ATTENUATION OF INTENSITIES IN INDIA

Umesh Chandra[1]

SUMMARY

The isoseismal maps for thirteen earthquakes in different parts of India were analyzed to study the attenuation of intensities. Based on a general consideration of regional geology and tectonics, the country was broadly divided into four attenuation provinces. In order of increasing attenuation, these are: Northeast province, Ganga Basin, Jammu and Kashmir - Himachal Pradesh, and Peninsular province. Empirical attenuation relations were derived by using an iterative least squares fit procedure, wherein an initial graphical estimate of epicentral intensity for each earthquake is successively improved. As a byproduct the analysis yielded improved estimates of epicentral intensity for each earthquake.

DATA

All published isoseismal maps for earthquakes in India were collected. After a careful examination of the quality of these maps, the earthquakes listed in Table 1 were considered suitable for the present study. The locations of these earthquakes are shown in Fig. 1.

In preparing the isoseismal maps, different intensity scales were used by the various authors. Jones (1885) used Mallet's designation of intensity effects into meizoseismal area, first, second and third isoseismals. Oldham (1899) adopted a scale having seven degrees of intensity. The following correspondence between this scale and the Rossi-Forel (R.F.) scale was suggested by Oldham (1899).

Oldham Scale	1	2	3	4	5	6	7
R.F. Scale	X	IX	VIII	VII and VI	V and IV	III and II	I

Richter (1958) gave the following correspondence between the Modified Mercalli (M.M.) and the Rossi-Forel scales.

M.M.	I	II	III	IV	V	VI
R.F.	I	I-II	III	IV-V	V-VI	VI-VII

M.M.	VII	VIII	IX	X-XII
R.F.	VIII-	VIII+ to IX	IX+	X

In the following analysis, all the isoseismal intensities for various earthquakes were converted to intensities on the Modified Mercalli scale using the above correspondence.

ANALYSIS

Recently the author (Chandra, 1979) proposed empirical relations, for the attenuation of M.M. Intensities, of the form

[1] Senior Principal Seismologist, Ebasco Services Inc., Boone Building, 2211 West Meadowview, Greensboro, N.C. 27407, U.S.A.

TABLE 1
EARTHQUAKES SELECTED FOR ATTENUATION STUDY

NO	DATE	LATITUDE °N	LONGITUDE °E	MAGNITUDE	INTENSITY SCALE	CALCULATED I_o (M.M.)	ISOSEISMAL REFERENCE
JAMMU AND KASHMIR – HIMACHAL PRADESH							
1	30 MAY 1885	34.1	74.8		MALLET	10.93	JONES (1885)
2	4 APR 1905	32.2	76.3	8.6	R.F.	9.74	MIDDLEMISS (1910)
3	19 JAN. 1975	32.5	78.4	6.8	M.M.	8.98	SINGH et al. (1976)
GANGA BASIN							
4	15 JAN. 1934	26.3	86.0	8.4	M.M.	11.03	DUNN et al. (1939)
NORTHEAST PROVINCE							
5	12 JUN. 1897	25.9	91.8	8.7	OLDHAM	12.27	OLDHAM (1899)
6	8 JUL. 1918	24.3	91.7	7.6	OLDHAM	8.76	STUART (1920)
7	3 JUL. 1930	25.5	90.0	7.1	OLDHAM	9.05	GEE (1934)
8	15 AUG. 1950	28.5	96.7	8.7	R.F.	11.29	TANDON (1954)
PENINSULAR PROVINCE							
9	8 FEB. 1900	10.8	76.8	6.0	M.M.	9.34	BASU (1964)
10	29 SEP. 1906	22.6	88.4		R.F.	7.92	MIDDLEMISS (1907-08)
11	14 MAR. 1938	21.5	75.8	6¼	M.M.	10.11	MUKHERJEE (1942)
12	21 JUL. 1956	23.0	70.0	6.1	M.M.	8.78	TANDON (1959)
13	10 DEC. 1967	17.7	73.9	6.0	M.M.	9.23	TANDON AND CHAUDHURY (1968)

