International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 05 Issue: 05 | May - 2021 ISSN: 2582-3930

Seismic Hazard Analysis of Tezpur City

Rishik Sarkar

School of Civil Engineering, Vellore Institute of Technology

---***---

Abstract -Seismic Hazard Analysis includes the quantitative assessment of ground shaking hazards at a specific region. Seismic dangers can be dissected deterministically as and when a specific tremor situation is accepted, or probabilistically, in which vulnerabilities in earthquake size, area, and season of the event are explicitly thought of. Deterministic Seismic Hazard Analysis (DSHA) utilizes geography and seismic history to recognize earthquake sources and interpret the strongest earthquake each source can create, regardless of the time because that earthquake might even happen the next day. Those are the Maximum Credible Earthquakes (MCEs), the biggest tremors that can sensibly be anticipated. This project is undertaken to carry out Deterministic Seismic Hazard Analysis of the city of Tezpur and hence plot the response spectra for ground acceleration. The results of DSHA indicate that the potential sources for Tezpur city are MCT (Main Central Thrust) and Kalyani Shear.

Key Words: Tezpur, Seismic Hazard Analysis, Peak Ground Acceleration, Ground Motion Prediction Equation, Response Spectrum

1. Introduction

A seismic hazard assessment is an attempt to predict the potential ground-shaking power from future earthquakes. North-east India sitting on the Assam gap of the Himalayan region is one of the six most seismically powerful areas on earth and reviewed as seismic zone V of India. Seismic gaps are the areas of the seismic plate boundary that have not ruptured in the previous 100 years and represent a high potential for future tremors. The Assam gap was created concerning the 1897 and 1950 incredible Assam earthquakes. The city of Tezpur in central Assam consistently encounters light earthquakes. Each seismic zone is allocated with an assessed hazard in terms of spectral acceleration that denotes the maximum value that can occur. For a practical evaluation of Peak Ground Acceleration (PGA), the previous seismicity of the area must be contemplated which requires a lot of known earthquake parameters. The reliable expectation of ground movements is significant for fruitful seismic hazard investigation. In deterministic or situation based seismic hazard assessment, Ground-Movement Prediction conditions (GMPEs) can be used. GMPEs offer benefits, for example, lower computational costs and lesser input essentials, attributable to which they are broadly utilized in both the probabilistic and deterministic seismic hazard analysis.

The city of Tezpur in North-East India is situated close to the Indo-Burmese curve, quite possibly the most seismically active areas of the nation, has seen two devastating historical tremors of size M ≥ 8 over the most recent 150 years, viz., M8.1 the Great Shillong earthquake of 1897 and M8.5 the Great Assam earthquake of 1950. All things considered, many moderate to huge seismic tremors have been happening frequently for quite a long time and have destroyed this area. The impact between the Indian and Eurasian plates in the north and the subduction of the Indian plate under the Burmese curve in the east portray the area as a triple intersection and give an ideal tectonic framework to exceptional seismic movement around there.

2. Methodology

ArcGIS 10.4 has been used for carrying out seismic hazard analysis. Firstly, a map which shows the active faults was obtained from the already available sources. The tectonic features that are likely to generate the significant ground motions in the study area were identified (from the various research papers). The active tectonics features of the Tezpur region were considered by taking an area with radius of 300 km around the study area. The source-to-site distance and the hypocentral distance between each grid point and each seism genic source were also computed.

The following Ground Motion Prediction Equation (GMPE) developed for North-eastern region (by P Neelima, C Rajaram, R K Pradeep, D Srinagesh) was used to predict the ground motion parameters.

$$\ln(S_a/g) = C_1 + C_2M + C^3M^2 + C_4r + C_5\ln\left(r + C_6e_7^{CM}\right) + C_8\log(r)f_o + \ln(\varepsilon)$$
$$f_o = \max(\ln(r/100), 0)$$

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 05 Issue: 05 | May - 2021 ISSN: 2582-3930

Finally, Ground motion parameters have been computed with respect to various seism genic sources for the computation of hazard at a point, the source causing maximum ground motion at the point of interest has been identified. For the grid point under consideration, the maximum magnitude potential of that seism genic source has been considered as the controlling earthquake.

