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AN EVALUATION OF THE SEISMICITY OF MANERI-BHALI HYDEL SCHEME, STAGE-I, UTTARKASHI DISTRICT, U. P.

A. S. DHANOTA*

INTRODUCTION

The Maneri-Bhali Hydel Scheme (Stage I) envisages the construction of a 41 m. high dam at Maneri (30°44′50″ ; 78°23′ ; 53J/10) ; a 8·3 Km long power tunnel and a power house at Tiloth (30°43′50″ ; 78°26′50″ 53J/6), in order to utilise the hydraulic drop between Maneri and Tiloth for power generation. The diversion dam will be founded on heavily jointed quartzites belonging to the Barahat Series, and the power house will be located on a sub-recent river terrace deposit.

The Himalayan belt is one of the most active seismic belts and has been the locale of some of the major earthquakes that have occurred in this country. With the development of major river valley projects in the Himalayan Region, special seismic studies have assumed increasing importance so that proper guidance can be had in selecting a suitable seismic coefficient for the design of major structure. This note deals with the geo-seismological considerations relating to the design of Maneri Bhali Hydel Scheme (Stage-I) which is now under construction in the Bhagirathi Valley. The Geo-seismological considerations relate to the available information concerning the past earthquake epicentres, their magnitude, frequency and distribution, and an evaluation of the activity of the various thrusts, faults and other geological features occurring within a 300 Kms. redial distance of the project.

EVALUATION OF PAST EARTHQUAKES

A. Periodicity of Earthquakes : There is no reliable or complete record of the earthquakes experienced in the region prior to 1950. Thus, while 4 earthquakes were documented for the period 1816 to 1900, and 22 earthquakes for the period 1901 to 1950, as many as 60 earthquakes were recorded for the period 1951 to 1969, within a radial distance of 300 Kms. of the Maneri Intake Dam site (Fig. I, II & Table-I). Therefore, any attempt to evaluate the periodicity of the shocks from the available records cannot be considered fully reliable. Taking only the past 9 years, *i.e.* between 1961-69, 48 shocks of Richter magnitude up to 6·7 have been recorded in the region encompassing a radial distance of 300 km. from the project. This gives an average of 5·3 shocks per year. The record for the last 9 years period appears to be quite accurate and, assuming that had enough documentation been available for the period prior to 1961, a similar picture may have emerged, it is considered probable that 5 to 6 shocks per year can be expected within a radial distance of 300 km. of the Maneri dam site.

While, as stated earlier, the periodicity is 5-6 shocks per year for the entire radial distance of 300 km. from the Maneri dam, as 3·5% of the total number of shocks were recorded within a radial distance of 50 km. of Maneri dam the probablitity of shock emanating within this radial distance works out to be 0·18 shocks per year, or, one shock in 5½ years Again, as 18·6% of the total number of shocks originated within a radial distance of 100 km. of the Maneri dam, the probability of an earthquake epicentre lying within this reach is calculated at 0·99 shock, or, say, one shock per year.

B. Intensity and Ground Accelerations : As it is well known, depending on the ground conditions, there is a large variation in seismic intensity at the same distance

*Geologist (Jr.), Geological Survey of India, E. G. Division, Northern Region, Lucknow.

from the epicentre. It is, therefore, difficult to formulate any definite relationship, between intensity and distance from epicentre. It is a common experience that the structures founded on rock usually suffer less damage as compared to the structures founded on soil. To quote a recent example, in the Anjar earthquake of 1956, the portion of the Bhuj town located on rock suffered less demage as compared to the portion of the town located on soil. Thus, the observed intensity had a very wide scatter. The likely seismic intensity and ground acceleration at a place will depend not only on its distance from the epicentre but also on the magnitude and the depth of focus of the earthquake and the type of foundation on which the structure is based. An empirical relationship between distance, magnitude, seismic intensity and ground acceleration has been worked out graphically by Tandon (1962).

