IMPACT OF RECURRENCE PERIOD ON PEAK GROUND ACCELERATION IN DETERMINISTIC SEISMIC HAZARD ANALYSIS

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Abstract
In this investigation, a deterministic seismic hazard approach was used to prepare the PGA contour maps, for District Headquarter Dhamtari of Chhattisgarh state. The District Headquarter Dhamtari, is one of the important business city of Chhattisgarh. In this paper, past tremor history of the area was considered for analysis. An attempt was made, to gather the event of past and recent seismic activities within 300 km radius, around the District Headquarter Dhamtari. The major yardstick and indicator involved in carrying out the hazard analysis is the exactness and completeness of the data which needs to be attained. From the present investigation the values of peak ground acceleration for 50 percentile and 84 percentile varies from 0.03892g to 0.05001 and 0.06194g to 0.07961g respectively.
Index Terms: Attunation, Deterministic seismic hazard, fault, PGA, Recurrence period,

I. INTRODUCTION

Seismic tremors are catastrophic events and result in immense misfortune to humankind and resources. In India, immense quantities of earthquakes occurred with low to high sizes. A few regions prior considered stable, have encountered extreme harms caused by seismic tremors. The noticeable seismic tremors occurred in India in different places, for example, Latur in Maharashtra, Bhuj in Gujarat and Jabalpur in Madhya Pradesh. Dhamtari is abbreviated from "Dhamma"+"Tarai", District is situated in the fertile plains of Chhattisgarh Region. This District is situated between 20°42' Latitude and 81°33' Longitude. The total area of the district is 2029 Sq.Km. and 305 Meter above the mean sea level. Its tributaries being Sendur, Pairy, Sondur, Joan, Kharun and Shivnath. The fertility of lands of Dhamtari district can be attributed to the presence of these rivers. The chief crop of this region is Paddy. Mahanadi one of the major river in central India originates in the hills of Sihawa flows in the direction of East into the Bay of Bengal. Unique feature of Dhamtari is, the total number of Rice Mills that is more than 136. In North lies Raipur, the heart and capital city of Chhattisgarh. Chhattisgarh's Major dam Ravishankar Sagar, that irrigates a main supply unit of safe drinking water resource, for state capital Raipur as well as supply to Bhilai Steel Plant, lies at almost 11 Km from the District capital. Asia's first ever Siphon dam was built in the year 1914 at Madamsilli.

II. METHODOLOGY: DETERMINISTIC SEISMIC HAZARD ANALYSIS

The literature review reveals the information regarding different parameters for evaluation of seismic hazard. Seismic peril assessment can be named Deterministic and Probabilistic. The peril at the site is characterized as per the ground movement, initiated at the site because of the tremor that can happen on the legitimately distinguished sources. Deterministic Seismic Hazard Analysis is the most on time approach, generally used for hazard assessment of atomic power industry, Dams sites and for important civil engineering structures. It gives a base to Probabilistic Seismic Hazard Analysis of tremor. A deterministic seismic peril investigation includes the improvement of a specific seismic situation where upon a ground movement risk assessment is based. The situation comprises of the proposed event of a seismic tremor of a predefined estimate, happening at a predetermined area.

A. Identification and Characterization of Sources

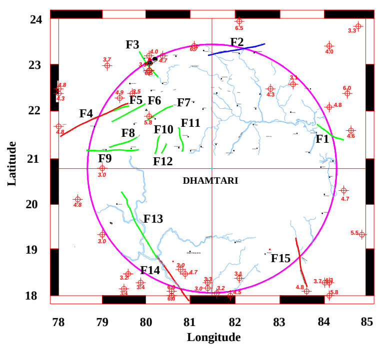

Fig.1. Fault Map for District Headquarter Dhamtari.

