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EARTHQUAKES IN INDIA AND GROWTH OF EARTHQUAKE ENGINEERING STUDIES

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Abstract

Earthquakes occur very frequently in various parts of India and considerable loss of life and property has occurred in the past during major earthquakes. This paper describes in brief the earthquake occurrence in India and highlights the significance and growth of earthquake engineering studies in the country during the last ten years. Brief descriptions of some of the important earthquakes during the present and last century has also been given.

Introduction

Since the evolution of man, he has battled against the forces of nature and one of the battle fronts has been the field of natural disasters due to earthquakes. History and legend record these events in succeeding generations and their unforeseen character has frequently been classed as 'acts of god', but scientists and engineers are beginning to find ways to protect man from its fury, even if as yet no means are available for forecasting or preventing them. It is, therefore, very essential to mobilise the various technical skills on a properly organised basis, so that the devastation and the appalling loss of human life and property in prevented or, at least, reduced.

With the rapid industrialisation and spread of urban civilisation throughout the world, the toll taken by earthquakes has, during the past hundred years, been steadily increasing. Systematic records of the damage and loss of life caused by earthquakes are only available for less than hundred years. These records show that over 350,000 people were killed in the second quarter of this century between 1926 and 1950, and damage to buildings and public works totalled near to Rs. 7,500 crores ($ 10,000 mln.) — a yearly average of 14,000 deaths and Rs. 300 crores ($ 400 mln.) damage. The worst years were 1927 (76,615 deaths), 1932 (76,202 deaths) and 1939 (61,082 deaths). In the first quarter of the century records are less complete, but five earthquakes alone are known to have claimed a total of 500,000 lives—more than all earthquake of the second quarter combined. Fatalities since 1950 have ranged from as few as about 100 in 1959 to 20,257 in 1960. During 1967 twenty disastrous earthquakes in various parts of the world killed 949 persons and did great damage.

After every large earthquake, various organisations and individuals that are concerned with earthquakes are flooded with question from the public and often the administrator : Why do we have earthquakes ? What can be done about all this ? But these are the questions that should be asked not after an earthquake, but before. Much progress has been made in the study of causes and probable effects of earthquakes, and every Indian can save himself a great deal of the worry and grief and perhaps thousands of rupees—by understanding the fact about earthquakes and learning to live with them. The most practical attitude would be to admit that India is a seismic country and earthquakes would continue to occur for countless centuries. Though there is no way of eliminating the causes of earthquakes, there is much that can be done about effects to eliminate or reduce damage ; and we should always be ready for the day when the shaking under our feet suddenly becomes the greatest earthquake of a decade.

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Earthquakes in India

India is one of the most active earthquake country and holds a significant position in the world of earthquakes. The country faced five "monster" earthquakes during the nineteeth and this century : 1819 in Cutch, 1897 in Assam, 1905 in Kangra, 1934 in Bihar and then again in 1950 in Assam. Most of the earthquakes which occur at short intervals are confined to the northern mountainous region and the plains, but past earthquake data has shown that there are no regions in India where the earthquake problem can be completely negleted. The following gives a brief account of some of the important earthquakes which occurred in various parts of India and significant damage was observed.

September 1, 1803, Garhwal Earthquake : This earthquake has also been referred as Muthra earthquake where the earthquake is reported to be very violent and lasted several seconds with many 'kucha' buildings thrown down. Extensive fissures in fields through which water rose with considerable violence were noted. Many buildings were ruined in Kumaon. It was very violent in upper Ganges Valley, Sirmoor and Garhwal. 200 to 300 persons died at Barabal. Badrinath also suffered severely. Several villages were destroyed. The upper portions of Qutub Minar in Delhi were destroyed.

