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Estimation Of Peak Ground Acceleration for Jabalpur City

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ABSTRACT

Earthquakes, the most destructive natural hazards in the world, manifest themselves in the form of vibrations of the earth which are caused by the abrupt release of strain that has accumulated over time. Recent years have witnessed an increase in awareness about earthquake and their causes. This article presents an engineering approach to estimate the existing seismic hazard for Jabalpur city which comes under zone 3 and surrounded by number of faults, one of them is Narmada Son Fault (North and South).Jabalpur already experience devastating earthquake of magnitude 5.8 on 22 May 1997 and there will be possibility of occurrence of earthquake in future. After assembling a catalogue of past earthquakes and also fault map , maximum magnitude at or near each sources are marked .The major aim of this study is to perform the seismic hazard analysis of Jabalpur i.e, to found Peak Ground Acceleration by using predictive relationship. It is observed that Jabalpur showed highest value of PGA of 0.15g.

Keywords: *Ground motion, Jabalpur city, seismic hazard analysis, PGA, PSHA.*

I) INTRODUCTION

Earthquakes are one of the most destructive natural hazards in the world. These natural events can cause massive damage to structures leading to total devastation of cities. Earthquakes, which manifest themselves in the form of vibrations of the earth, are caused by the abrupt release of strain that has accumulated over time. Many earthquakes in the past have left many lessons to be learned which are very essential to plan infrastructure and even to mitigate such calamities in future. Jabalpur (Madhya Pradesh) located in 79° 59' E 23° 10' N has population of about 1.2 million and come under seismic zone 3(BIS-1893-2002,Part I) and surrounded by number of faults, Narmada Son Fault is one of them. The city is located in Peninsular India (PI), which has experienced the devastating earthquake of magnitude 5.8 on 22 May 1997 at 04:22 am (local time) centered about 8 km southeast of the city of Jabalpur (epicenter 23.18·N 80.02·E) in the state of Madhya Pradesh in central India, depth of focus is at 33 km.
Major damages occurred in structures in the Jabalpur District, Mandla District, Seoni District and Chhindwara District in Madhya Pradesh. Jabalpur and Mandla were the worst affected districts. Paucity of recorded ground motion data introduces uncertainties into the nature of future ground motion and the dynamic forces to be considered in the design of manmade structures. The behavior of a building, dam or a power plant depends primarily on the local ground motion at the foundation level. A fairly accurate knowledge of such motion, due to all possible sources in the influence zone of about 300 km radius around the construction site, is the most sought after information in engineering practice.
A number of seismic and geological studies have been carried out in various regions of Peninsular India. Seismic hazard analysis has been done using the probabilistic approach for Mumbai city by Raghu Kanth and Iyengar (2006). An attenuation relation for finding out the Peak Ground Acceleration (PGA) for regions in Peninsular India has been formulated by Iyengar and Raghu Kanth (2004) and is
being used by various researchers for performing the seismic hazard analysis.

II) SEISMIC HAZARD ANALYSIS

Seismic hazard analysis is the study of expected earthquake ground motions at any point on the earth. In the context of engineering design, seismic hazard is defined as the predicted level of ground acceleration, which would be exceeded with 10% probability, at the site under consideration due to the occurrence of an earthquake anywhere in the region (Steven Kramer, 2008). A seismic hazard analysis involves the following steps: delineation of seismic source zones and their characterization, selection of an appropriate ground motion attenuation relation and a predictive model of seismic hazard.

The seismic hazard defines the potentially damaging ground shaking in terms of Peak Ground Acceleration (PGA), Peak Ground Velocity (PGV), and/or Peak Ground Displacement (PGD). The quantitative assessment can be achieved either through a deterministic or probabilistic approach. The former delivers absolute values, while the latter estimates the same in terms of probability of non-exceedance corresponding to a certain determined level at a site of interest.