The present study uses a Deterministic method of analysis for the Hazard Analysis of Dhamtari taking into consideration the location of Chhattisgarh, it is found to be located in the zone, where the occurrence of seismic activity is found to be very low. For identification of seismic sources, District Headquarter Dhamtari is selected as the target. A control region of radius 300 km around the District Headquarter, having centre at 20°42' N and 81°33' E, was considered for numbering of fault for further investigation. The fault map of this circular region which was prepared in reference with the Seismo-tectonic Atlas of India 2000 is, as shown in Fig. 1. A total of fifteen major faults, which influence seismic hazard at District Headquarter Dhamtari, were identified in the above map. Fault details are tabulated in Table 1, Appendix -1

B. Recurrence Relationship

To obtain the seismicity rates for each of the seismic sources, following form of Gutenberg-Richter's (1944) recurrence relationship has been first defined for each of the seismic sources

$$\text{Log10 } N = a - b*Mw$$

In this expression, N is the annual number of earthquakes with moment magnitude Mw or greater, "a" & "b" are the constants specific to the seismic source of interest. To evaluate these constants, the past earthquake data in the source zone has been converted into moment magnitude using empirical conversion relations (Chung and Bernreuter, 1981). The distribution of earthquake magnitude in a given period of time is described by Guttenberg-Richter (G-R) magnitude frequency recurrence relationship. Apply the completeness analysis, a recurrence relationship for District Headquarter Dhamtari has been developed as shown below:

$$\text{Log 10 } N = 3.1021 - 0.5403 \text{ Mw------(1)}$$

C. Deaggregation of Regional Hazards

The maximum probable earthquake magnitude for each of the seismic sources within the area was then estimated. Shortest distance to each source and site of interest was evaluated and taken as major input for performing DHSA. In the present investigation truncated exponential recurrence model developed by Mcguire and Arabasz (1990) was used and is given by following expression;

$$\lambda_m = N_i(m_0) * \upsilon * \frac{\exp[-\beta(m-m_0)] - \exp[-\beta(m_{max}-m_0)]}{1-\exp[-\beta(m_{max}-m_0)]} \quad \text{-(2)}$$

Where $\upsilon = \exp(\alpha - \beta * m_0)$ α=2.303*a, β=2.303*b and Ni(m0) is the weightage factor for a particular source based on recurrence. The threshold value having a magnitude 3.0, was adopted in the study.

D. Ground Motion Attenuation

Attenuation relationship developed by Iyenger and Raghukanth (2004) was considered for the analysis and PGA was calculated.

Maximum value of PGA has been taken, amongst the PGA calculated, by various source at each point.

$$\ln (PGA/g) = C1 + C2\ (M-6) + C3\ (M-6)^2 - \ln(R) - C4(R) + \ln \varepsilon \text{--- (3)}$$

