PROBABILISTIC SEISMIC HAZARD ANALYSIS FOR SEISMIC RISK ASSESSMENT

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Abstract - *Earthquakes have been a significant area of concern since its occurrence has been associated with huge loss of lives and the region's economy. This concern has led various groups of scientists from different fields to work in tandem with governments to quantify this and further mitigate the losses accompanying these events. Thus, Seismic Risk Assessment came into existence ic Risk refers to the possibility of damage to a locality in terms of injuries, fatalities, material, and monetary loss. A famous saying, "Earthquakes don't kill people, buildings do. Seismic Risk consists of components such as Seismic Hazard, Vulnerability of Building, and Exposure Seismic Hazard deals with the Intensity measures produced due to Earthquake These Intensity measures are further used in Vulnerability to compute the damage caused by these to the structures. Lastly, exposure deals with estimating the population affected by the damage caused to these structures. Thus, the loss in fatalities, injuries, economic loss due to structural damage, etc., can be estimated. Seismic Hazard deals with the prediction of Intensity Measures (like PGA, PGV) occurring at a site, assuming an earthquake of a given Magnitude occurs at a selected fault source. Seismic Hazard is an integral part of Risk Assessment. It acts as an input parameter for computing Vulnerability. Seismic Hazard computation is further done based on Deterministic and Probabilistic Methods. These methods follow a similar approach for hazard calculation. But as these have developed over different periods, thus these are based on different assumptions. So, the objective of this paper is to understand the working of the PSHA module in Risk IITB*

***Key Words*: Probabilistic Seismic Hazard Analysis (PSHA), Deterministic Seismic Hazard Analysis (DSHA)**

1. INTRODUCTION

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1.1 DSHA

Deterministic Seismic Hazard Analysis (DSHA) is the simplest method of Hazard Assessment based on the tectonic and geological features of the area and its historical seismicity. DSHA involves considering Maximum Credible Earthquake (MCE), either assumed or realistic, centered on a fault, source-to-site distance, and Magnitude considered. It is one of the most widely used methods to calculate the Risk of a critical structure for design purposes. DSHA is described as a four-step process:

1. **Identification and characterization of the earthquake sources.** It includes defining each source's geometry and earthquake potential based on the available knowledge.

2. **Ascertain the distance from the site to source** This distance is generally the shortest distance from source to site, called Joyner-Boore distance. Still, it differs based on the attenuation relationship considered for Analysis in some cases.

3. **Selection of the Magnitude of the Seismic Activity**. In general, two magnitudes are defined, one for design purposes and the other for safety purposes. The magnitudes are either chosen based on historical activity at the site or they can be estimated using fault scaling relations based on fault dimensions.

4. **Predicting the ground motions produced**. The ground motion values predicted are based on the variability considered Generally ε=1 or 84^{th} percentile values are considered as maximum ground motion values affecting the site

1.2 PSHA

Probabilistic Seismic Hazard Analysis in practice for the last 20-30 years due to its comprehensive way of analyzing the Risk associated with ground motion at the a particular site. The basic methodology was laid by Cornell et.al. (1968), which was later improved upon by R.K. McGuire. The PSHA accounts for all possible earthquake scenarios at the concerned site. It counts in the variability of all the input parameters along with its quantification of the probability of its occurrence basic PSHA methodology is explained below:

1. **Site Identification and Characterization** The various sources that can possibly produce the ground motion at the specific site are needed to be considered This is similar to initial DSHA calculations expect that, uncertainty pertaining to occurrence to potential rupture on the fault also needs to be calculated.

2. **Seismicity characterization of the zone**. Seismicity of a zone is characterized using recurrence relations calculate the average rate of exceedance of a size of the earthquake Size of the Earthquake is generally quantified in terms of Moment Magnitude though historically, various other related variables are used. This quantifies the probability of exceedance of Magnitude in a particular zone.

3. **Predicting the Ground motion** Ground motion at a site is predicted based on attenuation relationship assumed. Attenuation relations estimate mean Ground motions based on Magnitude and Source-to-site distance considered These relationships should be selected based on the given seismicity of the region, wave propagation and site response effects.

4. **Computing the rate of exceedance of the ground motion** It is calculated by combination of the various uncertainties in Magnitude, source-to-site distance and ground motion variability and is used to plot graphs between Annual Frequency of Exceedance

2. Risk. IITB

Around the world, a number of software's have been created like HAZUS, SELENA, CAPRA, RADIUS to quantify the Risk. These software's have been designed as per the data available for specific regions(eg: HAZUS for USA, CAPRA for Norway). Also these software's ask for the data inputs which is not possible in countries like India. IIT Bombay, conception of Risk.IITB was done Risk.IITB is a very flexible software which can be used in other regions with minute modifications as region specific module is only Vulnerability functions.

Risk.IITB is developed using Visual Studio Integrated Development Environment (IDE) using VB.NET language. Arc Objects were used as COM components in Risk.IITB to utilize the spatial capability of ArcGIS The ability of GIS to store, retrieve and analyze spatial data makes it perfect platform in handing huge amount of data used in seismic studies.

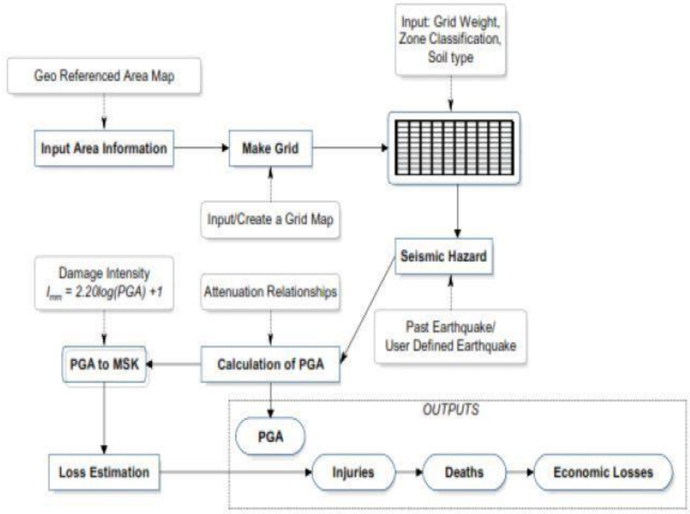

Chart -1: **Flow Chart depicting working of Risk. IITB**

3. CONCLUSIONS

From the above study, it can be concluded that Probabilistic Seismic Hazard Analysis is currently the most reliable method for computing Hazard. Thus, further study was performed in order to understand the basics of Seismology, Plate tectonics in order to have a better hold on the concepts of PSHA. Further, various models which were developed in order to estimate the uncertainty in Magnitude and Source-to-site distance were delved into Also a better understanding of GMPE gave a holistic view as to how Ground motions can be predicted based only on the two selected parameters . Further, computations for Intensity measures as opposed to their annual frequency of exceedance were done in order to obtain Hazard Curve and its probability of exceedance in longer run Based on these studies, the deaggregation curves are plotted to find the most likely case to cause damage given an Intensity Measure. Further using PSHA data, Uniform Hazard Curves are plotted with all the Spectral Acceleration at different Time Periods having the same probability of occurrence. Further the use of Logic Tree was discussed in relation to PSHA and its repercussion was also discussed. In the end, a sample example was solved so that the reader understands the concepts in a comprehensive manner.

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