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An Appraisal of Earth-Quakes in Built-Environment

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Abstract:
Earthquakes are one of the nature's greatest hazards to life on this planet. Throughout historic time they have caused the destruction of countless cities and villages on nearly on every continent. The hazards imposed by earthquakes are unique in many respects and consequently planning to mitigate earthquake hazards requires a unique architectural approach. An important distinction of the earthquake problem is that the hazard of life is associated almost entirely with man-made structures. With a successful prediction, people can be evacuated from buildings and houses into open fields where loss of life can be almost completely avoided, but, the destruction of structures could be a disastrous loss to the regional economy. This aspect of earthquake hazard can be countered only by the design and construction of earthquake resistant structures and therefore a completely successful earthquake prediction programme could not eliminate the need for the effective earthquake architecture. On the other hand, with effective application of earthquake architectural knowledge, the collapse of structure and the resulting life hazard can be avoided, which would greatly reduce the value of any earthquake prediction programme.

Keywords: architecture, construction, earthquake, hazards, prediction, resistant, structure

I. INTRODUCTION

An earthquake originates on a plane of weakness or a fracture in the earth's crust, termed 'Fault'. The earth on one side of the fault slides or slips horizontally or vertically with respect to the earth on the opposite side. This generates a vibration that is transmitted outward in all directions. This vibration constitutes the earthquake. Faults are classified in accordance with the direction and nature of the relative displacement of the earth at the fault plane. Probably the most common type is the 'Slip fault', in which, the relative fault displacement is mainly horizontal across an essentially vertical fault plane. Another type is 'Normal fault', in which, the relative movement is in an upward and downward direction on a nearly vertical fault plane. A less common type is the 'Thrust fault'- when the earth is under compressive stress across the fault and the slippage is in an upward and downward direction along an inclined fault plane.

II. EARTHQUAKE MOTION

Slippage along the fault occurs suddenly. It is a release of stress that has gradually built up in the rocks of earth's crust. Although the vibrational movement of the earth during an earthquake is in all directions, the horizontal movements exert forces on a structure because they accelerate. This acceleration is simply a change in the velocity of the earth movement. Since the ground motion in an earthquake is vibratory, the acceleration and force that it exerts on a structure reverses in direction periodically at short intervals of time. During an earthquake, the ground acceleration varies continually in an irregular manner. Accordingly, for each earthquake there is a maximum acceleration. The length of earthquake faults vary about 20 miles to as much as 600 miles and are difficult to determine since the slippages that produce earthquakes generally occur deep in the earth and the disruption along the fault often does not reach the surface. Different earthquakes show a wide variation in the amount of slippage on the fault and in the length of the fault. The permanent slippage of the earth on a fault should not be confused with the displacement of the earth due to vibratory movement. Although the slippage along the fault may be several feet, the vibratory movement is generally few inches. This vibratory displacement is not permanent. After the severe shaking, the earth returns to its original position. Some faults are classified as 'active' since it is believed that these faults may undergo movement from time to time in the immediate geologic future. There is a good deal of uncertainty in the identification of potentially active faults. The identification of active faults and geologically hazard areas for land use criteria and for hazard reduction by special architecture may be of questionable value. Only in very recent years geologists have begun to try to evaluate the potential activity of faults that have no historical record of activity. By close inspection of a fault, visible in the side walls of a trench that cuts across the fault, it is sometimes possible to determine it has been active in recent times. For example, if the trace of the fault extents through a recent alluvial material, then there must have been slippage since that material was deposited. However, fault ruptures may be very difficult to see in embedded material such as sand and gravel. Also, of course the location of the fault must be known and it must reach the surface of the ground in order to inspect it by trenching. Recently the theory of 'tectonics' has been used to explain the underlying mechanics at work in generating earthquakes. According to this theory, the earth's outer shell consists of huge plates up to 60 miles in thickness which floats on a partially plastic layer of the upper mantle. These plates are presumed to move laterally and grind together at their margins thus producing earthquake faults. The magnitude of an earthquake is commonly designated by a number in the Richter scale, which is based on the release on the earthquake and is closely related to the length of fault on which the slippage occurs. The modified Mercalli, intensity scale originated by Woods and Neumann in 1931 is widely used in the United States and in some other countries as the measure of the damage potential of an earthquake.