Tandon's relationship holds good for average foundation, as at the Maneri Intake dam, and for structures based on soil or unconsolidated material as at the Tiloth power house, the intensity has been taken higher by +1 on the Modified Mercalli Scale. For the purpose of working out the likely intensity at the Tiloth power house the alternative of poorer foundations, like water saturated sand, with a tendency to flow during earthquake shocks, has also been considered, which indicates that a still higher seismic intensity by +2 on M.M. scale has to be assumed on the values obtained from Tandon's graph.

The conventional method of computing the seismic intensity and ground acceleration for designing a major engineering structure is by using the value of intensity as computed for that place during the largest known past earthquake in the region. In this approach, it is assumed that the maximum intensity of the same order alone may recur in the region within the life span of the proposed structures. While this assumption may not be valid, using this conventional approach and the available record of the earthquakes in the region, the values of maximum intensity and ground acceleration have been worked out on the basis of Tandon's graph. These values are furnished in Table-II. In the subsequent chapter, a geological evaluation of the likely future patterns of seismic activity has been given, on the basis of which the likely intensities and accelerations at the project sites have been forecasted.

The data furnished in Table-II indicate that the maximum ground acceleration likely to have been felt during the past earthquakes at the site of the Maneri dam and Tiloth power house is 0.05 g and 0.12 g respectively. Taking the worst foundation conditions of water saturated sand, the maximum seismic intensity likely to have been experienced as VIII M.M, with the corresponding ground acceleration of 0.23 g. In fact the evidence of deep seated slump features in the adjacent hill mass housing the penstocks has been related by Krishnaswamy (personal communication) to the effect of some past earthquakes in the area.

SEISMIC STATUS IN TERMS OF TECTONIC SETTING

A. Lack of data for correlation : The thrusts and faults represent the potential avenues of earth movement in the geological past. Some of them are probably still having an active seismic status. The principal tectonic features, along with the epicentres of past earthquakes within a 300km. radial distance of Maneri dam, are shown on Fig. 1. At present there is no adequate network of seismological stations to pick up the epicentres and depth of focus of minor shocks and to correlate them with the downward extension of the known thrusts and faults. Therefore, any discussion on the seismic status of thrusts and faults is bound to be largely hypothetical and can offer only a tentative and qualitative approach to the likely correlation of earthquake epicentres with the thrusts and faults. This approach is presented below for the more important thrusts and faults.

B. Seismicity of Main Himalayan Thrust : This is a major tectonic feature in the area, and is prominently exposed, about 6km. upstream of the Maneri Dam along the Kumalti and Duggada *Gads*. The thrust dips at a low angle to the north and brings the Barahat Series in juxtaposition with the Central Himalayan Series. It has been napped in disconnected patches, and no work has been carried out so far to establish its seismic status. However, from the distribution pattern of the earthquake epicentres (Nos. 2,3,5,6,7,11,12,15,18,19,28,37 and 42), which occur on the down dip side of the thrust, it appears possible that some of these shocks may be related to seismic activity at different depths along this thrust plane. These earthquake epicentres lie between 16 to 50km. north of the Main Himalayan Thrust. None of the earthquakes, lying within 200 km. of Maneri dam, have shown a magnitude of above 6. However, two earthquake epicentres, Nos. 37 and 42 lying between 200-260 km. distance from Maneri, have magnitudes of 6·2 and 7·5 and appear to be related to the activity of this thrust.

No record of the focal depth of the thirteen earthquakes is available, except for the earthquake No. 42, having a magnitude of 6·2 and a focal depth of 50 km. This earthquake epicentre is situated approximately 35 km. north from the thrust trace and the dip of the thrust in this region is assessed at 55°N. Assuming the thrust plane to flatten at depth and to have dips varying between 55° to 35°, the cited earthquake can be correlated with seismic activity of this thrust and is likely to have had its focus along the extension of the thrust plane. Detailed geological and seismological studies of this thrust are called for before this postulation can be taken as confirmed.

