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Probabilistic Seismic Hazard Assessment For Ground Motion Studies At VNSGU Western India

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abstract: *The occurrence of earthquake is natural. Most of the regions in the world are leads to earthquake prone. The regions that are frequently exposed to large earthquakes are seismically active regions of the world. The Western Indian shield considered as a stable continental region, has become an area of low - moderate to high seismicity. During the last 50 years, more numbers of earthquakes of moderate magnitude have occurred in this region, 3 to 4 high risk earthquakes are occurred with higher magnitude. Recent earthquakes in the coastal regions of Gujarat have invoked interest to study the coastal seismicity in relation to morphological and tectonic lineament. the result of the seismic hazard computation is then used to construct uniform hazard curve for the two earthquake return periods. The PGA value obtained from PSHA approach for Veer Narmad South Gujarat University, Gujarat region is 0.081g and 0.105g for 475 and 2475 years return period.*
Keywords: *Earthquake, Seismic hazard, Peak ground acceleration, Uniform hazard spectra, Ground motion simulation*

I. INTRODUCTION

Proper execution of comprehensive earthquake risk reduction program is important to prevent an earthquake leads to a disaster. Earthquake disasters occur mainly due to failure of structures and facilities such as buildings and lifelines (dams, bridges, power plants, etc.) apart from earthquake induced landslides, liquefaction and tsunami. The Peninsular India (PI) is one of the stable continental regions (SCR), situated in the interior of the Indian plate. Major earthquakes such as the Killari [moment magnitude (Mw) 6.2, 1993], Jabalpur (Mw 5.7, 1997) and Bhuj (Mw 7.7, 2001) have initiated seismic hazard studies in many regions of the Peninsular India. The scope of earthquake-resistant design is to produce a structure or facility that can withstand a certain level of shaking without excessive damage. Seismic hazard analysis (SHA) involves the quantitative estimation of ground-shaking hazards at a particular site (Kramer, 1996). in this study has been estimation of ground motions due to the recent fault activity has also been carried out using the stochastic simulation model. The results of the hazard analysis are presented in the form of peak ground acceleration (PGA) for different return periods, uniform hazard spectra (UHS) and spectrum compatible acceleration time histories.

II. LITERATURE REVIEW AND METHODOLOGY

A. Literature Review

Research is ever expanding and review of literature helps the particular research field to attain new horizons and accomplish the research objectives. This chapter provides an overview of the PSHA methodology, uncertainties involved in each of the steps and a review on the use of logic tree to reduce the identified uncertainties in the Probabilistic seismic hazard analysis. In India, several investigators [Shankar, D. and Singh, V. P. (1997)., 19 and Angadi S et al., 2016, 2017, 2019] have used Gumbel's Type-I distribution and truncated exponential distributions for prediction of seismic hazard associated with northern Himalayan and some of the southern shield regions of India. Several researchers [Evernden 1970, [8] for worldwide data; Chinnery and Rogers 1973 [7] for Southern New England; Nuttli 1974 for Central Mississippi; Basham et al. 1979 for Canada; and Bollinger et al. 1989 [4] for South Eastern United States] have applied the frequency magnitude relation to the regional earthquake data available in different form to define the seismogenic activity. The estimated parameters were used further to interpret in terms of seismic hazard associated with the region. Seismic hazard analysis (SHA) is the evaluation of potentially damaging earthquake-related phenomena to which a facility may be subjected during its useful lifetime. A probabilistic seismic hazard analysis (PSHA) is based on total expected seismicity (different magnitudes) during a specified life time and proper spatial distribution of earthquakes with respect to the site of interest. There are various methods to define seismicity in Probabilistic seismic hazard analysis methodology.

B. Methodology

Probabilistic seismic hazard analysis has come a long way since its inception by Cornell in 1968. Many improvements have been made in the methodology since then, however the final equation of combining all forms of uncertainty remains the same in most of the cases. The general procedure of carrying out probability based seismic hazard analysis is discussed in [Cornell, C. A. (1968), Campbell, K. W. (1985), McGuire, R. K. (2004) and Angadi S et al., 2016]

The procedure of Probabilistic seismic hazard analysis can be summarized into four main steps:

1. Identification and characterization of source geometry.
2. Characterization of seismicity of source zones.
3. Determination of ground motions using attenuation relationships.
4. Probability calculations.

