To simulate the transient character of real earthquakes, x(t) are usually multiplied by an intensity function I(t).

$$.x(t)I(t) \sum_{i=1}^{n} A_i \sin(\omega_i t + \varphi i) \qquad (2.1)$$

Where Ai is the amplitude and □i is the phase angle of the i th contributing sinusoid; I(t) is the intensity function used to simulate the transient character of real earthquakes. The intensity function I(t) can be a trapezoidal, or exponential, or compound intensity envelope.

2.1 Duration time

The duration time and envelope function are necessary in the simulation process of ground motion. the duration time is related with the time required for the fault to complete the rupture. In addition, the delays and advances of seismic waves make the waveform longer, if there are many paths for the seismic waves. An example of the equation for duration time is as follows.

$$T_d = 10^{0.31M-0.774} \qquad 2.2$$

Where, M is earthquake magnitude, the most essential value in design is the maximum response. In addition, strong motion records are digitized with time interval of 0.005 to 0.02 second. The spectrum-compatible motion can be defined with any of the time interval it should be specified as smaller when evaluate the response with prevailing higher modes.

2.2 Envelope function

Envelope function is necessary in the simulation process of ground motion. For the present work exponential enveloped function of intensity is use.

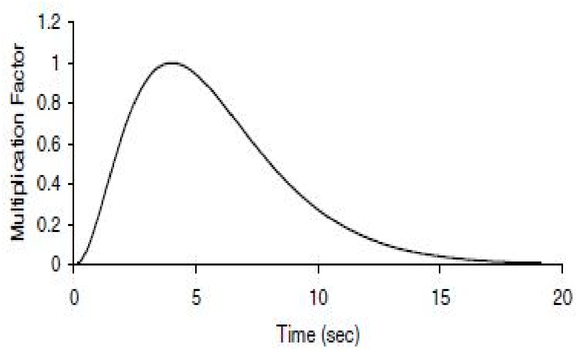

Fig 1 intensity envelope

2.3 Generation of Response Spectra

Response spectrum y(t) is calculated from the following equations for a SDOF system

$$\ddot{y}(t) + 2\zeta_t \omega_i \dot{y}_t + \omega_i^2 y(t) = x(t) \qquad (2.3)$$

Where x(t) is the artificial earthquake ground motion as shown in Equation (2.1)

2.4 Arias Intensity

Arias intensity, AI, is a ground motion parameter that has been used to evaluate damage potential. It is defined as:

$$AI = \frac{\Pi}{2g}\int_0^T a^2 \ (t)dt \qquad (2.4)$$

Where a(t) is the acceleration time history of total duration T. The energy in the accelerogram can be quantified by the Arias intensity.

III. RESULTS & DISCUSSION

The present study is concentrated on generation of artificial earthquake time history for Mumbai reiogn which has experienced the devastating Koyna, khillari Jabalpur and bhuj. Duration of this earthquake is calculated by using empirical relation between duration and magnitude .duration and enveloped function of intensity is primary input used in seismoartif software.Magnitude and duration of this earthquake is shown in table 1.

Sr no.	Fault location	magnitude	Calculated Duration	Enveloped function
1	Jabalpur	5.6	9.162	Exponential
2	Khillari	6.1	13.09	Exponential
3	Koyna	6.3	15.1	Exponential
4	Bhuj	7.7	17.41	Exponential

Table: 1 parameter of earthquake

Generated time history should be compatible with design spectra. In seismoartif software firstly specify the design spectra for damping ratio, figure 2 shows the design response spectra by IS 1893, figure 3 shows the artificial earthquake time history for duration 9.162 sec with pga 1.097g. ,pgv 99.044 cm/sec and pgd 24.069 cm . Figure 4 shows the response spectra for Jabalpur faults compatible with response spectra IS1893. Similary generation of artificial time history for khllari ,koyna, and bhuj are shows in fig5 ,fig 7, and fig 9 . The simulated ground motion for khillari,koyana and bhuj is compatible with response spectra for rock for 5 percent damping IS 1893 .shown in fig 6 , fig 8, fig 10 respectively .