C. Seismicity of the Chail Thrust : This demarcates the apparent boundary of the Chails with the underlying krols and equivalent rocks. The homologue of this thrust in U. P. is the Garhwal thrust (Krishnaswamy and Swaminath, 1965). It runs nearly parallel to the Krol thrust. Hukku (1962) studied this thrust in the Mandi-Sundernagar section, H. P. and found that the thrust contact has in-tact igneous injections, which had presumably taken place in a post-granitisation phase in the Miocene. The intact injections show that thrust was probably seismically inactive after the emplacement of these injections.

The chail thrust is also covered under the sub-recent deposits of the Suket basin over a distance of 13 km. and no evidence of any perceptible displacement has been noticed by Hukku in these deposits. Therefore, the Chail thrust can be taken to have been seismically inactive, probably since the Pleistocene times.

D. Seismicity of the Krol Thrust : This thrust generally forms the apparent line of demarcation between the older Tertiaries (Subathu-Dagshai-Kasauli-Murree) and the overriding masses of the Pre-Tertiaries (Krols or Shalis) west of longitude 78° East of this longitude, however, the Krol thrust is termed as the Main Boundary Fault, (Krishnaswamy and Swaminath, 1965), here, it overlaps the lower Nahan thrust, and hence the Pre-Tertiaries are brought directly over the Younger Tertiaries (Siwaliks). In parts of Himachal Pradesh this thrust is homologus with the Shali thrust and further beyond in J&K with the Murree thrust (Krishnaswamy 1966).

In Mussoorie area, the thrust forms a 'Nappe' far removed from the root zone, and there appears to be a complete release of stress, because of which the thrust is considered seismically inactive. In the Tons valley of U. P. the Krol thrust has brought the Pre-Tertiary Mandhali rocks over the Older Tertiaries. The thrust contact dips at about 25° in a northerly direction. There is no positive evidence to suggest that further shocks will necessarily be related to the Krol thrust (Mehta, 1962). In the Sundernagar area of H. P., the Krol/Shali thrust zone dips, at angles ranging from 50° and above towards the east. From the available geological evidence in this area, Hukku (1962) concluded that there had been no major seismic activity along the thrust since the pleistocene times.

E. Seismicity of the Nahan Thrust : The Nahant thrust forms the apparent demarcation line between the younger Tertiaries (Siwaliks) and the older Tertiaries (Subathu-Dagshai-Kasauli-Murree). No positive evidence of currently active seismic status of the Nahan thrust was found in the Tons area, U. P. (Mehta 1962). As stated earlier, west of longitude 78°, the Nahan thrust is the equivalent of the Main Boundary Fault. This thrust should occur below the Krol thrust at an approximate distance of 45-50 kms. to the south of the project. This thrust has to be assumed to be seismic, although for lack of focal depth data, the past earthquake epicentres cannot be confidently related to the activity of this thrust.

F. Seismicity of the Satlitta Thrust : This thrust brings the upper Siwalik beds over Sub-Recent beds of gravels and clays. The thrust has a NW-SE trend in the Beas Valley. H. P., and dips at angles ranging from 20° to 70° in a north easterly direction. The Satlitta thrust has been proved to have been active in the geologically recent times (Jalote, 1962). Krishnaswamy (1962) has postulated that the continuing adjustment at depth along the downward extension of this thrust may have been responsible for the Kangra earthquake of 1905. The satlitta thrust and its homologue, the Markanda thrust have been traced over a length of 220km. from Pathankot to Nahan. Further south-east, the trace of this thrust is hidden under Dum gravels. It is expected to lie about 100km. south west of the Maneri dam. In the Paonta area of H.P. the Markanda thrust has also shown geologically recent activity (Shome and Dayal 1966).

Although it is likely that most of the earthquake epicentres occurring on the northern side of the Chail thrust i. e. Nos. 17, 29, 36, 55 (Kangra shock) 78, 79 may have orginated because of movement along the Satlitta thrust plane at depth, a positive conclusion cannot be offered in the absence of focal depths of all these shocks. These earthquakes' are located mostly between 60 to 75km distance from Satlitta thrust. The earthquake Nos 57, 80 and 81 are located between 30 to 45 km. away from the trace of the thrust. Focal depth of only three earthquakes *viz.* Nos. 77, 80 and 81 are available, which are 30, 28 and 41 kms. respectively. If the net dip of the Satlitta thrust is worked out between 30° to 50°, some of these earthquakes can be correlated with the down dip extension of the thrust.