The Probabilistic seismic hazard analysis is normally conducted for large regions or for a particular site. The PSHA is widely carried out using Cornell-McGuire approach [Cornell, C. A. (1968), Campbell, K. W. (1985), McGuire, R. K. (2004). In this approach, the seismic hazard is evaluated in terms of the probability of exceedance of the selected strong ground motion parameter in a given area at a specific interval of time. The spatial and temporal phenomena in earthquake hazard modelling are characterized by uncertainty and variability. The probabilistic approach to hazard analysis is not limited only to the consideration of worst-case scenarios but extended to looking at all feasible scenarios and its related consequences [Campbell, K. W. (1985)]. The probability of occurrence of such scenarios is becoming an additional key aspect to be quantified in order to rationally and quantitatively handle the uncertainty. Two major factors have shaped the developments in seismic hazard analysis [Angadi S et al., 2016, 2017, 2019]

III. DESCRIPTION OF STUDY AREA AND SEISMICITY

Brief description of the study area given in this section— Veer Narmad South Gujarat University, Gujarat state in Western India. Somnath is on the border area with Pakistan. Gujarat is having Rajasthan in northeast, Madhya Pradesh in side of east, Maharashtra in south side and Union territories of Daman and Diu in South-East. The Arabian Sea borders the state both to the west and the south-west. It includes 33 districts and covers an area of surrounding approximately196,024 sq. km and having coordinates of the area is as latitude20°53′16.9″ North 70°24′5.0″, the average altitude of around 8.77 m above the Mean Sea Level (MSL) of Somnath temple, at Somnath as shown in Figures 1. The Gujarat state has been categorized under zone V, IV, III and II of the seismic zoning map of India (Bureau Indian Standards (BIS), 2016). Somnath is situated in the banks of Arabian sea. Where, effects of high tide and low tide or effects of any natural disaster are prominently visible. So that protection of the important VNSGU, Surat and economic cities in western India is very essential. the complex structure with associated numerous faults, fractures, Peninsular India has been one of the most interesting region to study for earthquake phenomena associated with the intraplate activities [Rao and Murty 1970; Chandra 1977]. A slow and steady accumulation of strain energy in prominent tectonic pockets of the Peninsula has resulted in earthquakes of low to moderate magnitudes in the past. The geologic zonation of earthquake sources used in the present study is primarily based on various evolutionary units and the associated tectonic features in the Peninsular shield of India (Figure. 1).

A. Complete Earthquake Database

A complete earthquake catalog with uniform scaling for expressing the size of past earthquake is prerequisite for a reliable parameterization of the magnitude distribution function. A working catalog has been prepared based on the available information of the earthquake data from various sources. Earthquake catalogues constitute the basic critical input for the characterization of seismic sources and helps in preparation of a unified working catalogue for a region under consideration. For the function of characterizing identified seismic sources, the activity rates of the seismicity can be used and compiled in catalogue using information from several sources. Internationally recognized earthquake catalogues on the internet, such as the National Earthquake Information Center (NEIC), the International Seismological Centre (ISC), Institute of Seismological Research (ISR), United States Geological Survey (USGS)and the India Meteorological Department (IMD) have also served as sources for the historical and instrumental data. In all, a total of 623 earthquake data (Mw≥ 3.0) from the Gauribidanur Array (GBA) and global sources from the year 1968 to 1991 have been compiled. The current earthquake catalogue for Gujarat, Western India, includes 406earthquakes with Mw≥ 3.0 from 1819 to 2016. The Gutenberg and Richter recurrence law are used to characterize the seismicity of given the region. All the probability calculations needed for the hazard evaluation of the study area are carried out using Cornell-McGuire approach [Cornell, C. A. (1968), Campbell, K. W. (1985), McGuire, R. K. (1977), and McGuire, R. K. (1978)]. Gutenberg and Richter studied the frequency of past earthquakes with respect to magnitude and proposed a log linear relationship between number of earthquakes of magnitude M or greater per unit time and the observed range of magnitude.

