PROBLEM OF EARTHQUAKES

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The most uncontrollable force that nature unleashes on mankind is that through earthquakes which occur without warning and which are unpredictable. Science has not been able to help either in knowing about their occurrence before hand or preventing them in future. The man, therefore, looks helpless in the wake of this destructive force which results in tremendous loss of life and property in different areas of the world from time to time. The feeling of an earthquake is most awful since the very earth to which we look up for stability, begins to tremble and this naturally causes fear psychologically and quite often a very real one. In the last 4 years several devastating shocks have occurred starting from Agadir in Morocco followed by Lar in Iran, the five big shocks of Chile coming one after the other within 24 hours in 1960, heavy damage in Libya, the devastation of a great part of Tehran last year and the latest one resulting in destruction of the town of Scopje in Yogoslavia. Luckily for India we have not had any major shock since the great earthquake of 1950 in Assam, but we had more than our share in the last 60 to 70 years. The 1950 Assam earthquake was preceded by Bihar earthquake of 1934, (11,000 people killed) Kangra valley earthquake of 1905 and perhaps the greatest earthquake of Assam in 1897 and many other smaller ones which may not have left a deep scar on the history of the country but did do considerable damage locally. These four earthquakes were perhaps the biggest shocks experienced anywhere in recent history, and therefore, India is susceptible to considerable loss due to this force of nature on which we have no control. Since, for many years no big shock has occurred in Western Himalayas, one should be expected in the near future. It is, however, fortunate that in the last six years there have been several small shocks which may lessen the intensity of the bigger shock to follow. Similar is the situation in Gauhati-Shillong axis. The earth as a whole experiences about 800 to 900 shocks a year which can cause damage locally. Most of them occur either in sea or in unpopulated regions. We, therefore, hear only of those which shock the thickly populated areas. Following are the biggest shocks of the twentieth century:

Year	Country	Human Beings Killed
1905	Kangra (India)	19,000
1908	Italy	75,000
1915	Italy	30,000
1920	China	1,80,000
1923	Japan	1,00,000
1932	China	70,000
1934	Bihar (India)	11,000
1935	Quetta (Pakistan)	30,000
1939	Turkey	23,000
1950	Assam (India)	1,526
1957	Iran	2,500
1960	Agadir	12,000
1960	Chile	5,700
1962	Iran	10,000
1963	Skopje	2,000

It has not been possible so far to give a precise scientific explanation of how the earthquakes actually occur. Several theories have, however, been put forward from time to time, the most reliable among them being based on the principle that volumetric changes take place inside the earth mass continuously because the temperature and pressure of the material inside the earth are very high and some readjustments connected with the "origin of Earth" continue to take place. These changes result in the earth material being strained and, when the strains become too big rupture takes place. This rupture

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COMPARATIVE STUDY OF ENERGY RELEASED BY THE EARTHQUAKES OF DIFFERENT MAGNITUDES M