III. PGA CONTOUR MAP

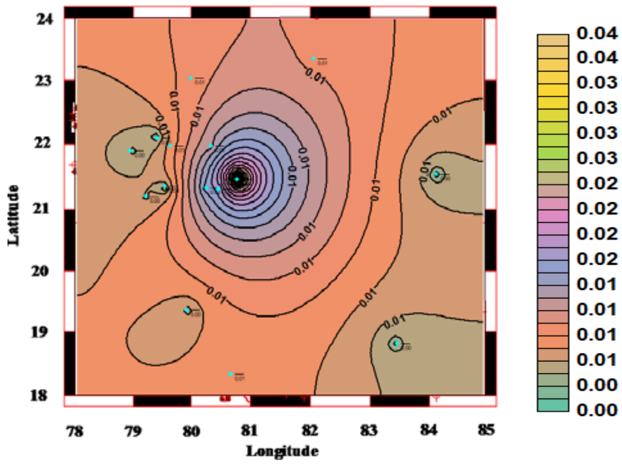

Fig. 2 PGA Contour Map for 50 Percentile, Recurrence Period 100 Years

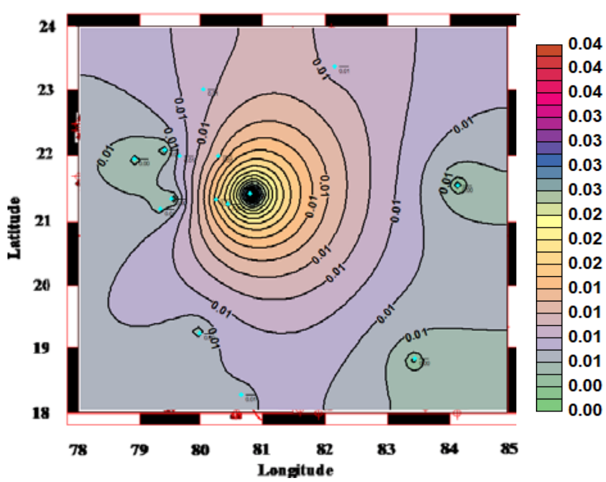

Fig. 3 PGA Contour Map for 50 Percentile, Recurrence Period 500 Years

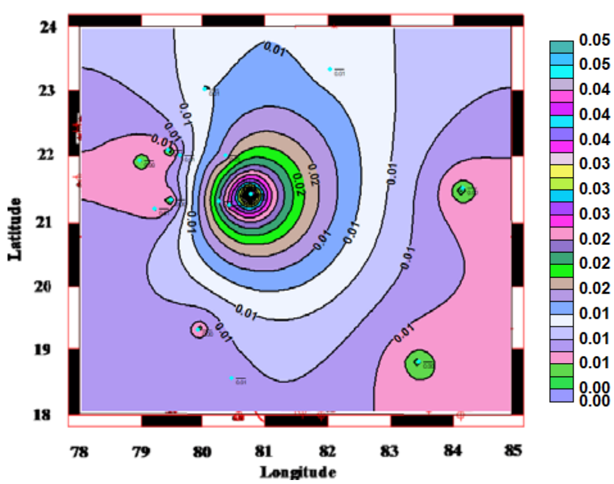

Fig. 4 PGA Contour Map for 50 Percentile, Recurrence Period 1000 Years

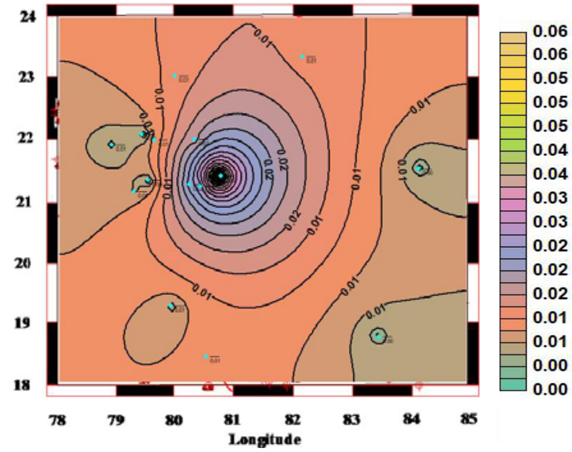

Fig. 5 PGA Contour Map for 84 Percentile, Recurrence Period 100 Years

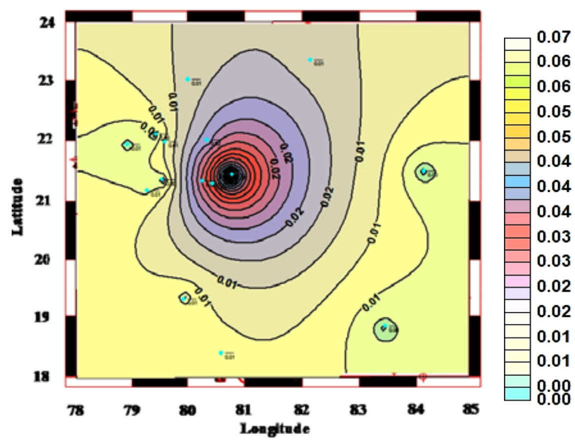

Fig. 6 PGA Contour Map for 84 Percentile, Recurrence Period 500 Years

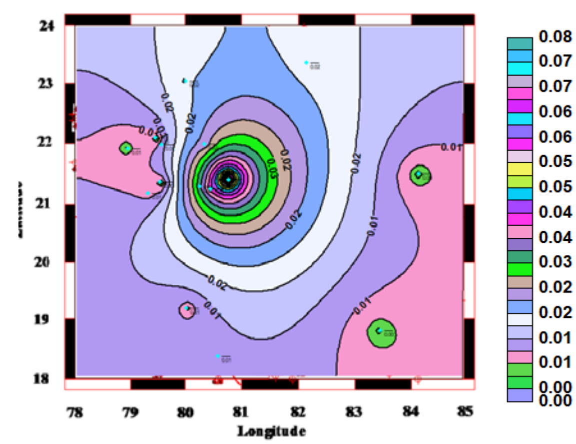

Fig. 7 PGA Contour Map for 84Percentile, Recurrence Period 1000 Years

The Attenuation relationship developed by Iyenger and Raghukanth (2004) was used to estimate PGA values at bed rock level for recurrence periods 100 years 500 years and 1000 years. The PGA contour maps were prepared for the above recurrence periods and depicted in Fig.2 to Fig.7.

IV. CONCLUSION

In the present research, the seismic hazard analysis carried out for the establishment of PGA at substratum level for District Headquarter Dhamtari, was based on deterministic approach. An effort has also been made to evaluate the seismic hazard in terms of PGA at the bed rock level. The Regional Recurrence Relationship obtained for District Headquarter Dhamtari as depicted in Equation 1. shows the obtained "b" value as 0.5403 for low seismicity. The Values of P.G.A. for various linear sources for recurrence periods 100, 500 & 1000 years have been shown in Appendix -1, Table. 2 to 4. It is observed that Maximum of Peak Ground Acceleration (PGA) values for above recurrence periods increases from 10.50% to 28.52% for 50 Percentile for fault F11. On the other hand Peak Ground Acceleration (PGA) values for above recurrence periods increases from 2.6% to 5.8% for 50 Percentile for fault F1. In the PGA values the % increment is more in F11 fault due to less hypo central distance of 84.3856 km wherein the Fault F1 has the hypo central distance as 276.525 km so this indicated that, the % increment is less with increase in hypocentral distance.