$$I(R) - I_o = b\,R + c \log (1 + R/D) \qquad (1)$$

where I_o is the epicentral intensity, I(R) is the intensity at a distance R from the epicenter, b and c are parameters appropriate to the region under consideration, and D is a suitably chosen constant. In this analysis, the value of D was assumed equal to 20 km for all the four attenuation provinces. Initial I_o values for different earthquakes were estimated graphically, and the parameters b and c were determined for each attenuation province by using the iterative least squares fit procedure developed by the author (Chandra, 1979). The following attenuation relations and corresponding standard errors, σ of $I-I_o$, were obtained.

Jammu and Kashmir - Himachal Pradesh

$$I(R) - I_o = 3.975 - 0.00100\,R - 3.055 \log (R+20)$$
$$\sigma = 0.472 \quad R < 650 \text{ km} \qquad (2)$$

Ganga Basin

$$I(R) - I_o = 3.470 - 0.00210\,R - 2.667 \log (R+20)$$
$$\sigma = 0.193 \quad R < 1100 \text{ km} \qquad (3)$$

Northeast Province

$$I(R) - I_o = 2.501 - 0.00452\,R - 1.922 \log (R+20)$$
$$\sigma = 0.244 \quad R < 1050 \text{ km} \qquad (4)$$

Peninsular Province

$$I(R) - I_o = 4.987 - 0.00204\,R - 3.833 \log (R+20)$$
$$\sigma = 0.338 \quad R < 400 \text{ km} \qquad (5)$$

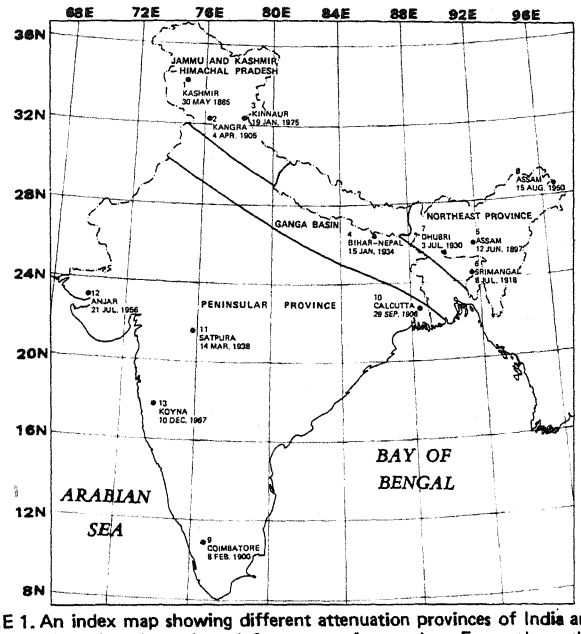

FIGURE 1. An index map showing different attenuation provinces of India and location of earthquakes selected for attenuation study. For each earthquake, an identification number (Table 1), name of the nearest locality, and date of occurrence is given.