June 16, 1819, Cutch Earthquake : This earthquake was the second largest earthquake in India in the nineteenth century, next to 1897 Assam earthquake. This shock was felt through out India and did considerable damage in very large area. Maximum damage occurred near Cutch. Bhooj was reduced to ruins and 2000 people perished. Extensive damage to buildings occurred in whole of the Kathiawar, in the north upto Jaisalmer and in the east beyond Ahmedabad. The damage region was quite comparable to ~~that~~ of 1897 Assam earthquake and 1934 Bihar earthquake. At Ahmedabad great damage to mosques and other buildings occurred and 500 people assembled for a wedding feast perished in the ruins. The western parts of the town of Sindri and adjoining parts were inundated and submerged by tremendous rush from the ocean due to approximately 14 feet sinking of the ground. While 5 miles to the north of this tract a low ridge of about 15 miles width extending for fifty miles in east–west was formed. The natives called this "Allah Band" or Mound of God. In the runn of Cutch numerous jets of blackish muddy water were thrown out from fissures and cones of sand 6 to 8 feet high.

June 6, 1828, Kashmir Earthquake : During this earthquake which probably had its epicentre about 10 miles east of Srinagar about 1000 people were killed and 1200 houses collapsed. Fissures in the ground, and water fountains were observed. The earthquake was followed by numerous after shocks for two month at the rate of 100 to 200 per day.

August 26, 1833, Bihar–Nepal Earthquake : This earthquake was felt at great distances. About 125 houses were destroyed at Kathmandu and similar fate overtook other affected areas also.

April 1, 1843, Deccan Earthquake : This earthquake which was felt with violent intensity at great distances, and damaged many houses throwing down walls and roofs, had its epicentre near Bellary. The various other places affected included Sholapur, Maktal, Singrurgarh, Kurnool and Belgaum.

January 10, 1869, Cachar Earthquake : This earthquake was felt over an area of 250,000 square miles, with its epicentre on the north-east side of the Shillong plateau. Earth fissures and sand craters were very abunant.

May 30, 1885, Kashmir Earthquake : This was another major shock which affected the Kashmir valley, with its epicentre close to the 1828 Kashmir earthquake. Great damage occurred to the buildings and ground was badly cracked and fissured. About 3000 persons lost their lives in this earthquake. This is a large number considering that the valley is thinly populated.

June 12, 1897, Great Assam Earthquake : This earthquake was probably the largest earthquake which has occurred in the historic times and was felt over an estimated area of 1,750,000 square miles. Over 1600 persons were killed. Great damage was observed in an area of radius 300 miles. Stone buildings in Shillong, Gopalpur, Gauhati, Nowgong and Sylhet were almost entirely destroyed. Pebbles were seen bouncing on the ground "like peas on a drum head", posts shot out of their holes and boulders lifted out of the ground without cutting the edges of their former seats, all indicating that the maximum accleration exceeded that of gravity. This high accleration was consistent with the observed wide spread surface distortion and shattering of granitic rocks of the Shillong plateau. Displacements observed in surface faultings were of the order of 35 feet. Calcutta was also seriously affected.

February 8, 1900, Coimbatore Earthquake : This earthquake was felt in the whole of South India, with severe intensity in Mysore, Madras, Bangalore, Calicut and Negapatam. The epicentre was near Coimbatore where significant damage is reported to have occurred.

April 4, 1905, Kangra Earthquake, Near 31°N: 79°E, M=8.6+ : This is the earliest large Indian earthquake for which a well document instrumental magnitude (8.6+) could be assigned. This earthquake caused great disaster and about 20,000 people lost their life. Kangra, Dharamshala and neighbouring places were completely ruined. Another area, 100 miles away, including Dehradun and the foot hills indicated high intensity, lower than that at Kangra but not approached elsewhere. This could have resulted due to two seperate earthquakes in this tectonic belt.

July 8, 1918, Srimangal Assam Earthquake, 24.5°N: 91.0°E, M=7.6 : This earthquake was felt over an area of 800,000 square miles and the epicentre was 8½ miles south of Srimangal on an alluvial tract. Many tea gardens were ruined.