REFERENCES

[1] Anbazhagan P. and Sitharam T. G., Seismic Microzonation of Bangalore, India. Journal of Earth Systems Science 117 (S2), 833–852. 2008

[2] Ambraseys, N.N. (1995). The prediction of earthquake peak ground acceleration in Europe. Earthquake Engineering and Structural Dynamics. 24:4, 467–490.

[3] A.K.Parashar, S. Atmapoojya, S.S. Rathore,Seismic Hazard Analysis of Sondur Dam Site of Chhattisgarh State, European Scientific Journal,Vol.11, No.6 Feb. 2015, pp 122-130

[4] A.K.Parashar, S. Atmapoojya, S.S. Rathore, Deterministic Seismic Hazard Analysis For Shallow Earthquakes For Ballar Dam of Chhattisgarh State (India), International Journal of Engineering and Applied Sciences, Volume-2, Issue-1, Jan. 2015,pp 1-4

[5] Bulent Ozmen, B. Burçak Başbug Erkan, Probabilistic earthquake hazard assessment for Ankara and its environs, Turkish Journal of Earth Sciences, Turkish J Earth Sci, (2014) 23: 462-474

[6] Bonilla, M.G, Mark R.K., and Lien kaemper J.J. (1984). Statistical relation among earthquake magnitude, surface rupture and surface fault displacement. Bulletin of the Seismological Society of America 74:6, 2379-2411.

[7] Bazzurro P. P. and Cornell C. A., Disaggregation of Seismic Hazard,Bulletin of the Seismological Society of America, 89, 2, pp. 501-520, April 1999 Bulletin of the Seismological Society of America, 89, 2, pp. 501-520, April 1999

[8] Boore, D.M; Joyner, W.B., and Fumal T.E. (1997). Equations for estimating Horizontal Response Spectra and Peak Acceleration from Western North American Earthquakes: A Summary of Recent Work. Seismological Research Letters. 68:1, 128-153.