G. Seismicity of the Srinagar Thrust or Fault : This thrust or fault has been traced over a strike length of over 100 kms. and it brings the Barahat Series against the Simla Slates and Chandpurs. In the Bhagirathi and Ganga Valleys it has a dip varying from 30° to steep angles in a northerly to north easterly directions, although, in some sections a southerly dip is also seen. Portions of this thrust lie within 50 kms. of the Maneri intake dam site and the thrust also extends to distance of 150—200 kms. from this dam site.

The geological investigations carried out by Metha *et al* (1969) have indicated that the Srinagar thrust/fault to be of geologically recent age. The presence of nick points at some of the stream crossing of the thrust has been explained by them as due to the continuous release of stresses by the way of creep along the trace of the thrust fault.

From the distribution pattern of the earthquake epicentres (Nos. 1, 10, 14, 16, 20, 22, 25, 26, 27, 32, and 35) there appears to be some relationship with the Srinagar thrust. fault. These earthquake epicentres are located 34 to 55 kms. north of the thrust trace. Focal depths of earthquakes Nos. 14, 16, 22, 25 and 34 are 40, 19, 25 20, and 35 kms. respectively. It is likely that thrust plane dips at a gentler angle with depth. If so, it is postulated that most of these earthquakes are correlatable with the activity of the Srinagar thrust or fault.

H. Seismicity of the Moradabad and Sohana Faults : The earthquake (Nos. 53, 61, 62, 68, 82, 84, 85 and 86) which originated in the vicinity of Delhi, may have had their foci along the likely extensions of the Moradabad and Sohana faults (Krishnaswamy, 1962, 1965 Hukku 1966, Srivastava, 1966) which are considered to have an active seismic status. The exact location of the Sohana fault is uncertain and has yet to be proved by geophysical surveys. The Moradabad fault is located 120-250 kms. south of the Maneri Project area, although, so far, its activity is now only in the extension of the fault near Delhi, which is 250-300 kms. south west of the project site.

I. Sesimicity of Unknown Thrust and Faults : A large number of earthquakes had been recorded east of Almora, between 250-300 kms. distance and SE to ESE of the Project Area. A complete geological and structual interpretation of this area is not yet available and, as such, no attempt can be made to correlate these earthquakes with the tectonic features. The maximum magnitude of these earthquakes is 6·3 and in view of their distance, the intensity likely to be felt in Project area, on account of revival of activity at the past centres, is adjudged to be less then VI M. M.

FORECAST OF POSSIBLE FUTURE SEISMICITY

As the Satlitta thrust is very young in its tectonic age, it is reasonable to postulate that this thrust can get revived any where along its strike extension to the SE of the past centres of activity. Such a south easterly migration of earthquake foci on the downward extension of the thrust will bring the epicentres of future earthquakes much close to the project area than in the past. The epicentres can then lie within a radial distance of any where from 50 to 300 kms. The maximum magnitude of the earthquake that appears to have emanated on the satlitta thrust in the recent historical times is that at Kangra which is 8 Assuming this magnitude and different radial distance to possible future centres the expectable intensity and acceleration has been computed in table III.

The earthquakes correlatable with the Srinagar thrust/fault have epicentres located within 200 kms. radius distance of Maneri dam. If the centre of activity migrate north-west wards along strike from 30° north/80° East, the possibility of any future earthquake, due to seismic activity along the Srinagar thrust plane occurring within 50 kms. of the Project area cannot be ruled out. The maximum magnitude of earthquake that can be attributed to the activity on the Srinagar thrust is 6·5. Assuming a similar magnitude shock to arise within different radial distance, the intensity and acceleration have been furnished in table III.