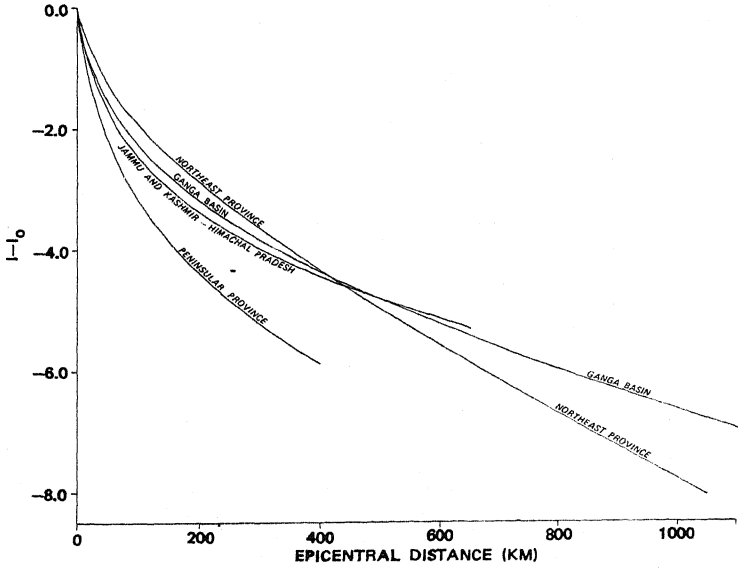

FIGURE 2. Attenuation of intensities for different regions of India.

DISCUSSION AND CONCLUSIONS

The attenuation relations corresponding to equations (2) to (5) are plotted in Fig. 2. It is observed that at distances less than about 430 km, the attenuation of intensities in the Northeast province is the smallest. This is followed by the attenuation for Ganga Basin, and Jammu and Kashmir - Himachal Pradesh. The Peninsular province shows the highest rate of attenuation.

As a byproduct, the analysis yielded improved estimates of I_o (presented in Table 1) for each earthquake. The epicentral intensities thus derived are based on an analysis of all isoseismal contours and are, therefore, independent of the subjective judgment of assigning intensity at one observation point. Also, because the attenuation relations derived in this study are based on these revised I_o values, which are generally larger than the maximum mapped or observed intensities, for practical application of these results a reevaluation of epicentral intensities of earthquakes of significance to the seismic design of critical facilities is recommended.

REFERENCES

Basu, K.L. (1964). A note on the Coimbatore earthquake of 8 February, 1900, Ind. J. Met. Geophys., 15, 281-286.

Chandra, U. (1979). Attenuation of intensities in the United States, Bull. Seism. Soc. Am., 69, 2003-2024.

Dunn, J.A., J.B. Auden, and A.M.N. Ghosh (1939). The Bihar - Nepal earthquake of 1934, Chapter II, Discussion of Scales and Isoseismals, Mem. Geol. Surv. India, 73, 7-26.

Gee, E.R. (1934). Dhubri earthquake of the 3rd July, 1930, Mem. Geol. Surv. India, 65, Pt. 1, 1-106.

Jones, E.J. (1885). Report on the Kashmir earthquake of 30th May 1885, Rec. Geol. Surv. India, 18, Pt. 4, 221-227.

Middlemiss, C.S. (1907-08). Two Calcutta earthquakes of 1906, Rec. Geol. Surv. Ind., 36, Pt. 3, 214-232.

Middlemiss, C.S. (1910). The Kangra earthquake of 4th April, 1905, Mem. Geol. Surv. India, 38, 409 p.

Mukherjee, S.N. (1942). Seismological features of the Satpura earthquake of the 14th March, 1938, Proc. Indian Aca. Sci., 16, Sec. A, 167-175.

Oldham, R.D. (1899). Report on the great earthquake of 12th June, 1897, Mem. Geol. Surv. India, 29, 379 p.

Richter, C.F. (1958). Elementary Seismology, W.H. Freeman and Co., San Francisco.

Singh, S., A.K. Jain, P. Sinha, V.N. Singh and L.S. Srivastava (1976). The Kinnaur earthquake of January 19, 1975: A field report, Bull. Seism. Soc. Am., 66, 887-901.

Stuart, M. (1920). The Srimangal earthquake of 8th July, 1918, Mem. Geol. Surv. India, 46, Pt. 1, 1-70.

Tandon, A.N. (1954). Study of the great Assam earthquake of August 1950 and its aftershocks, Ind. J. Met. Geophys., 5, 95-137.

Tandon, A.N. (1959). The Rann of Cutch earthquake of 21 July, 1956, Ind. J. Met. Geophys., 10, 137-146.

Tandon, A.N. and H.M. Chaudhury (1968). Koyna earthquake of December 1967, India Meteorol. Dept., Scientific Report No. 59, 12 p.