July 3, 1930, Dhubri Earthquake, 25.8°N: 90.2°E, M=7.5 : The earthquake was felt over an area of 350,000 square miles. Dhubri suffered considerable damage. Maximum intensity felt at Gauhati, Rangpur and Berhampur was M.M. IX.

January 15, 1934, Bihar-Nepal Earthquake, 26.5°N: 86.5°E, M=8¼ : This was one of the most severe earthquakes in Indian history, and was felt over an area of 1,900,000 square miles. About 10,000 persons were killed and property worth crores of rupees was destroyed. The extent of damage and other effects places this earthquake only a little below that of 1897. M.M. intensity X was assigned to a belt about 80 miles long by 20 miles wide and to two spots almost 100 miles distance from the main belt, at Monghyr to the south and in the Nepal Valley to the north. The three isolated regions of maximum damage may be related to three independent events occurring near about the same time along a N-S trending tectonic lineament. The isoseismal IX, about 190 miles long and of irregular width exceeding 40 miles in places, was demarcated as the slump belt in which tilting and slumping of building due to liquefaction of alluvium and subsidence of roads, cause-ways and railway embankments were marked. Within isoseismal X most of the houses were razed to the ground.

March 14, 1938, Satpura Earthquake, 21.6°N : 75.0°E, M = 6¼ : This earthquake was felt upto distances greater than 600 miles and did damage at Bhusawal, Khandwa, Godhara, Baroda and Nasik. The maximum MM intensity in the epicentral tract at Amalner was VII.

August 15, 1950, Assam Earthquake, 28.7°N : 96.6°E, M=8.6 : This was a disastrous earthquake which affected Assam and bordering regions of Tibet and China. Strictly this was not an Indian earthquake, the epicentre being near Rima outside Indian borders. This shock was more damaging in Assam in terms of damage than the 1897 earthquake. To the effects of shaking were added those of floods ; the rivers rose high after the earthquake, bringing down sand, mud, trees and all kinds of debris. This was largely due to enormous slides. Alterations of relief were brought about by many rock falls in the Mishmi hills and destruction of forest areas. In the Abor hills 70 villages were destroyed with 156 casualties due to landslides. Dykes blocked the tributaries of Brahamputra; that in the Dibang Valley broke without causing damage, but that at Sibansari opened after 8 days and the wave 22 feet high submerged several villages and killed 532 persons. Estimated area in India, Pakistan and Burma over which the earthquake was felt was 650,000 sq. miles. Seiches due to this earthquake were observed as far away as Norway and England. The main shock was followed by a train of after shock some of which reached destructive magnitude near epicentre.

July 21, 1956, Anjar Earthquake, 23.34°N : 70.02°E, M=7 : This earthquake was felt at large distances in Western India and did considerable damage to the village houses. Very few brick masonry structures escaped damage and were badly cracked and partially collapsed. But houses built of bulky walls in randum ruble stone masonry with mud mortar or of mud collapsed completely. The toll of life lay in the faulty construction of these houses.

October 10, 1956, Khurja Earthquake, 28.15°N ; 77.67°E, M=6.7 : This earthquake was felt in a large area. 23 persons were killed in Bulandshahar and some injuried in Delhi.

December 28, 1958, Kapkote Earthquake, 30.01°N : 79.94°E, M=6¼ : The earthquake caused ground ruptures with gaping cracks and few landslides in an area of 100 sq. miles around Kapkote. Partial collapse of walls and cracking of buildings had taken place at several localities including Hatsila, Pharsila, Bhainsoyi and Sulmati.

August 27, 1960, Delhi Earthquake, 28.2°N : 77.4°E, M=6 : Minor property damage at New Delhi. About 50 persons were injured. It was felt also at Jaipur and Kanpur.

September 2, 1963, Badgam (Kashmir) Earthquake, 33.9°N : 74.7°E, M = 5.5 : Though of small magnitude, this shock did considerable damage in the Badgam Tehsil of Srinagar district. About 65 persons were killed and 400 injured. More than 2000 houses mostly of mud construction collapsed, while about 5000 houses suffered partial damage. Timber structure and good masonry houses did not suffer any damage.