The maximum magnitude of the earthquake that has been correlated with the Main Himalayan thrust is 7·5 at coordinates 30° north 81° east. The plane dips away from the project area at an angle of probably about 30° as seen in the adjacent Ganga Valley, therefore within a radial distance of 50 kms. to the north, the focal depth will be around 25kms. with a deeper focus, the future earthquake arising on this thrust may lie beyond 50 kms., to the north of the dam. Assuming that the foci of earthquakes of the maximum magnitude already recorded, because of the seismic activity of the Main Himalyan thrust may migrate north westwards, its intensity and ground accelerations likely to be left in Project area is given in Table III.

It will be seen from table III that designing the engineering structures for an earthquake of 8 magnitude within 100kms of the project area, may not be practicable from engineering and economic point of view and it is possible to reasonably cater to such magnitude shocks arising only beyond a distance of 150 kms, if a coefficient for ground accelerations for 15 percent gravity for the Maneri dam and 20 percent gravity for the Tiloth Power House is taken in the design.

The possibility of experiencing a severe earthquake, because of migration of foci along the Main Himalayan thrust planes, with epicentres lying within 50 kms. of Maneri dam, is also difficult to provide *in toto* in design. However it would be seen that major engineering structures can be designed for earthquake epicentres that may arise on this thrust at a dip distance of 50-100kms. from the Project area, by providing a seismic coefficient for ground acceleration upto 15% gravity for the Maneri dam and 20% gravity for the Power House.

In the case of an earthquake of 6·5 magnitude orginating because of future seismic activity along the Srinagar thrust plane, if the epicentre should lie within 50 kms. distance from major engineering structures the ground accelerations proposed above can reasonably safeguard the structure from total damage, although substantial damage cannot be avoided.

From the foregoing discussions about the possibilities of migration of foci along the three seismically active thrust planes that are of importance to the project deign, it is concluded that the designing of major engineering structures of the Maneri Project to ensure absolute safety against severe damage may not be feasible. However, if seismic coefficient of 0·15 g. for Maneri dam and 0·20 g. for Titloth Power House, are provided for possible future ground accelerations this may provide safety within reasonable limits. It is necessary, however, to carry out dynamic design studies, with the tentatively chosen ground acceleration and a spectrum of an earthquake recorded in epicentral areas with average or moderately hard rock foundations.

A net work of seismological stations has to be set up in the area of recording the miner shocks and for finding the relationship of earthquake foci of these shocks with the various thrust or faults. Three seismological stations have already been recommended by Sri B S. Krishnaswamy Director, E. G. Northern Region, Geological Survey of India, for studying the seismic status of the Main Himalayan and Srinagar thrusts. At least two station seem to be an immediate necessity for satisfactory evaluation of the seismicity of the area.

Blasting experiments are recommended to be carried out at Maneri and Tiloth, sites, for ascertaining the natural period of vibration of the foundation material. This will provide additional information for aseismic design of the proposed structure.