IV. RESULTS AND DISCUSSION

A. Uniform hazard spectrum

For an intended time, span, probability of exceedance which is having the same acceleration ordinates of pseudo spectral nature are defined as Uniform hazard spectrum. The uniform hazard spectrum is inbuilt part of Probabilistic seismic hazard analysis. For acceleration time history scaling and response spectrum method of structures or as the target spectrum, UHS are frequently used [Angadi S et al 2019]. For the estimation of hazard curve and UHS return period (RP) are taken as 475 and 2475 (10% POE and 2% POE in 50 yrs) years with 5% damping at the level of level and stiff or rock ground conditions. The horizontal component of ground motions are derived from hazard curves. From derived uniform hazard spectrum, design basis earthquake phenomenon has been checked as shown in the following graphs. For PGA values are from the 475 and 2475 years return period are found to be between 0.081 and 0.105g respectively (Figure 2 and 3.). Design basis earthquake (DBE) concept can be developed with consideration of hazards of 475 year return period which is moderately affecting the structure in it is design life. Maximum considered earthquake (MCE) is represented as the hazard levels of return Period for 2475 years inclusive of most severe earthquakes. According to in the seismicity map of an Indian code (IS: 1893 Part 1 2002, 2016 [14]), Veer Narmad South Gujarat University, Gujarat lies in Zone III. For MCE and DBE, the expected PGAs are 0.08g and 0.16g respectively.