A. Deterministic Seismic Hazard Analysis (DSHA)

In the early years of geotechnical earthquake engineering, the use of DSHA was prevalent. DSHA involves the development of a particular seismic scenario upon which a ground motion hazard evaluation is based. A typical DSHA can be described as a four-step process consisting of:

- Identification and characterization of all earthquake sources capable of producing significant ground motion at the site. Source characterization includes definition of each source's geometry (the source zone) and earthquake potential.
- Selection of a source-to-site distance parameter for each source zone. In most DSHAs, the shortest distance between the source zone and the site of interest is selected.
- Selection of the controlling earthquake (i.e., the earthquake that is expected to produce the strongest level of shaking), generally expressed in terms of some ground motion parameter, at the site.
- The hazard at the site is formally defined, usually in terms of the ground motions produced at the site by the controlling earthquake.

The DSHA procedure is shown schematically in Figure 1. It is a very simple procedure. DSHA provides a straightforward framework for evaluation of worst-case ground motions for structures for which failure could produce catastrophic consequences, such as nuclear power plants and large dams.

B. Probabilistic Seismic Hazard Analysis (PSHA)

Probabilistic Seismic Hazard Analysis (PSHA) provides a framework in which the uncertainties can be identified, quantified and combined in a rational manner to provide a more complete picture of the seismic hazard. The PSHA can also be described as a procedure of four steps, each of which wear some similarity to the steps of the DSHA procedure and is illustrated in Figure 2.

- The first step, identification and characterization of earthquakes sources, is identical to the first step of DSHA, except that the probability distribution of potential rupture locations within the source must also be characterized.
- Next, the seismicity or temporal distribution of earthquake recurrence must be characterized. A recurrence relationship, which specifies the average rate at which an earthquake of some size will be exceeded, is used to characterize the seismicity of each source zone. The recurrence relationship may accommodate the maximum size earthquake, but it does not limit consideration to that earthquake, as DSHAs often do. The ground motion produced at the site by earthquakes of any possible size occurring at any possible point in each source zone must be determined with the use of predictive relationships. The uncertainty inherent in the predictive relationship is also considered in a PSHA.
- Finally, the uncertainties in earthquake location, earthquake size, and ground motion parameter prediction are combined to obtain the probability that the ground motion parameter will be exceeded during a particular time period.

The primary output of a PSHA is a hazard curve showing the variation of a selected ground-motion parameter, such as Peak Ground Acceleration (PGA) or Spectral Acceleration (SA), against the probability of annual frequency of exceedence.

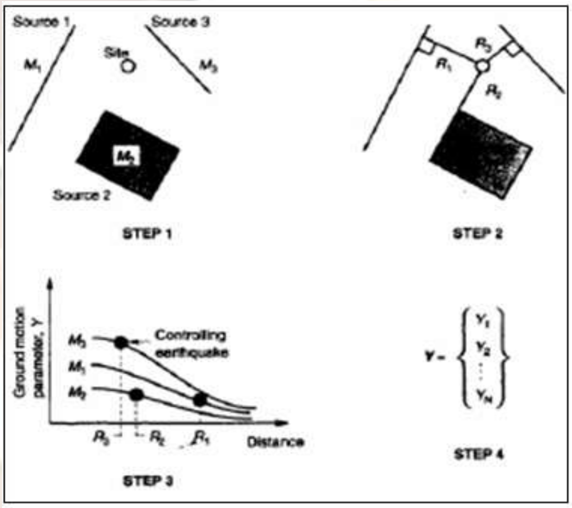

Figure 1 Steps for deterministic seismic hazard analysis

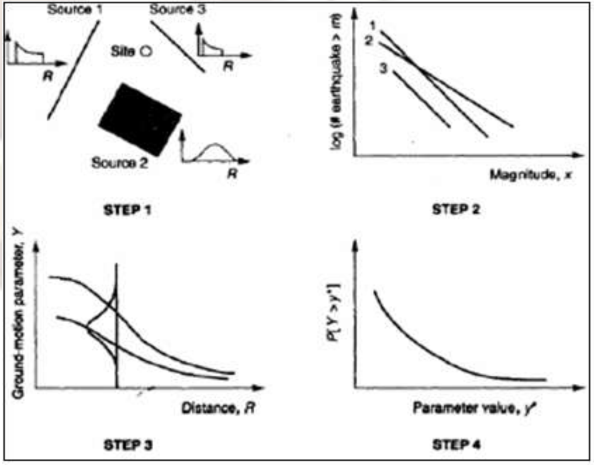

Figure 2 Steps for probabilistic seismic hazard analysis

III)GEOLOGICAL AND SEISMIC DETAILS OF JABALPUR

A large number of seismic data are required for the hazard analysis. Seismic data includes the magnitude of the event with year of occurrence, its longitude and latitude , focal depth, etc. These data are collected from the Indian Earthquake catalogue (Dr. S.T.G. Raghukanth) and from Seismo-tectonic Fault Map, detail of surrounding faults in vicinity of 300 km are noted and maximum magnitude on each and nearby faults are marked. There are total twenty-three faults.