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TABLE I

RADIAL DISTANCE VERSUS MAGNITUDE. PERIODICITY AND FREQUENCY OF EARTHQUAKES

Radial distance	No. of Eqks	Magnitude: Range of Magnitude	Magnitude: Frequency of Eqks.	Magnitude: Cumulative frequency of Eqks.	Periodicity: Period	Periodicity: Frequency of Eqks.	Periodicity: Cumulative frequency of Eqks.
1	2	3	4	5	6	7	8
0–50 km.	3	5–5	3	3	1800–1850	—	—
		5·1–6	—	—	1851–1900	—	—
		6–6·5	—	—	1901–1920	—	....
		6·6–7	—	—	1921–1940	1	1
		7·1–7·5	—	—	1941–1960	2	2
		7·5–8	—	—	1961–1969 (June)	—	—
50–100 km.	13	5–5	4	7	1800–1850	1	1
		5·1–6	9	9	1851–1900	—	—
		6–6·5	—	—	1901–1920	3	3
		6·6–7	—	—	1921–1940	2	3
		7·1–7·5	—	—	1941–1960	4	6
		7·5–8	—	—	1961–1969 (June)	3	3
100–150 km.	9	5–5	4	11	1800–1850	—	1
		5·1–6	5	14	1851–1900	1	1
		6·1–6·5	—	—	1901–1920	—	3
		6·6–7	—	—	1921–1940	—	3
		7·1–7·5	—	—	1941–1960	3	9
		7·6–8	—	—	1961–1969 (June)	5	8
150–200 km.	10	5–5	3	14	1800–1850	2	3
		5·1–6	5	19	1951–1900	—	1
		6·1–6·5	2	2	1901–1920	—	3
		6·6–7	—	—	1921–1940	2	5
		7·1–7·5	—	—	1941–1960	4	13
		7·6–8	—	—	1961–1969 (June)	2	10
200–250 km.	19	5–5	2	16	1800–1850	—	3
		6·1–6	13	32	1851–1900	—	1
		6·1–6·5	2	4	1901–1920	2	5
		6·6–7	1	1	1921–1940	2	7

		7·1–7·5	1	1	1941–1960	1	14
		7·6–8	—	—	1961–1969 (June)	14	24
250–300 km.	32	5–5	15	31	1800–1850	—	3
		5·1–6	13	45	1951–1900	—	1
		6·1–6·5	2	6	1901–1920	1	6
		6·6–7	1	2	1921–1940	1	8
		7·1–7·5	—	1	1941–1960	6	20
		7·6–8	1	1	1961–1969 (June)	24	48

TABLE II

COMPUTED PROBABLE INTENSITY AND GROUND ACCELERATION BASED ON PAST EARTHQUAKE HISTORY

Past Eqk. Magnitude	Distance from Project site (Km)	Maneri Diversion Dam (on average rock foundation)		Tiloth Power House (on terracce foundation)		Tiloth Power House (on saturated sand foundation)	
		Seismic intensity M. M. scale	Ground accelera-tion	Seismic intensity M. M. Scale	Ground accelera-tion	Seismic intensity M. M Scale	Ground acceleration
8*	260	VI	0·05g	VII	0·12g	VIII	0·23g
7·5	245	VI–V	0·05g	VI	0·05g	VII	0·12g
7	200	VI–V	0·05g	VI–V	0·05g	VI to VII	0·05 to 0·12g
6·5	150–200	VI–V	0 05g	VI–V	0·05g	VI to VII	0·05 to 0·12g
6	50–150	VI–V	0·05g	VI–V	0·05g	VII	0·12g
5	0–50	V –IV	negligible	V	<0·05g	VI	0·05g

*This shock was the Kangra Earthquake of 1905.

Within a distance of 50 Kms., the past history indicates only less than magnitude 5 earthquakes, for which the expected intensities and accelerations at the intake dam power house sites are not computable because Tandon's graph only covers magnitudes upto 6. Probable values are indicated.

TABLE III

COMPUTED PROBABLE INTENSITY AND GROUND ACCELERATION BASED ON POSTULATED FUTURE SEISMIC ACTIVITY

Name of thrust & max. magnitude of past eqk. as interpreted for the thrust	Assumed future condition No.	Distance at which future eqks. may originate (Km.)	Maneri Diversion Dam (on rock foundation)		Tiloth power House (foundation on terrace deposit)	
			Seismic intensity M.M. Scale	Ground acceleration	Seismic intensity M.M. Scale	Ground acceleration
Satlitta Thrust 8	1	0–50	IX to X	0.4 to 0·8g	X & above	0·8 & above
	2	50–100	VIII to IX	0.23 to 0·4g	IX to X	0·4 to 0·8g
	3	100–150	VII to VIII	0·12 to 0·23g	VIII to IX	0·23 to 0·4g
	4	150–200	VI to VIII	0·05 to 0·12g	VII to VIII	0·12 to 0·23g
	5	200–250	VI to VII	0·05 to 0·12g	VII to VIII	0·12 to 023g
	6	250–300	VI to V	0·05	VII	0·12
Srinagar Trust 6·5	7	0–50	VII to X	0·12 to 0·8g	VIII to X	0·23 to 0.8g
	8	50–100	VI to VII	0·05 to 0·12g	VII to VIII	0·12 to 0·23g
	9	100–150	VI to V	0·005	VI	0·05
Main Himalayan Thrust 7.5	10	0–50	VIII to X	0·23 to 0·8g	IX & above	0·4 & above
	11	50–100	VII to VIII	012 to 0·23g	VIII to IX	0·23 to 0·4g
	12	100–150	VI to VII	0.05 to 0.12g	VII to VIII	0.12 to 0·23g
	13	150–200	VI to V	0·05	VI to VII	0·05 to 0·12g