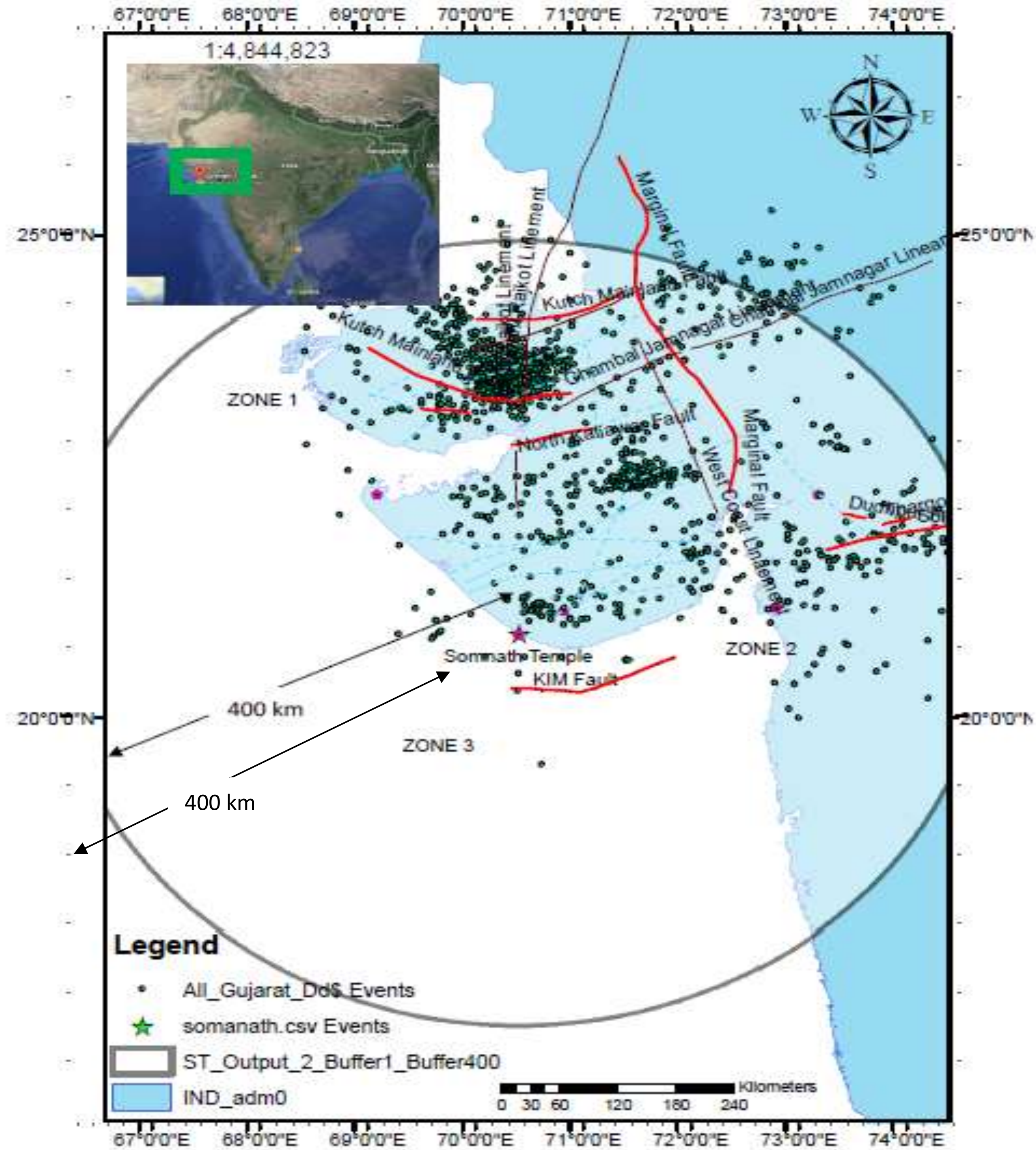

Fig. 1. Map of Western India showing the location of the studied site, geologic and tectonic features, Somnath temple region

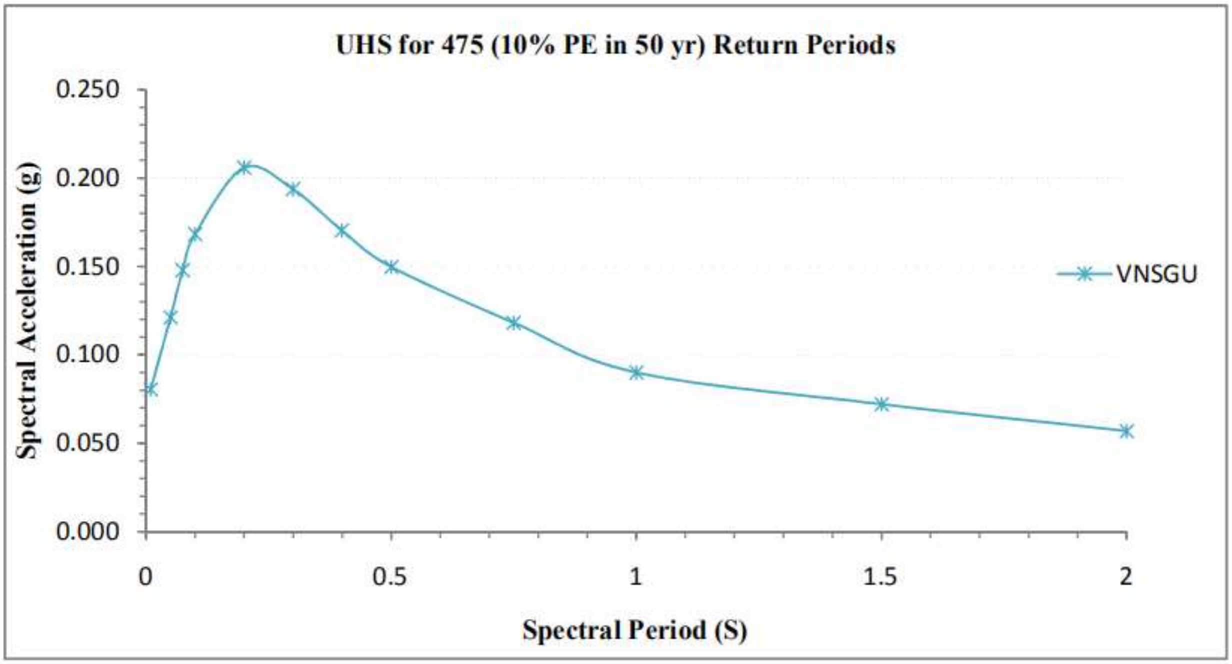

Fig. 2 Horizontal components of UHS for 475 (10% PE in 50 yr) return periods at Veer Narmad South Gujarat University