Among the 23 faults in Jabalpur, the details of 14 active faults are listed in Table 1.

Table 1 Fault details of Jabalpur

S.no	Name of Faults	Length (KM)	Maximum Magnitude
1)	Narmada Son Fault(South)	534	5.2
2)	Narmada Son Fault(North) (Subsurface)	86	4.3
3)	Narmada Son Fault(North)	349	4.6
4)	Bamhni Chipla Fault	142	4.1
5)	Fault 1	74.13	5.8
6)	Fault 2	119	5.8
7)	Fault 3	116	5.2
8)	Fault 4	184	4.3
9)	Fault 5	90	5.5
10)	Fault 8	153	4.3
11)	Fault 9	46	4.1
12)	Fault 10	29	4.1
13)	Fault 11	24	4.3
14)	Fault 12	10	6.5

IV) METHODOLOGY

To perform the seismic hazard analysis of Jabalpur , the probabilistic approach has been adopted. Initially on fault map the area around 300km is marked. After assembling a catalogue of past earthquake, on fault map, maximum magnitude at or near each sources are marked. The seismic data collected from various sources give an overall idea about the seismicity details associated with each fault source. The maximum magnitude of earthquakes for all the faults that were obtained from the available seismic details is also presented in Table 1.

The peak ground acceleration (PGA) at bedrock level is estimated using the attenuation equation of strong ground motion proposed for Peninsular India (Iyengar and RaghuKanth, 2004, Raghu Kanth and Iyengar, 2006).

$$\ln (y) = C1 + C2(M-6) + C3(M-6)2 - \ln(R) - C4R + \ln \epsilon \qquad (1)$$

where C1 = 1.6858; C2 = 0.9241; C3 = −0.0760; C4 = 0.0057 . M, y, R and ϵ refer to moment magnitude (obtained from data collected), PGA in g, hypocentral distance in km and standard deviation factor respectively. The average of the error term $\ln \epsilon$ is zero for PSHA. The hypocentral distance, R, may be evaluated as

$R = \sqrt{}(d2+f2)$, where 'd' is the shortest distance from the site to the fault considered and 'f' is the focal depth.

The focal depth for each magnitude is taken from catalogue and the hypocentral distance is calculated for all fault sources.

A typical evaluation of PGA values using equ. 1 due to all the faults for Jabalpur district is presented in Table 2

Table 2 PGA values for Jabalpur district

Fault No.	Distance d (km)	Hypo-central Distance R(km)	M	PGA (g)
1	13	35.46	5.8	0.10g
2	115.06	119.50	4.3	0.003g
3	34.20	50.11	4.6	0.02g
4	150	151.00	4.1	0.004g
5	8.00	34.00	5.8	0.12g
6	**6.00**	**30.20**	**5.8**	**0.15g**
7	13.42	35.62	5.2	0.05g
8	93.94	100.12	4.3	0.005g
9	113.18	113.62	5.5	0.015
10	279	280.94	4.3	0.0006g
11	281	281.17	4.1	0.0005g
12	286	288.00	4.1	0.0004g
13	291	292.90	4.3	0.0005g
14	116	121.00	6.5	0.03g

V) CONCLUSION

The seismic hazard assessment of Jabalpur is performed using the probabilistic approach. PGA values are evaluated using the attenuation relation. From the analysis, the following conclusions are obtained:

1) The maximum Peak Ground Acceleration is obtained for Jabalpur districts, with the value of 0.15g.

2)The different fault showed varying values of PGA such as the fault number 1 shows value 0.10g and fault number 3 has value 0.02g.

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