Note : It will be seen that no structure can be designed for the assumed future condition Nos. 1, 2, 7, & 10. A structure designed for the assumed remaining nine conditions can be considered reasonably safer from severe damage.

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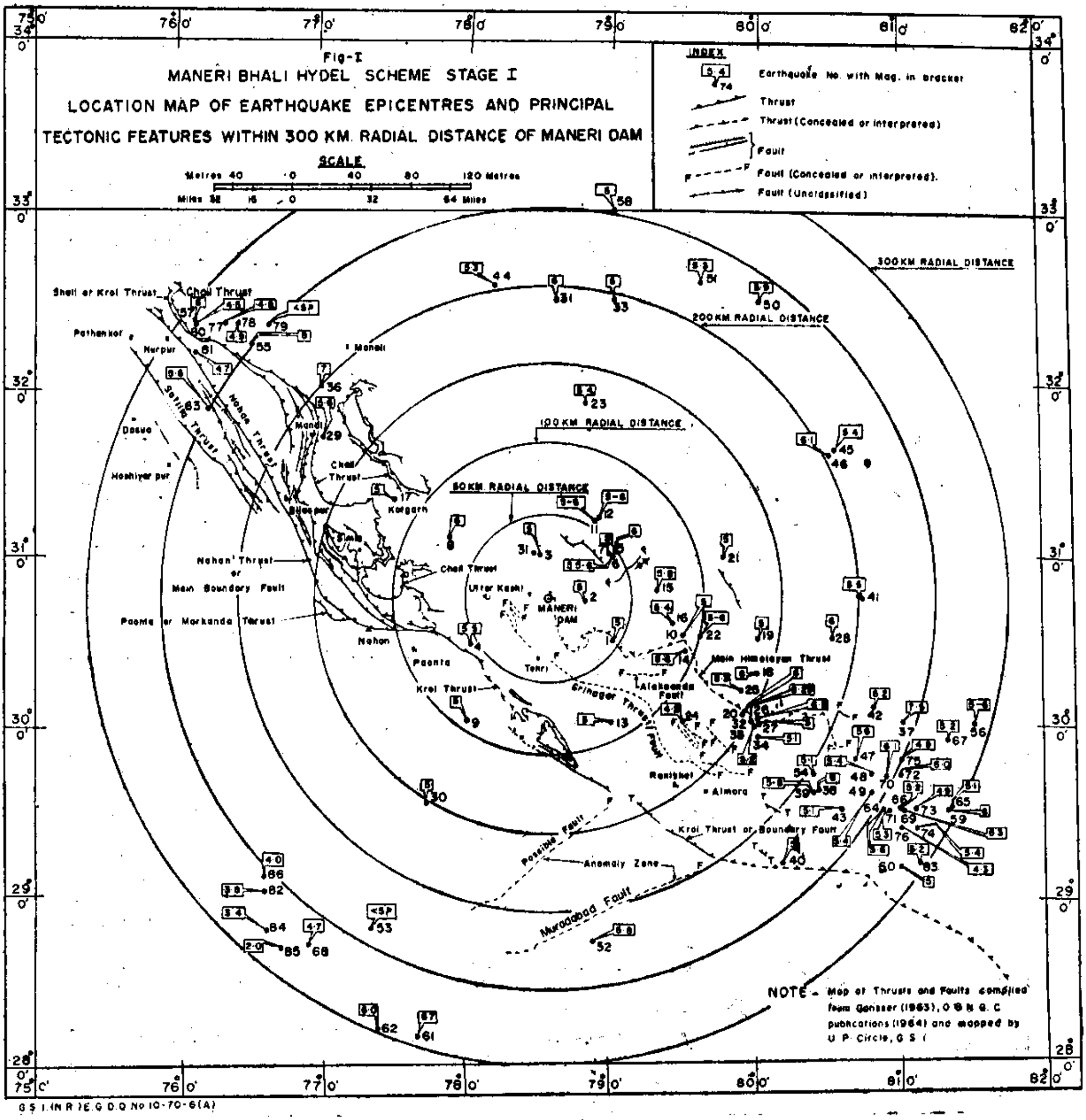
Fig-I
MANERI BHALI HYDEL SCHEME STAGE I
LOCATION MAP OF EARTHQUAKE EPICENTRES AND PRINCIPAL
TECTONIC FEATURES WITHIN 300 KM. RADIAL DISTANCE OF MANERI DAM
SCALE
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300 KM RADIAL DISTANCE
200 KM RADIAL DISTANCE
100 KM RADIAL DISTANCE
50 KM RADIAL DISTANCE
MANERI DAM
Main Himalayan Thrust
Krol Thrust
Nahan Thrust or Main Boundary Fault
Moradabad Fault
Possible Fault
Anomaly Zone
NOTE - Map of Thrusts and Faults compiled from Gansser (1963), O N G C publications (1964) and mapped by U P Circle, G S I
G S I (N R) E G D O No 10-70-6(A)