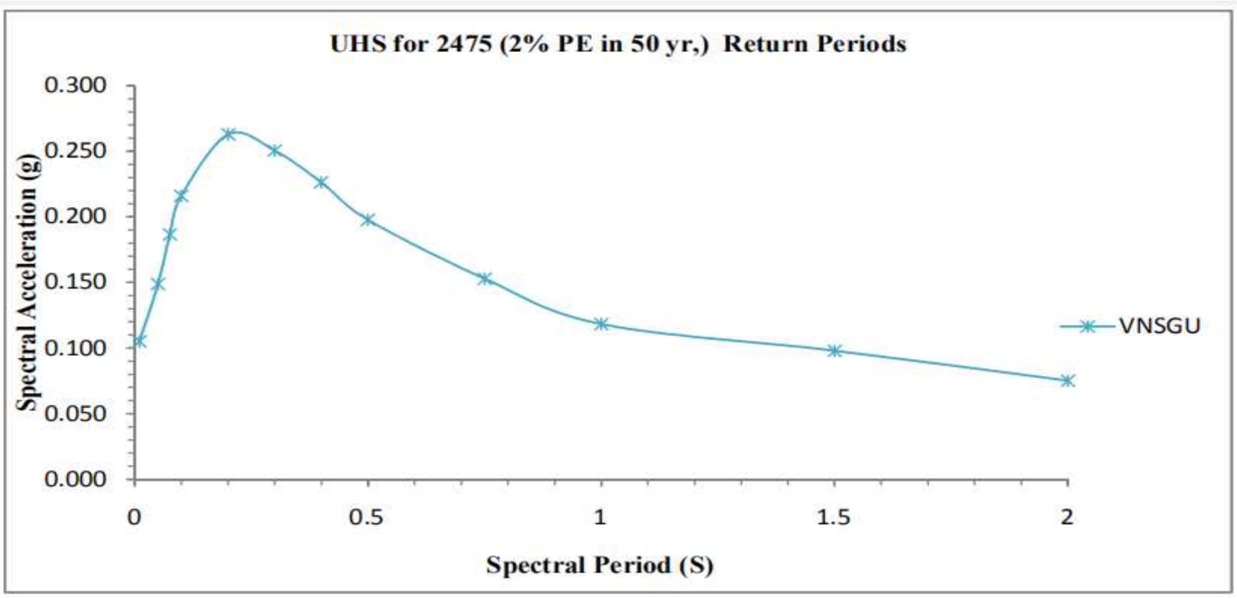

Fig. 3 Horizontal components of UHS for 2475 (2% PE in 50 yr) return periods at Veer Narmad South Gujarat University

IV. CONCLUSION

The probabilistic methodology is the essential tool for quantifying tectonic hazards, as it considers all potential sources in a region, allows uncertainty to be fully quantified and provides hazard estimates for a spectrum of return periods. The estimation of the annual rate of exceedance of a specified ground motion at a site due to known and suspected earthquake sources are summarized in the PSHA technique. The results of the hazard analysis are provided in the form of peak ground acceleration (PGA), uniform hazard spectrum (UHS) and acceleration time-histories at bedrock level. Deaggregation of seismic hazard provides the relative contributions to hazards from sources of different magnitude and distances. The hazard curve gives the probability of exceedance for a suite of PGA levels from all sources. The PGA value obtained from PSHA approach for Veer Narmad South Gujarat University, Gujarat region is 0.081g and 0.105g for 475 and 2475 years return period.

V. FUTURE SCOPE

The main aim of present investigation is to characterize the site and to assess the ground motion characterization for the stable continental region. Earthquake-resistant design measures based on experience, judgment, and careful probabilistic seismic hazard analysis will provide adequate protection against the failures of structures, damages to infrastructure and a potential threat to human lives.

- On further development, a full wave form of the surface waves can be obtained using non-linear arrays. This can be used for shallow site characterization.
- One can develop a 3D surface profile by using all these test results.

.**Conflict of Interest:** The data collected in-situ is very difficult in real situation or else can be fully automated to reduce testing time. While doing experiments we should have all data points and parameters to predicting ground motion.

REFERENCES

[1]. Abrahamson, A. N., Silva, J. W., and Kamai, R., (2014). "Summary of the ASK14 Ground Motion Relation 1025-1055. for Active Crustal Regions." Earthquake Spectra." August 2014, Vol. 30, No. 3, pp. 1025-1055.