[9] Campbell, K.W., and Bozorgnia, Y. (2003). Updated near-source ground-motion (attenuation) relations for the horizontal and vertical components of peak ground acceleration and acceleration response spectra. Bulletin of the Seismological Society of America. 93:1, 314–331.

[10]Catalogue of Earthquakes in India and Neighborhood, (From Historical period up to 1979) Indian Society of Earthquake Technology, Roorkee-1993.Criteria for Earthquake Resistant Design of Structures (Part, General Provisions and Buildings, IS-1893:2002.

[11]Datta D. and Ghoshe S., Uniform hazard spectra based on park-ang damage index Journal of Earthquake and Tsunami, Vol. 2, No. 3 (2008) 241–258

[12]Iyenger, R N and Raghukant, S T G Attenuation of Strong Ground Motion in Peninsular India. Seismological Research Letters. Volume 75, Number 4, July/August 2004, pp530-539.

[13] Iyengar, R. N. and Raghu Kanth, S. T. G., Seismic Hazard Estimation for Mumbai city.

Current Science 91 (11, 10), 1486-1494. 2006
[14] Khan, S.A., Shah, M.A., and Qaisar, M. (2003). Seismic risk analysis of coastal area of Pakistan. Acta Seismologica Sinica (Earthquake Science). 16:4, 382-394.
[15]Kramer, S.L., 1996. Geotechnical Earthquake Engineering, Prentice-Hall, Inc. Upper Saddle River, New Jersey 07458, USA.
[16]McGuire, R.K. (1978). Seismic Ground Motion Parameter Relations. Journal of the Geotechnical Engineering Division, ASCE. 104:GT7, 41-490.
[17]Wells, D.L., and Coppersmith, K.J. (1994). New Empirical Relationships among Magnitude, Rupture Length, Rupture Width, Rupture Area and Surface Displacement. Bulletin of the Seismological Society of America. 84:4, 974-1002.

Appendix -1

Table 1: District Headquarter Dhamtari Faults Considered for Hazard Analysis

Fault no.	Length (kM)	Fault Name	Min. Map Distance (kM)	Hypo Central Distance (kM)
F1	75	----	276.344	276.525
F2	140	Bamhni - Chilpa	274.327	274.509
F3	76	-----	257.817	258.011
F4	182	Gavilgarh Fault	256.676	256.871
F5	38	-----	251.775	251.974
F6	91	-----	228.027	228.246
F7	70	-----	178.897	179.176
F8	70	-----	196.678	196.932
F9	125	-----	183.526	183.798
F10	45	-----	142.533	142.883
F11	58	-----	83.791	84.3856
F12	25	-----	125.105	125.504
F13	180	-----	225.913	226.134
F14	130	Godavari Valley	253.082	253.279
F15	121	Parvatipuram-	263.064	263.254

Table 2: District Headquarter Dhamtari Faults Considered for Hazard Analysis

Fault no.	Length (kM)	Hypo Central Distance (kM)	100 years Reccurance M100	PGA Values (g) (100Years)	
				50 Percentile	84 Percentile
F1	75	276.525	5.039	0.00155	0.00246
F2	140	274.509	6.809	0.00826	0.01315
F3	76	258.011	6.587	0.00805	0.01282
F4	182	256.871	5.551	0.00316	0.00503
F5	38	251.974	5.232	0.00240	0.00381
F6	91	228.246	6.099	0.00705	0.01122
F7	70	179.176	6.023	0.01108	0.01764
F8	70	196.932	4.849	0.00278	0.00443
F9	125	183.798	5.252	0.00494	0.00787
F10	45	142.883	5.911	0.01540	0.02451
F11	58	84.3856	5.983	0.03892	0.06194
F12	25	125.504	5.699	0.01581	0.02517
F13	180	226.134	5.510	0.00411	0.00654
F14	130	253.279	6.304	0.00661	0.01053
F15	121	263.254	5.249	0.00219	0.00348