III. EFFECT ON DAMAGES

There are two basic results of earthquakes:-

1. Loss and impairment of human life

2. Destruction and damage of the constructed and natural environment

Vibration and acceleration are the most important earthquake effects, where there are other effects also like disruption of the surface of the ground, strain in the ground at the surface, liquefaction of foundation soils and landslides etc. An architect can do little or nothing to protect a structure from damage due to the other effects. He can only recommend that structures not to be built where they are likely to occur. For this purpose, the architect should have the advice of professionals in other fields namely soil engineering, geology and seismology. No structure should be built on a fault, whether or not the fault is believed to be active. If the disruption of the surface of the ground due to faulting occurs under a building, it will be seriously damaged. Nothing can be done to prevent this. Often strains in the earth occur adjacent to a fault that ruptures the surface of the ground during an earthquake. The strains may be due to shear stress to tension and compression that produce changes in length. Such compressive charges cause broken curbs, broken pipes and buckled pavements as well as building damage. Liquefaction may occur due to earthquake acceleration of sand soils, generally where there is a high water table. Liquefaction reduces the bearing capacity of soil, which may result in settlement of building foundations. Also widespread liquefaction of foundation soil may cause land sliding.

IV. PREDICTION OF EARTHQUAKE

Effective prediction, particularly with regard to place or location, requires knowledge of all the active faults where strong earthquake may originate, but this information is not yet available. Concerning the maximum magnitude of the earthquake that will occur on any given fault, it may be expected that it will be at least as great as the maximum earthquake that has occurred on the fault in the past. A determination of the probable maximum magnitude therefore requires a relatively long history of earthquakes of varying magnitudes that have occurred on the fault and for which the magnitudes have been recorded. The number of such recorded earthquakes that is required for a reliable statistical determination of maximum magnitude is not generally available. The prediction of the probable time of occurrence of an earthquake is subject to even more uncertainty than the other two parameters. In the first place, this prediction must be entirely dependent on premonitory signs and these signs must be recorded on an extensive network of instruments. As mentioned above, existing instrument networks are inadequate. Also, since an earthquake might occur immediately after a change in some sign, the observation and recording of signs must be continuous. The establishment of any useful correlation between the recorded premonitory signs and the time of occurrence of earthquakes will certainly require many earthquakes and long periods of observation.

V. SOIL CHARACTERISTICS AND THEIR EFFECT

Several characteristics of ground and foundation have to be classified in order to employ dynamic analysis in the design of building foundations.

1. Dry Sand

Fairly large amount of laboratory tests have been carried out concerning shear strength or bearing capacity of dry sands under vibration. The results of experiments are influenced by the method of experiments and by researcher, but it can be approximately described that the decrease of shear strength or bearing capacity is not a predominant influence on the earthquake resistance but only to a small degree. Damage of houses on dry sands during earthquake is mainly caused by the slide of the slope under vibration.

2. Saturated Sand

It is a well-known fact that saturated sand loses its strength or bearing capacity under vibration with fairly small acceleration compared with dry sand by the so called liquefaction phenomenon. The particular ground conditions for the liquefaction in sand layer under the ground water cannot be defined yet, but the ground which satisfies the following five conditions, may have the possibility of suffering serious damage of buildings from liquefaction during earthquakes:-

- Almost pure sand less than 10% of slit and clay is distributed from the surface to the depth of 15-20m
- Uniform sand (co-efficient of uniformity less than 5) and medium grain size (mean grain size = 0.2 to 1.0 mm)
- The sand layer is under the ground water
- Loose sand more than a certain thickness
- Period distribution curve of micro tremors is in wide range including long period

The ground which satisfies the above conditions can be found in a filled area or around a new river which is less than 300 years old.