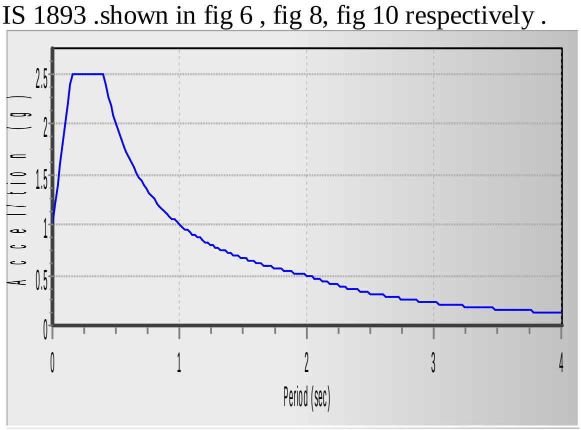

Fig: 2 response spectra for rock for 5 percent damping IS 1893

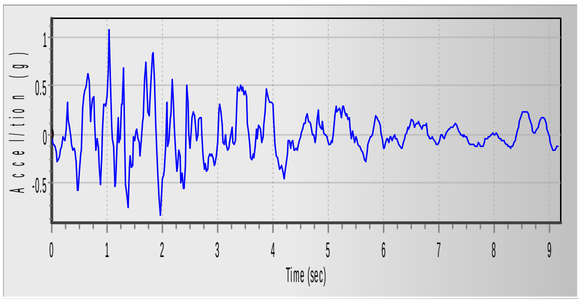

Fig: 3 artificial accelerogram for Jabalpur fault

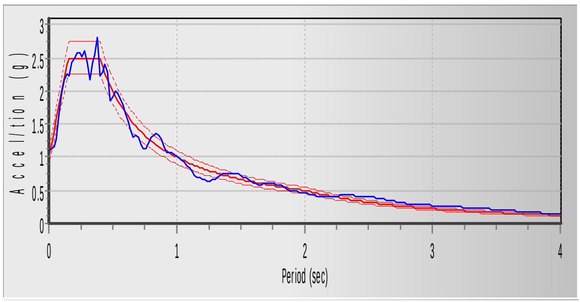

Fig: 4 response spectra for simulated ground motion for fault 1

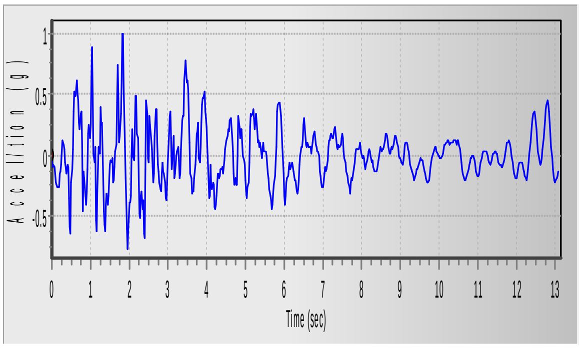

Fig:5 Artificial accelerogram for khillari fault

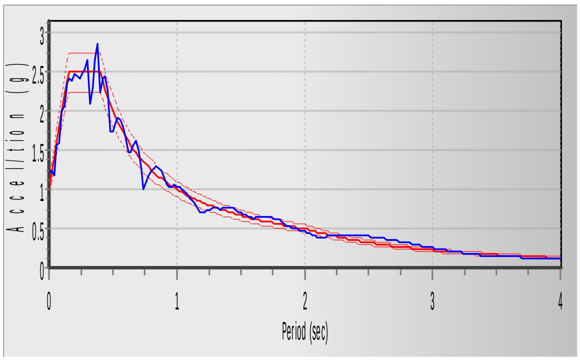

Fig: 6 response spectra for simulated ground motion for fault 2

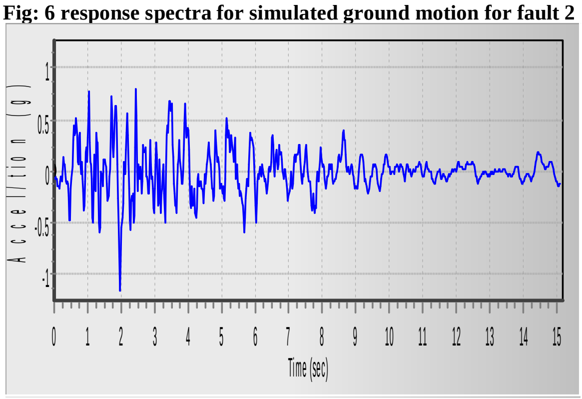

Fig: 7 Artificial accelerogram for Koyna Fault

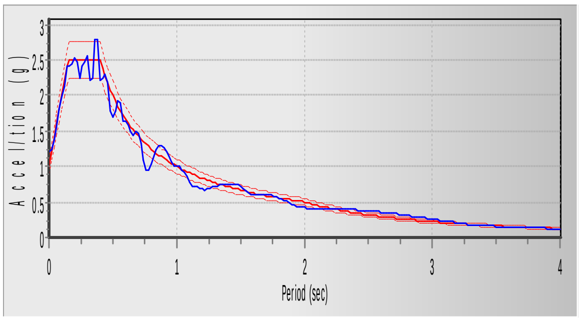

Fig:8 response spectra for simulated ground motion for fault 3

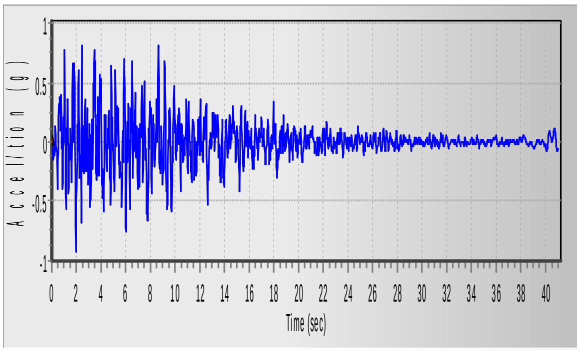

Fig: 9 Artificial accelerogram for bhuj fault

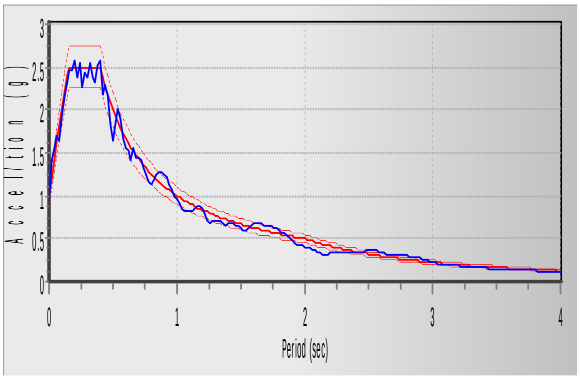

Fig: 10 response spectra for simulated ground motion for fault 4

3.2 Arias Intensity

AI, is a ground motion parameter that has been used to evaluate damage potential. Table 2 shows the variation of duration with arias intensity. The energy in the accelerogram is quantified by the Arias intensity. For large magnitude of earthquake higher energy in the simulated ground motion.

Table 2 arias intensity

Sr no	Fault location	magnitude	duration	Arias intensity
1	Jabalpur	5.6	9.162	8.55
2	Khillari	6.1	13.09	11.107
3	Koyna	6.3	15.1	12.509
4	Bhuj	7.7	17.41	19.185

CONCLUSION

1. The simulated ground motions generated in this study can be applied as the input ground motions for a nonlinear response analysis of high-rise building structures for Mumbai region

2. For generation of artificial earthquake time history envelope function is important parameter because without envelop function artificial accelerogram has non-realistic records and do not represent the general characteristics of real earthquakes time history.
3. Artificial earthquake time history records generally have an excessive number of cycles of strong motion, and consequently have unrealistically high energy content.
4. It can be observed from the generated ground motion, that when the time step, is smaller higher integration accuracy can be obtained.
5. It is observed that duration of earthquake is affects energy content which is used for damage indices.

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