3. Procedure

- The seismotectonic data has been obtained from ***BHUKOSH***, a portal for accessing geo-scientific data of Geological Survey of India.
- The seismic sources around Tezpur have been identified and are presented below:

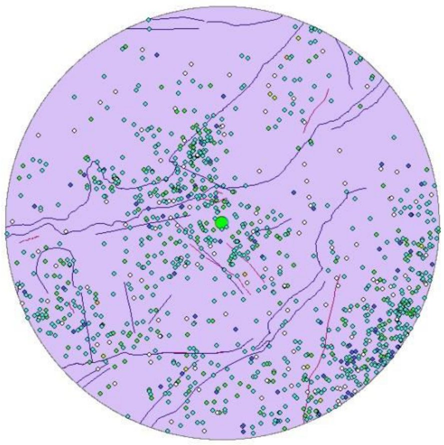

Figure 1: Seismic Sources

- The major seismic sources present around Tezpur which have considered for the deterministic hazard analysis are given below. The figure also consists of the location of the past earthquakes that occurred in the north-eastern region. Tezpur city is represented by the green dot at the centre of the circle.

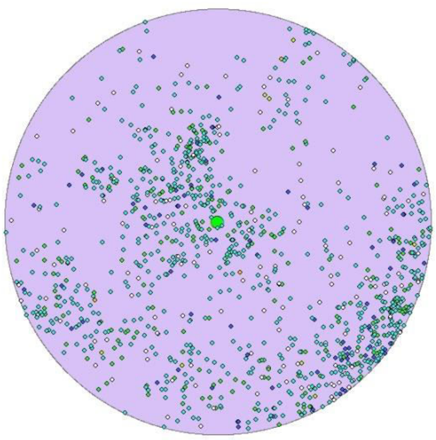

Figure 2: Location of past earthquakes

- The length of the Faults, Maximum magnitude of earthquake for each fault and their hypocentral distances from Tezpur have been calculated by using the following attenuation relationship recommended by NDMA:

$$\ln(S_a/g) = C_1 + C_2M + C^3M^2 + C_4r + C_5\ln\left(r + C_6e_7^{CM}\right) + C_8\log(r)f_o + \ln(\varepsilon)$$
$$f_o = \max(\ln(r/100), 0)$$

- The values of the coefficients have been obtained from the NDMA, PSHA report (2010), for the North-eastern region.