[2]. Angadi S., Hiravennavar A., Desai M.K., Solanki C.H., Dodagoudar G.R. (2019) Development of Gutenberg–Richter Recurrence Relationship Using Earthquake Data. In: Drück H., Pillai R., Tharian M., Majeed A. (eds) Green Buildings and Sustainable Engineering. Springer Transactions in Civil and Environmental Engineering. Springer, Singapore

[3]. Angadi, Shivamanth & Desai, M.K. & Solanki, C.H. & Dodagoudar, G.R. (2017). Characterization of ground profile using multichannel analysis of surface wave at somnath temple. International Journal of Civil Engineering and Technology. 8. 969-976.

[4]. Bollinger, G. A., Davison, F. C., and Sibol, M. S. (1989). "Magnitude recurrence relations for the South Eastern United States and its subdivisions." Journal of Geophysical Research. Vol. 94, No. B3, 2857-2873.

[5]. Cornell, C. A. (1968). "Engineering Seismic Risk Analysis." Bulletin of Seismological Society of America, Vol. 58, 1583-1606.

[6]. Campbell, K. W. (1985). "Strong Motion Attenuation Relations: A Ten Year Perspective." Earthquake Spectra, Vol.1, 759-804.

[7]. Chinnery, M. A. and Rogers, D. A. (1973). "Earthquake statistics in Southern New England." Earthquake Notes, Vol. XLIV, No. 3-4, 89-103.

[8]. Colvile, R. N., Hutchinson, E. J., Mindell, J. S., and Warren, R. (2000). Millennium Review for submission to Atmospheric Environment. Africa (Lond)., pp. 1–28.

[9]. Evernden, J. F. (1970). "Study of regional seismicity and associated problems." Bulletin of Seismological Society of America, Vol. 60, No. 2, 393-446.

[10]. McGuire, R. K. (1977). "The character of high-frequency strong ground motion." Bulletin of Seismological Society of America, Vol. 67, 827-848.

[11]. McGuire, R. K. (1978). "Seismic ground motion parameter relations." Journal of the Geotechnical Engineering Division, ASCE, 104(GT4), 481–490.

[12]. McGuire, R. K. (1978). "Seismic ground motion parameter relations." Journal of the Geotechnical Engineering Division, ASCE, 104(GT4), 481–490.

[13]. McGuire, R. K. (2004). "Seismic hazard and risk analysis." Monograph by Earthquake Engineering Research Institute, 221.

[14]. IS:1893 (Part-1). (2002). "Indian Standard Criteria for Earthquake Resistant Design of Structures (Fifth Revision)." Bureau of Indian Standards, New Delhi.

[15]. Reiter L. (1985). “Earthquake Hazard Analysis: Issues and Insights.” Elsevier Scientific Publishing Company, U.S.A.
[16]. Stepp, J. (1973). “Analysis of completeness of the earthquake sample in Puget Sound area.” Seismic zoning edited by S. T. Harding, NOAA Tech. Report ERL 267-ESL30, Boulder, Colorado, U.S.A.
[17]. Shankar, D. and Singh, V. P. (1997). “Seismic risk analysis for the occurrence of medium size earthquakes in Kangra region of Himachal Pradesh, India.” Proc. Ind. Nat. Sci. Acad, Vol. 63, A, No.2, 197-202.
[18]. Shankar, D. (1998). “Earthquake evaluation in Koyna region of Maharashtra, India.” Acta. Geod. Geoph. Hung., Vol. 33(2-4). 335-340.
[19]. Sharma, M. L. and Shanker, D. (2001). “Estimation of Seismic hazard parameters in the Himalayas and its vicinity from mixed data files.” ISET Journal of Earthquake Technology, Vol. 38, No.2-4, 93-102.
[20]. Shivamanth Angadi, Desai M.K., Solanki C.H., Dodagoudar G.R. (2016). Development of Subsurface Profile Using Geophysical Test Data, International Journal of Earth Sciences and Engineering ISSN 0974-5904, Vol. 09, No. 03, June, 2016, pp. 161-164.