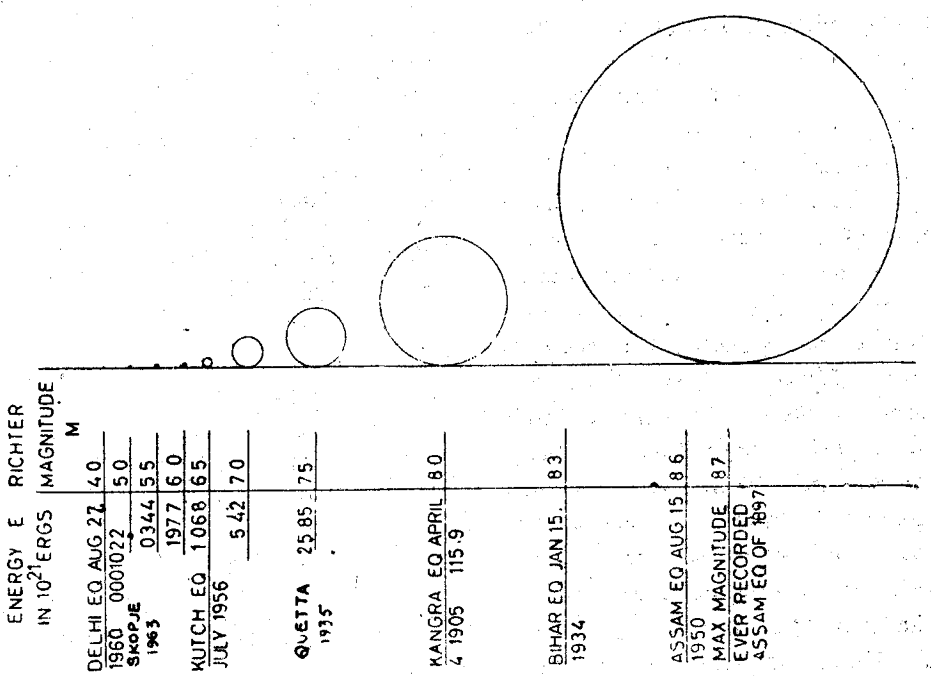


Fig. 1

Fig. 3. A Typical Station

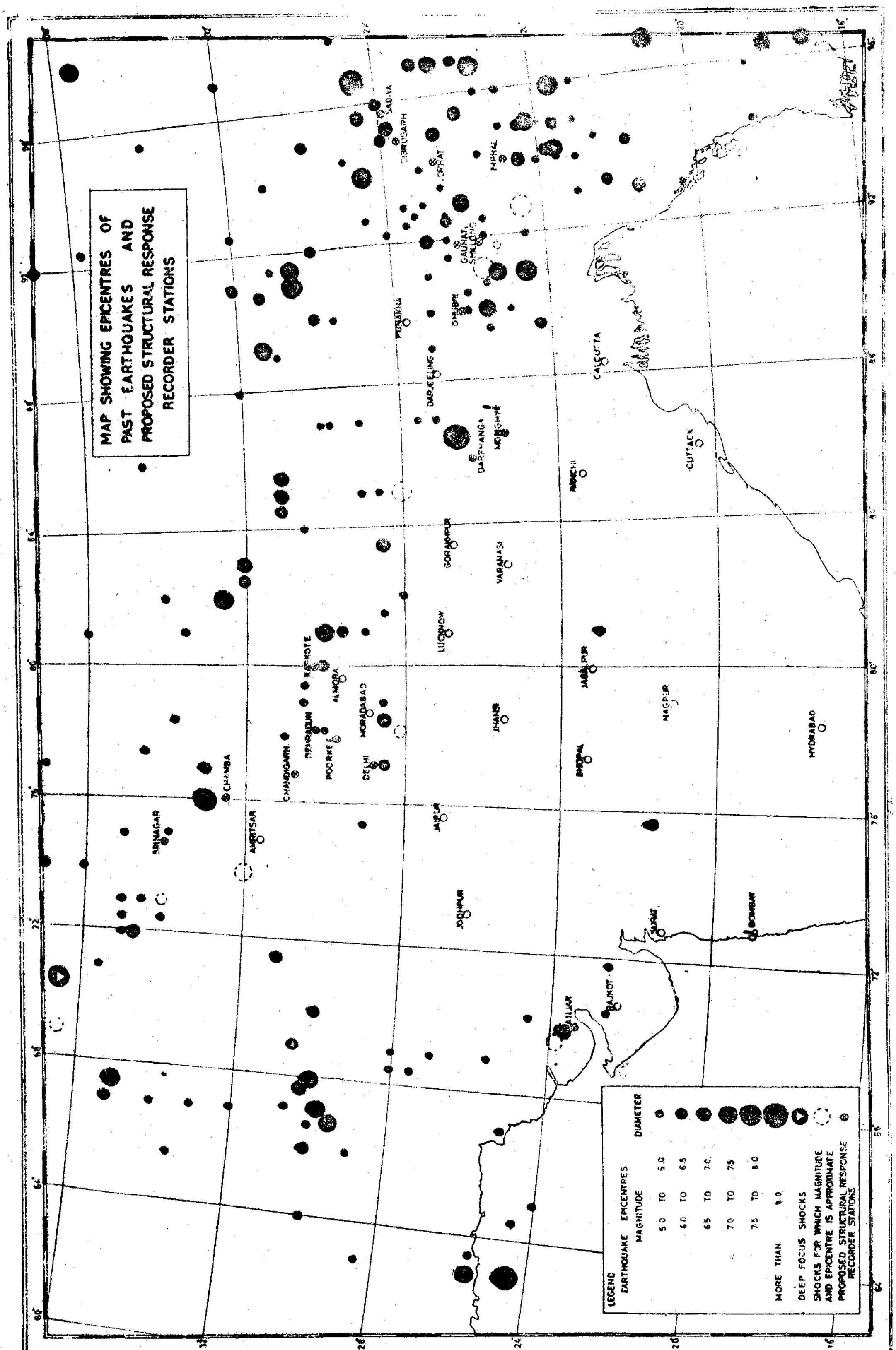
may occure over many miles and the bursting process may involve hundreds of cubic miles of earth mass. It would thus be seen that tremendous amount of energy is released which traveis in the form of waves to the surface shaking everything that came in their way. It is only when these waves reach the surface that we feel the occurrence of an earthquake. Anything standing on ground is vibrated to and fro and if the buildings and other structures are not designed for earthquake forces they collapse resulting in demage to life and property. Sometimes the travel of the waves causes loud frightening noise but that by itself is not anything dangerous. It is the excessive vibrations which can be dangerous. Perhaps the greatest loss of life occurred in the China earthquake of 1920 and the Tokyo Earthquake of 1923, where over 180,000 and 100,000 people respectively were known to have died, although these earthquakes in terms of energy released, were not bigger than our giant earthquakes of Bihar and Assam but, since the areas where these occurred were thickly populated, the loss of life was much greater. Energy released during an earthquake is so huge that some times big dams crack and are washed away. Even the smallest earthquake of consequence generates much more energy than the biggest man-made nuclear bomb. For comparison series of spheres shown in Fig. 1 indicate the measure of the energy released in different major earthquakes.