June 6, 1966, Hindukush Earthquake, 36°N : 69°E, M=6.1 : Though the epicentre of this earthquake was at Hindukush, it did significant damage in the Kashmir Valley, and was felt upto great distances and even at Roorkee. In Srinagar the Museum building was damaged and 100 houses developed deep cracks. The ceiling of the central hall of the Museum collapsed and almost all the walls of the building had suffered cracks. Show cases containing rare manuscripts were damaged when the ceiling came down. The Civil Secretariate building at Srinagar also suffered minor cracks. The chimney of the High Court building fell down. Most of the telephone connections went out of commission.

June 27, 1966, Darchula (West Nepal) Earthquake, 29.5°N : 81.0°E, M=6.3 : This earthquake did great damage in West Nepal, where about 300 houses were destroyed or damaged, leaving nearly 10,000 people homeless. About 80 people were killed and many injured. Significant damage also occurred in Indian side bordering Nepal. This earthquake shook the whole of Uttar Pradesh and was felt upto Amritsar, Agra, Bahraich and other places. Some buildings in Delhi, Ambala and Nainital developed cracks. In Ambala city the roof of a double storey building, housing the main post office, collapsed. In Moradabad several old houses collapsed.

August 15, 1966, Moradabad Earthquake, 28.0°N : 79.0°E, M=5.3 : This earthquake was felt extensively in Uttar Pradesh and adjoining areas of Delhi, Haryana and Punjab. In Moradabad thirty persons were injured, fifteen of them seriously in house collapses. A few houses, some well built, were damaged. Minor damage also occurred at Barielly and Meerut. 14 persons were killed due to collapse of dilapidated houses in Delhi.

December 16, 1966, West Nepal Earthquake, 29.5°N : 81.°E, M=5.7 : This earthquake was felt extensively in Uttar Pradesh and adjoining areas of neighbouring states. Several houses collapsed at Dharchula due to the earthquake. The earthquake caused cracks in some buildings at Pilibhit and Moradabad.

February 20, 1967, Anantnag Earthquake, 33.5°N ; 75.5°E, M=5–5.7 : This earthquake was felt upto Lahore, Pakistan and other places. During this earthquake about 50 houses of poor construction collapsed and another fifty were damagad in the Anantnag district. One person was killed and another was seriously injured. The maximum M.M. intensity in the region did not exceed VII.

September 13, 1967, Koyna Earthquake, 17.4°N : 73.7°E, M=.58 : This earthquake, which was followed and preceeded by a large number of smaller shocks, was felt over a wide area upto Bombay. It caused some damage in Koynanagar and neighbourhood.

December 11, 1967, Koyna Earthquake, 17.37°N : 73.74°E, M=6.5 : This is considered one of the greatest earthquake of the Peninsular shield. The earthquake caused considerable damage in Koynanagar and neighbouring areas. About 180 people were killed and 2300 injured. This earthquake was felt over a large area of radius about 400 miles It was felt very strongly at Poona and Bombay. The maximum intensity near the epicentre was VIII + in the M.M. scale. There was 100 percent damage to radium rubble stone masonry in Koynanagar and 25 percent were completely demolished. Total loss is estimated to be Rs. 30 lakhs. Production loss in Bombay region due to closure of power was estimated to exceed Rs. 2 crores. About 5000 people were left homeless. Koyna dam resisted this shock well though cracks and other distress feature were developed at several parts of the dam.