Table 3: District Headquarter Dhamtari Faults Considered for Hazard Analysis

Fault no.	Length (kM)	Hypo Central Distance (kM)	500 years Reccurance M500	PGA Values (g) (500Years)	
				50 Percentile	84 Percentile
F1	75	276.525	5.064	0.00159	0.00253
F2	140	274.509	6.935	0.00913	0.01453
F3	76	258.011	6.772	0.00937	0.01492
F4	182	256.871	5.571	0.00322	0.00513
F5	38	251.974	5.292	0.00255	0.00406
F6	91	228.246	6.165	0.00748	0.01191
F7	70	179.176	6.128	0.01219	0.01941
F8	70	196.932	4.870	0.00285	0.00453
F9	125	183.798	5.270	0.00504	0.00802
F10	45	142.883	6.043	0.01740	0.02770
F11	58	84.3856	6.092	0.04301	0.06847
F12	25	125.504	5.884	0.01887	0.03004
F13	180	226.134	5.569	0.00435	0.00693
F14	130	253.279	6.308	0.00664	0.01057
F15	121	263.254	5.268	0.00223	0.00355

Table 4: District Headquarter Dhamtari Faults Considered for Hazard Analysis

Fault no.	Length (kM)	Hypo Central Distance (kM)	1000 years Reccurance M1000	PGA Values (g) (1000Years)	
				50 Percentile	84 Percentile
F1	75	276.525	5.094	0.00164	0.00261
F2	140	274.509	7.150	0.01076	0.01713
F3	76	258.011	7.110	0.01221	0.01943
F4	182	256.871	5.595	0.00330	0.00525
F5	38	251.974	5.381	0.00279	0.00444
F6	91	228.246	6.274	0.00825	0.01312
F7	70	179.176	6.267	0.01381	0.02198
F8	70	196.932	4.894	0.00292	0.00466
F9	125	183.798	5.295	0.00517	0.00823
F10	45	142.883	6.250	0.02098	0.03339
F11	58	84.3856	6.260	0.05001	0.07961
F12	25	125.504	6.214	0.02554	0.04065
F13	180	226.134	5.595	0.00447	0.00711
F14	130	253.279	6.479	0.00770	0.01225
F15	121	263.254	5.295	0.00229	0.00365

Table 5: PGA Increment Variation for 50 Percentile for District Headquarter Dhamtari

Fault no.	Length (kM)	Hypocentral Distance R in Km	PGA Values (100Years) (g)	PGA Values (500Years) (g)	PGA Values (1000Years) (g)	% Increment in PGA Value Recurrence Period increases from 100 years to 500 years	% Increment in PGA Value Recurrence Period increases from 500 years to 1000 years	% Increment in PGA Value Recurrence Period increases from 100 years to 1000 years
			50 Percentile	50 Percentile	50 Percentile			
F1	75	276.525	0.00155	0.00159	0.00164	02.60%	03.15%	05.80%
F11	58	84.3856	0.03892	0.04301	0.05001	10.50%	16.30%	28.50%

Table 6: PGA Increment Variation for 84 Percentile for District Headquarter Dhamtari

Fault no.	Length (kM)	Hypocentral Distance R in Km	PGA Values (100Years) (g)	PGA Values (500Years) (g)	PGA Values (1000Years) (g)	% Increment in PGA Value Recurrence Period increases from 100 years to 500 years	% Increment in PGA Value Recurrence Period increases from 500 years to 1000 years	% Increment in PGA Value Recurrence Period increases from 100 years to 1000 years
			84 Percentile	84 Percentile	84 Percentile			
F1	75	276.525	0.00246	0.00253	0.00261	02.85%	03.16%	06.10%
F11	58	84.3856	0.06194	0.06847	0.07961	10.54%	16.26%	28.52%