Table 1: Attenuation Relationship Coefficient

Period	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	$\sigma(\varepsilon)$
0.0000	-4.2427	1.3100	-0.0097	-0.0031	-1.3159	0.0172	1.0279	0.1083	0.4424
0.0100	-4.2462	1.3069	-0.0095	-0.0031	-1.3145	0.0168	1.0306	0.1083	0.4410
0.0150	-3.2699	1.1651	0.0002	-0.0032	-1.2902	0.0119	1.0720	0.1046	0.4988
0.0200	-3.1139	1.1599	0.0002	-0.0032	-1.2834	0.0115	1.0743	0.1049	0.4759
0.0300	-3.0689	1.1659	-0.0004	-0.0032	-1.2760	0.0114	1.0734	0.1041	0.4453
0.0400	-3.1870	1.1912	-0.0023	-0.0032	-1.2705	0.0120	1.0666	0.1043	0.4331
0.0500	-3.3512	1.2267	-0.0050	-0.0031	-1.2696	0.0127	1.0581	0.1048	0.4271
0.0600	-3.6194	1.2894	-0.0096	-0.0031	-1.2684	0.0146	1.0392	0.1047	0.4226
0.0750	-3.9007	1.3424	-0.0136	-0.0031	-1.2617	0.0157	1.0292	0.1041	0.4193
0.0900	-4.2122	1.4221	-0.0196	-0.0030	-1.2619	0.0201	0.9982	0.1041	0.4177
0.1000	-4.4638	1.4880	-0.0242	-0.0030	-1.2695	0.0240	0.9758	0.1062	0.4162
0.1500	-5.8209	1.8267	-0.0487	-0.0029	-1.2711	0.0445	0.8973	0.1056	0.4164
0.2000	-7.1113	2.1560	-0.0724	-0.0029	-1.2706	0.0687	0.8408	0.1070	0.4182
0.3000	-9.5795	2.8058	-0.1183	-0.0029	-1.2853	0.1340	0.7572	0.1092	0.4240
0.4000	-11.6654	3.3577	-0.1566	-0.0028	-1.2962	0.2120	0.7011	0.1120	0.4303
0.5000	-13.4385	3.7880	-0.1860	-0.0028	-1.2841	0.2313	0.6899	0.1104	0.4328
0.6000	-15.1386	4.2035	-0.2137	-0.0028	-1.2828	0.2685	0.6716	0.1111	0.4344
0.7000	-16.2898	4.4858	-0.2320	-0.0027	-1.2874	0.2832	0.6681	0.1103	0.4344
0.7500	-16.8403	4.5993	-0.2392	-0.0027	-1.2769	0.2676	0.6733	0.1091	0.4345
0.8000	-17.4118	4.7372	-0.2477	-0.0027	-1.2831	0.2763	0.6710	0.1117	0.4330
0.9000	-18.5053	4.9764	-0.2624	-0.0027	-1.2779	0.2687	0.6757	0.1095	0.4325
1.0000	-19.0253	5.0821	-0.2686	-0.0026	-1.2738	0.2580	0.6804	0.1084	0.4323
1.2000	-20.5318	5.3671	-0.2844	-0.0025	-1.2595	0.2229	0.6984	0.1073	0.4270
1.5000	-21.8434	5.5932	-0.2946	-0.0024	-1.2622	0.1930	0.7206	0.1060	0.4229
2.0000	-23.3177	5.7719	-0.2982	-0.0023	-1.2473	0.1237	0.7830	0.1039	0.4201
2.5000	-24.1965	5.7795	-0.2916	-0.0022	-1.2027	0.0485	0.8985	0.0979	0.4223
3.0000	-24.6659	5.6577	-0.2737	-0.0020	-1.1729	0.0131	1.0680	0.0919	0.4233
4.0000	-24.7444	5.3029	-0.2351	-0.0019	-1.1223	0.0008	1.4322	0.0849	0.4319

- The response spectrum was plotted for three cases:
  i. Maximum Occurred Earthquake
  ii. Maximum Occurred Earthquake + 0.5
  iii. Maximum Potential Earthquake (M_w = 8.8)
- The Peak Ground Acceleration for all the above three cases were estimated.

4. Results and Discussions

- Length of the faults, maximum occurred earthquakes and their Hypocentral distances from Tezpur have been tabulated. The below table also consists of the Peak Ground Acceleration values for all the three response spectra cases calculated by using the attenuation relationship recommended by NDMA.