Correlating the geology and tectonics with the known epicentres of past earthquakes in India, a definite pattern of earthquake activity is observed, which indicates that all these earthquakes are in general of tectonic origin. In the mountainous Himalayan belt abuting the Indo-Gangetic plains, the major earthquakes are considered to be associated with the movements along faults, thrust and nappes in this region of youthful mountains. In the alluvial tracts these are considered to be related to the movements along fractures, faults and rifts in the basement underlying the sedimentary cover, and in the Deccan Peninsular shield with the various rifts and fracture zones probably produced by the cymatogenic uplift of this crustal block. Some of these faults and thrusts have been well demarcated by detailed geological mapping by various organisations, while the likely presence of others is indicated by indirect inferences based on geophysical surveys as well as the alignment of the epicentres and the pattern of earthquake occurrence. The causative forces which produce these movements are not fully known and various views have been expressed regarding them. In the Himalayan region isostatic imbalance appears to be the main cause and large earthquakes occur very frequently. In the Peninsular shield, whose extensions also form the basement of the alluvial plains, cymatogenic warping of the crust due to subcrustal currents coupled with isostatic readjustment appears to be the main activating force. Although minor earthquake tremors are frequently felt in various parts of Peninsular India and Indo-Gangetic Plains, a study of known earthquakes during the last few centuries indicates that there were comparatively large periods of quiteness with shorter periods of activity as compared to the very frequent earthquake occurrence in the Himalayan belt. Thus it appears that the smaller magnitude of isostatic imbalance and the tectonically stable character of the Peninsular India inhibits rapid build up of strain which would be responsible for large frequent earthquakes. However, this does not preclude the occurrence of a large earthquake after considerable lapse of time, though in many cases in past having occurred after several decades or having damaged inaccessible or inhabited or small areas may have escaped to arise attention and recorded in historical documents. This lack of data on occurrence of earthquakes led many to believe this region seismically inactive and stable. December 11, 1967 Koyna earthquake has shattered this common concept and has highlighted the necessity of evaluation of the seismic status of this large segment of the country.

Seismic Zoning of India

Based on the data collected during the past earthquakes, various attempts have been made to prepare earthquake zoning maps of the country. In these maps the country was divided into three to four zones indicating probable occurrence of the earthquakes (frequent, occassional, few) or probable accelerations (10 to 30 percent gravity, less than 10 percent gravity, etc.) or likely intensity of damage (heavy, moderate, slight etc.) or factor of safety to be adopted in the design of structures, etc. The construction of these maps utilised data on past earthquakes and geologic and tectonic features of the country.

In order to give a unified picture of the zoning map, the Indian Standards Institution formed a panel of experts to prepare a seismic zoning map of the country and published its first map in 1962 (IS : 1893–1962). This map had seven zones and it appears was prepared considering that a rational approach to the problem would be to arrive at a zoning map which show the maximum intensity (M.M. intensity scale) of earthquakes likely to occur at each point based on data of the known earthquakes, assuming all other conditions as being average, and to modify such an average idealised isoseismal map in the light of tectonics, geology, soil conditions and the maximum intensities as recorded from damage surveys. Zones with M.M. intensity V, VI, VII, VIII, IX and X (and above) were designated as zones I, II, III, IV, V, and VI, and region with M.M. intensity less than V was designated as zone 0. This 'zero zone' was not a zone of 'zero earthquakes', but the designation was given to suggest that no earthquake problems of any significance may occur in this region. However, as only preliminary tectonic map of the country was available this zoining map probably had greater emphasis on available historical earthquake records and the resulting zones mostly wraped around the epicentres of the five 'monster' earthquakes, of the country. Design seismic coefficeint for each of these zones, which depend on the type of structures, materials of construction, soil condition, soil-structure inter-action and duration of shaking, in addition to the intensity of the earthquake and ground accelerations, were also recommended.

With additional knowledge of geology and tectonics and earthquake epicentres in subsequent years it was felt that this map required modifications. A revised seismic zoning map was published in 1966 (IS : 1893–1896), which incorporated data on all past earthquakes of magnitude 5 and more from the earliest times to December 1965. In this map more tectonic evidences were used for interpolation and extrapolation of seismic data, and the expected intensity along marginal depressions and mobile belts bordering the Peninsular shield and along known active faults in various regions was changed, to take into consideration that as earthquakes have occurred with higher intensity in some parts of a tectonic zone, earthquake of comparable intensity may arise along the whole length of the same zone or in another zone with similar structure and history.