Since it is not possible to prevent the occurrence of earthquakes nor is it possible even to predict them, the only alternative available to engineers is to study the science of strengthening the buildings, dams and other structures in such a manner that when earthquakes occur they remain safe. This, of course, poses a difficult economic and psychological problem. Earthquakes do not occur every day in one region. Perhaps it may not occur even once in 50 years and, the public memory being short, there is always a tendency to ignore them or minimise their danger. Some designers would argue that an earthquake may or may not occur in the life time of the building and we might as well economise by ignoring these forces. Even when an engineer decides upon designing a building against earthquake forces, the problem before him is to decide as to which size of an earthquake he should design it for. The force that a building is subjected to in an earthquake depends upon the place where the earthquake originates i.e. the distance of the origin from the building, and the size of the earthquake. The greater is the force for which a building is designed, the greater is its initial cost. The designer has thus to make a compromise between two requirements. The guidance to this decision should come from the more familiar case of taking out an insurance policy. One always insures himself according to his financial ability and the importance of his life to his dependants. Another instance with which we are more familiar is that of the design of a bridge. Rivers, in India carry water whose quantity varies very greatly from one season to the other and from one year to the other. A designer has always got to take a decision as to what size of flood he should design the bridge for, and this would depend upon its importance and the effect on the initial cost. In the case of earthquake resistant design also this decision has to be made by the designer on the same basis taking into account the known history of the place and assuming that in future also earthquakes of similar sizes will take place, and the financial implications of the decision. He must, of course, realise that, whatever he does, he is not in a position to guarantee that the structure was safe for all possible earthquakes that nature was capable of unleashing if the epicentre happens to be within a few miles of the structure. He can, however satisfy himself because the probability of such an occurrence is very small and, on that basis, whatever safety he provides for, is likely to prove adequate against failure. But this uncertainty about the future should not thwart our efforts to understand the problem, carry out research and use the existing knowledge to the best of our ability. Nor should this make us take the position that we take no notice of them and look to the immediate gain by not taking the earthquake forces into account. The price of this attitude may have to be paid very dearly later. The recent occurrences in India and outside are a clear pointer to this.