Table 2: Peak Ground Acceleration values

Name of Fault	Length of the fault (Km)	Maximum occured earthquake (M_w)	Hypocentral Distance from Tezpur (Km)	PGA (g) (based on maximum occurred earthquake)	PGA (g) (based on maximum occurred earthquake + 0.5)	PGA (g) (based on maximum potential earthquake) (M_w = 8.8)
Dauki Fault	142.61	6.98	143.36	0.0711	0.1140	0.2861
Dauki Fault	122.15	5.875	186.46	0.0149	0.0259	0.2229
MBT	573.38	5.62	41.71	0.0935	0.1528	0.6373
Kalyani Shear	65.99	5.62	37.52	0.1069	0.1732	0.6650
Naga Thrust	272.42	5.025	125.44	0.0103	0.0182	0.3188
Bame-luting Fault	65.16	4.43	240.89	0.0019	0.0033	0.1655
Bomdila Lineament	91.37	5.45	40.94	0.0804	0.1329	0.6423
Sylhet Fault	111.96	6.045	167.98	0.0212	0.0364	0.2477
MCT	584.61	7.405	87.93	0.1904	0.2721	0.4141
Kulsi Fault	62.66	5.28	151.16	0.0105	0.0185	0.2732
Barapani Shear	47.12	5.11	110.97	0.0135	0.0236	0.3486
Atherkhet Fault	130.57	5.28	42.57	0.0639	0.1071	0.6319
Dhansiri-Kopili Fault	127.30	5.11	42.22	0.0538	0.0911	0.6341
Dudhnoi Fault	83.94	7.915	208.85	0.1019	0.1523	0.1968
Indus Suture Zone	106.26	4.43	239.45	0.0019	0.0034	0.1668
MFT	98.20	5.365	186.97	0.0084	0.0147	0.2223
Andaman Trench	194.34	5.705	154.18	0.0165	0.0286	0.2684
Disang Thrust	127.40	5.025	142.27	0.0086	0.0152	0.2880
MBT	12.66	5.62	280.54	0.0056	0.0098	0.1346
Eocene Hinge Zone	49.04	5.535	230.64	0.0072	0.0126	0.1748
Eocene Hinge Zone	45.59	5.45	232.80	0.0064	0.0113	0.1728
Dhubri Fault	17.14	5.195	282.22	0.0034	0.0060	0.1334
Indus Suture Zone	74.85	4.43	244.35	0.0018	0.0033	0.1625
Indus Suture Zone	100.26	5.79	235.92	0.0092	0.0161	0.1700
Goalpara Ridge	144.71	5.365	205.01	0.0072	0.0127	0.2010
Bhalukpong Thrust	10.5195	5.7	37.6404	0.1154	0.1856	0.6642
Nameri Thrust	30.8484	5.45	25.6772	0.1434	0.2283	0.7527
Bhalukpong Thrust	9.6244	4.345	35.8267	0.0289	0.0502	0.6767
Ultapani Fault	26.0555	5.365	246.0479	0.0053	0.0093	0.1610
Kopili Fault	95.9236	7.32	47.0634	0.3498	0.4589	0.6042
Chorachandpur Mao Fault	188.8807	5.875	166.2642	0.0178	0.0308	0.2502
Dighalpani-Kakijan fault	68.5689	7.32	24.6979	0.5841	0.6875	0.7606
Chedrang Fault	16.4844	5.28	227.3706	0.0055	0.0097	0.1779
Miri Thrust	64.877	5.28	155.2912	0.0101	0.0177	0.2667

- From the figure below, it can be observed that the maximum PGA for max occurred earthquake is 0.19g for MCT (Main Central Thrust), followed by 0.115g for Kalyani Shear.

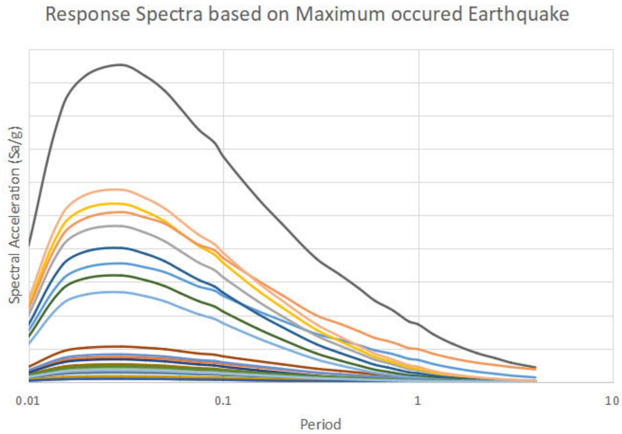

Chart -1: Response Spectra based on Maximum occurred earthquake

- From the figure below, it can be observed that the maximum PGA for max occurred earthquake is 0.27g for MCT (Main Central Thrust), followed by 0.185g for Kalyani Shear.