Soon after the publication of the revised zoning map, an earthquake of magnitude 6.5 occurred in Koyna valley on December 11, 1967, in a region which was considered to be of comparatively low seismic status, due to lack of data regarding existance of active tectonic lineaments in the region. This event has illustrated that in the modification of seismic zones that may be undertaken in the future, geologic and tectonic features should be given greater recognition. Attempts should be made to identify and demaracate the various active tectonic belts along which an earthquake can occur in future. This would require detailed geologic and tectonic mapping of the various regions and evaluation of complete history of the tectonic evolution of the regions through the various geological ages with particular reference to the recent movements of the crust. Also at present many small tremors, originating from various tectonic zones, along which a devastating earthquake may occur in future, are missed as the net work of the seismological station in India is not close enough. Thus, many zones which may be active have not been recognised. It is, therefore, essential that a closer network of seismograph station is built in the country. It is hoped that with more information a better picture of the seismic zones of the country would be evolved.

Field survey of earthquake disasters has shown that in many cases the damage is due to the failure of the ground. Liquefaction and settlement of soils, landslides and lateral spreading, and fissures, cracks and lurching of the ground have led to the sinking, tilting and collapse of the structures. It is therefore essential that for the planning and development of urban centres and site selection of industrial projects, detailed geomorphological, geohydrological and soil survey be carried out and local seismic zoning maps be prepared. Regions likely to undergo liquefaction and other damage can be left as open spaces. Unfortunately no systematic studies in this connection have been initiated in the country. Many of our towns which are being allowed to grow on land, without assessing their vulnerability to damage during future earthquakes, may be responsible for great loss of life and damage to property.

Growth of Earthquake Engineering Studies in India

During earthquakes man had been the victim, and thus his natural instincts forced him to evolve better means of protection against its hazards. In regions of frequent earthquakes, various types of earthquake resistant construction was adopted, based on the experience during various disasters, but in many regions modifications to safeguard against the rigours of the climatic conditions, non-availability of the suitable construction material and lack of adequate 'know how' in design and construction methods made them unsafe.

Systematic studies of earthquake engineering problems in India started at the beginning of this decade, though a number of organisations engaged in construction and maintenance of buildings had drawn out various design specifications and construction practices based on their experience from past damage. The University of Roorkee played a very significant role in the initiation of earthquake engineering studies in India by organising the First Symposium on Earthquake Engineering in February, 1959, which highlighted the necessity and importance of these studies and enumerated the various problem which needed investigations. The School of Research and Training in Earthquake Engineering was established at Roorkee in 1960, and research and training on various aspects of earthquake engineering is being carried out at this School. The University of Roorkee, has organised two more symposia on earthquake engineering during 1962 and 1966, at which data on the investigations carried out in the country was presented. The work being carried out at the Earthquake School at the University of Roorkee in this field of enquiry, has also lead other organisations and institutions in the country to initiate similar studies. In this brief period, since 1959, research and investigations in the country have helped in creating some confidence and capacity in the country to tackle problems concerning behaviour of structures during earthquakes.

Some of the significant development in the growth of earthquake engineering studies are described as follows :

Standard Recommendations for Earthquake Resistant Design of Structures : No unified code of practice for earthquake resistant design of structure existed in the country. The first Indian standard recommendations were brought out in 1962 (IS : 1893–1962). These have been revised in 1966 incorporating recent advances made in the design practices and methods.

Code of Practice for Earthquake Resistant Construction : This code was brought out in 1967 (IS : 4326–1967) and recommends the construction methods for various type of buildings in various seismic zones of the country. In this special emphasis has been given to utilise local available construction materials, so that the cost of construction is not appreciably altered. Methods of reinforcing brick and stone masonry and timber houses which are the most prevailent type of construction in the country have been dealt in detail in this code.