Fig. 1.

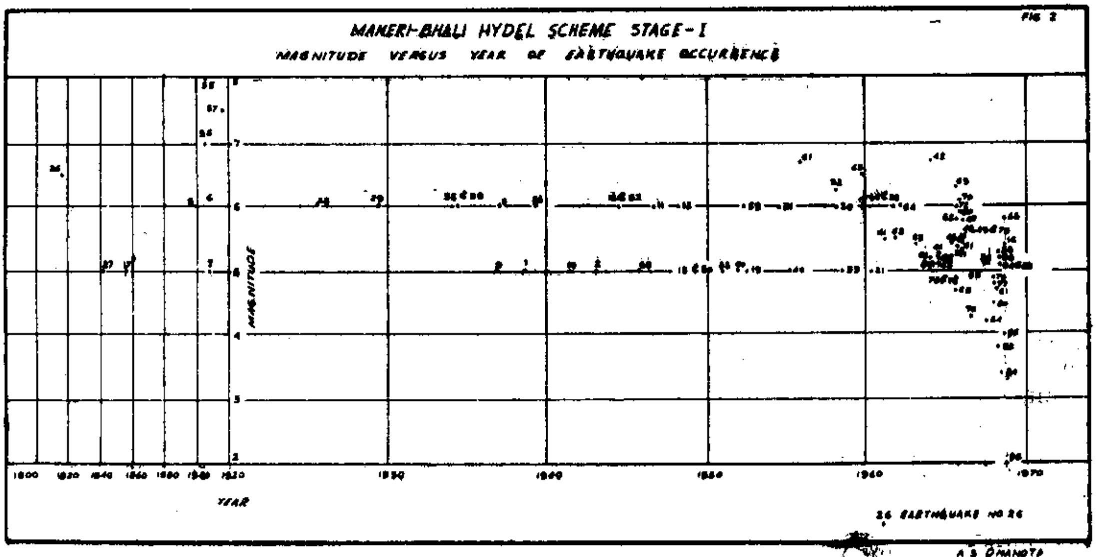
MANERI-BHALI HYDEL SCHEME STAGE-I
MAGNITUDE VERSUS YEAR OF EARTHQUAKE OCCURRENCE
FIG 2
MAGNITUDE
YEAR
26 EARTHQUAKE NO 26
A S DHANOTA

Fig. 2.