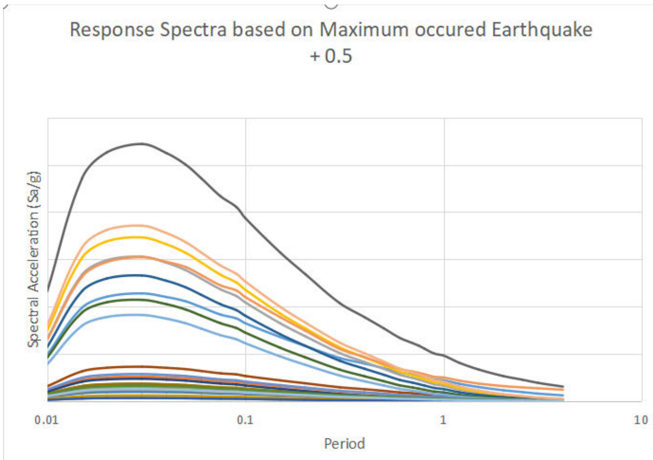

Chart -2: Response Spectra based on Maximum occurred earthquake + 0.5

- From the figure below, it can be observed that the maximum PGA for max occurred earthquake is 0.66g for MCT (Main Central Thrust), followed by 0.52g for Kalyani Shear.

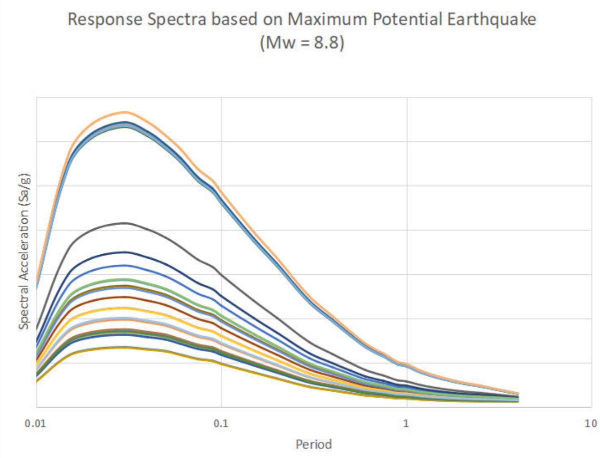

Chart -3: Response Spectra based on Maximum Potential earthquake

5. CONCLUSION

- Seismic hazard analysis of Tezpur city was carried out using Deterministic approach.
- The study area of 300 km radius around Tezpur city was considered for the analysis.
- The peak horizontal acceleration (PGA) at bed rock level and response spectrum were calculated for the following three cases:
  i. Maximum occurred earthquake of each source
  ii. Maximum occurred earthquake plus 0.5 for each source
  iii. Maximum potential magnitude (M_{max}) of 8.8 for all the sources.
- It can be observed from the results of DSHA that the potential sources for Tezpur city are MCT (Main Central Thrust) and Kalyani Shear.

ACKNOWLEDGEMENT

The author would like to extend his gratitude to Dr. Chandrasekaran SS (Professor – School of Civil Engineering, Vellore Institute of Technology, Vellore) for teaching him this subject with sheer dedication and also imparting practical knowledge wherever necessary. This work couldn't have been completed without him. Further, it gives the author immense pleasure to thank a fellow student of VIT, Rishudh Thakur for helping him out in this regard. Last but not the least, the author is also grateful to the NPTEL portal for delivering great content to students in the form free video lectures.

REFERENCES

[1] Vishwa B.S. Chandel (2015) "Geo-Physical Disasters in Himachal Pradesh, India: A Spatial Perspective" Volume 02, No.5.

[2] T.G. Sitharam, Naveen James (2015) "Probabilistic assessment of surface level seismic hazard in India using topographic gradient as a proxy for site condition" Volume 6, Issue 6.

[3] Nilesh Patil, Ashwani Kumar, Josodhir Das (2014) "Probabilistic seismic hazard assessment of Himachal Pradesh and adjoining region" No. 2.

[4] S. Elayaraja, S.S. Chandrasekaran, G.P. Ganapathy (2015) "Evaluation of seismic hazard and potential of earthquake-induced landslides of the Nilgiris, India" International Society for the Prevention and Mitigation of Natural Hazards, vol. 78(3).

[5] M. Rai, A. Rodriguez Marek (2012) "Topographic effect on strong ground motion their results".