Period and Damping Measurements : The modern earthquake design practices use the oscillation period and damping of structures as design parameters. Extensive field and laboratory studies have been carried out in the country to measure the periods of vibrations and damping characteristics of various types of structures.

Structural Response : The design seismic coefficients vary with the dynamic characteristics of the structures as indicated by response spectra of recorded strong ground motion. No strong ground motion records were available for any earthquakes in India and studies were being careied out from records obtained in USA and other countries. The first strong ground motion accelerograph records were obtained during the 1967 Koyna earthquakes. Response spectrum curves have been drawn for the various components recorded on the accelerograph for December 11, 1967, Koyna earthquake, and in future would enable us to calculate structural response on the basis of recorded ground motion incorporating the local effects of geology and soil conditions. Strong ground motions is recorded on accelerographs, and we have very few accelerographs installed in India. This is mostly due to their non-availability in the country. These are now being manufactured in Roorkee and it is essential that necessary steps be undertaken to establish a network of accelerograph stations in seismic regions. Because of the relatively high cost and complexity of the accelerograph, a low cost simplified strong motion earthquake recorder (structural response recorder) has been developed at Roorkee which, though does not measure ground motion, records the maximum response of a mechanical system idealising the dynamic characteristics of the structures. These structural response recorders give the overall effects of the geological and soil conditions of the site and serve very useful purpose in the greater instrumental coverage for strong ground motion studies in the country. More than forty structural response recorder stations have been established in various parts of India.

Model Studies : Laboratory investigations of models for evaluating the behaviour of the prototype structures is an essential part of earthquake engineering studies. Facilities now exist for carrying out these model studies, as well as, the study of the dynamic behaviour of the actual full size structures. Shake tables, acceleration, velocity and displacement pick ups, pore water pressure pick ups, earth pressure cells and vibration generators for exciting various models and prototype structures have been designed and fabricated in the country.

Dissemination of Result of Research Investigations : Dessemination of results of investigations is an essential requirement for the growth of the subject. The publications of the proceedings of the three symposia in earthquake engineering held at Roorkee, and Bulletins of the Indian Society of Earthquake Technology, have helped greately in the growth of earthquake engineering studies in the country. Publications in other allied technical journals and periodicals have also helped in bringing these problems to the attention of the various persons and organisations interested in this field. These provide an avenue for the presentation, discussions and exchange of views and results of the research investigations being carried out by engineers, geologists, seismologists and others with the aim of advancing knowledge of earthquake technology in all its aspects.

Conclusion

Considerable progress in research in earthquake engineering has been made in the country. This has resulted due to coordinated efforts of the engineers and scientists of the various organisations. There is no place in India where the earthquake engineering problem can be completely neglected, and therefore it is essential that better and more economical eathquake-resistant design and construction methods for different types of buildings, dams, power houses, factories and other structures and foundations be evolved.

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SYMPOSIUM ON KOYNA EARTHQUAKE OF DECEMBER 11, 1967 AND RELATED PROBLEMS

Calcutta, June 1 and 2, 1968

The Proceedings of **the Symposium on Koyna Earthquake of December 11, 1967 and Related Problems** held at Calcutta on June 1 & 2, 1968 are being published by M/s. Indian Construction News, Construction Garden, Budge Budge Road, P.O. Maheshtala, 24 Parganas, West Bengal. The Publishers have agreed to supply the *Proceedings* at a discount of 25% to the members of the Indian Society of Earthquake Technology and other sponsoring bodies of the Symposium. Each author will get 25 reprints of his paper. If the paper is in joint authorship the 25 reprints will have to be distributed amongst the various authors. Those who wish to have additional reprints are requested to approach the publishers, who will indicate them the price of the same. The publishers would like to get an idea of additional requirements of reprints as early as possible. All members of the Society who wish to purchase the above *Proceedings* are requested to place their orders with the publishers or the Secretary, Mining Metallurgical and Geological Institute of India, 29 Chowringhee, Calcutta-16.