The map of India and the surrounding region (Fig.2) indicates the positions of the epicentres of the past earthquakes in the present century. Many more must have occurred earlier. Bulk of these regions were unpopulated so far but with the rapid pace of industrialisation large townships, oil refineries, many industrial concerns of large and small sizes, dams and irrigation works, bridges and numerous other structures are being planned in these regions and the construction of some of them has already been taken in hand. The question of determining the cheapest methods of strengthening these buildings and other structures against earthquake forces is of paramount importance to this country. Unfortunately very little scientific data regarding the behaviour of structures in these regions is available, and for a long-term study, steps would have to be taken to collect this data. In the meantime, laboratory study will provide considerable information that would be helpful in design work.

Anticipating these requirements of industry and other engineering projects, the Council of Scientific and Industrial Research sanctioned the establishment of a School of Research and Training in Earthquake Engineering at the University of Roorkee in 1960. The School has since built up the necessary facilities and has embarked upon the programme of research on the methods of strengthening buildings, dams, water towers and other structures against earthquake forces. Some work has already been published. As a part of long-term work, Simple Pendulum Recorders have been designed and it is proposed to instal them at different stations shown on the map. In future earthquakes these instruments will record more precise information about the behaviour of buildings and other structures, so that the future designer could strengthen these structures more scientifically. A typical station is shown in Fig. 3. India has, therefore, gone ahead to meet the designers' future need. Another important step already taken by the Indian Standards Institution is to draft a code of practice for "Earthquake Resistant Design" and it has recently been published. This provides adequate guidance for the design of simple structures.

Although research will yield much information in course of time to make the task of the designer more precise and the structures consequently more economical and safe, a good deal of information already exists which can be made use of for insuring our buildings and other structures against failure to a great extent for normal earthquakes. There is absolutely no need to fall back on "Fate", and suffer the consequences. At the same time complacency in areas where a shock has not occurred in the last 50 years is also dangerous. Prevention in this case too is far better than cure. Past experience has shown that the buildings designed for earthquake forces have stood the shocks much better than others not designed for them. The konwledge has further advanced in the last 25 years enabling even safer construction. Further work is in progress which will cut down losses to a minimum.


MAP SHOWING EPICENTRES OF PAST EARTHQUAKES AND PROPOSED STRUCTURAL RESPONSE RECORDER STATIONS
LEGEND
EARTHQUAKE EPICENTRES
MAGNITUDE
DIAMETER
5.0 TO 6.0
6.0 TO 6.5
6.5 TO 7.0
7.0 TO 7.5
7.5 TO 8.0
MORE THAN 8.0
DEEP FOCUS SHOCKS
SHOCKS FOR WHICH MAGNITUDE AND EPICENTRE IS APPROXIMATE
PROPOSED STRUCTURAL RESPONSE RECORDER STATIONS
SADIYA
DIBRUGARH
IMPHAL
SHILLONG
CALCUTTA
DARJEELING
DARBHANGA
MONGHYR
CUTTACK
RANCHI
GORAKHPUR
VARANASI
LUCKNOW
JABALPUR
NAGPUR
HYDRABAD
JHANSI
BHOPAL
ALMORA
MORADABAD
DEHRADUN
ROORKEE
DELHI
CHANDIGARH
CHAMBA
SRINAGAR
AMRITSAR
JAIPUR
JODHPUR
SURAT
BOMBAY
RAJKOT