3. Cohesive Soil

There is no significant influence on the strength as in case of dry sand under vibrations up to 200 gals. But, cohesive soil with very high sensitivity loses strength under vibration. There are two kinds of soil investigations in seismic design. One is a common investigation of the long term design conditions and the other is carried out for special objective to get particular information for the seismic design. Boring soil test and vertical load test belong to the former and horizontal pile loading test and measurement of K-value and micro tremors belong to the latter.

VI. ANALYSIS OF SEISMIC ZONING MAP OF INDIA

Seismic zoning of India with accuracy is difficult at present as expecting approximate locations of the epicenters of earthquakes that have occurred in the past and present century and the location of parts in certain local areas. There is no complete survey available of the faults that exist in the Himalayans and other ranges. Therefore, one of the first essential studies should consist of more extensive geological survey of the entire seismic area to locate the fault. It is realized that such an extensive survey is expansive and time consuming, yet it must be started that without it, seismic zoning will remain tentative and approximate. The maps as shown in the figure-1 seem to have been prepared on the basis of the damages to the towns and cities in the past earthquakes. If in a certain area, considerable damage had occurred in the past that has been included in the ‘heavy damage’ zone and where damage has been somewhat less, it has been classified as ‘moderate zone’ and so on. It will however appear that there was scope for further thought about this as the extent of damage not only upon the intensity of the ground motion, size of the earthquake and its duration, but also on the method and material of construction of a structure, the nature of soil on which it stands and its distance from the epicenter. There are so many factors which come in to the actual damage that it is quite possible that a town consisting of strong structures only, even it is near to the epicenter than another town which has all reinforced or mud buildings, may not all be damaged while latter may be completely destroyed. It will be difficult to allot ‘intensities’ to different areas unless all conditions are similar. It therefore appears to be necessary that the zoning is based on the acceleration expected in a certain region and may not correlate with the damage observations. This will make the zoning independent of the method and nature of construction which obviously influence the damage. The following assumptions may be made:-

i) The whole of the area lying north –east to the ABC as shown in figure-2, should be considered as a ‘very heavy damage’ area because further earthquakes may occur anywhere in this zone and may have their epicenter in close vicinity of the structure that may be built in this area. The area lying to the south-west of this line will have decreasing ground motion as the distance increases from this line, on the assumption that the epicenter will lie on this line or north-east of it. The worst situation will arise when it lies on this line itself.

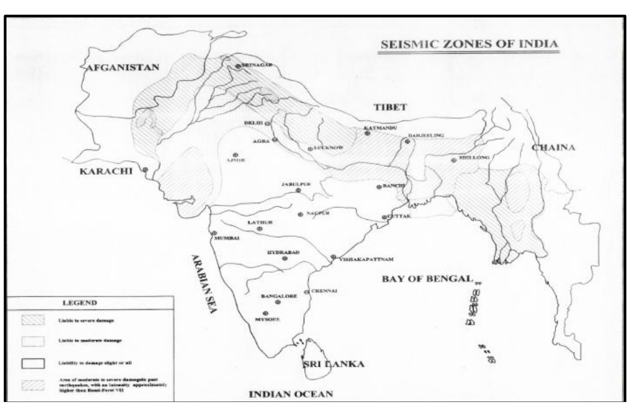

Figure.1.

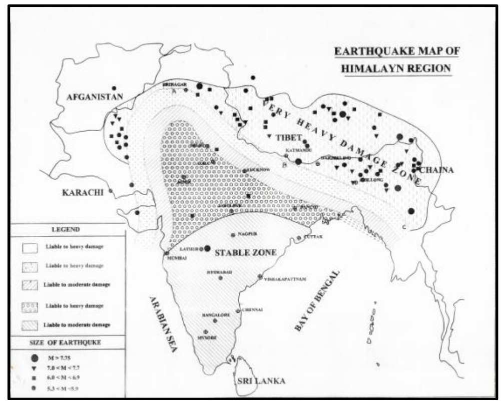

Figure.2.

ii) The Richter’s magnitude of the earthquake for which all important structures should be designed is 08 and the acceleration should be worked out for this size of shock for classification of zones. For areas north-east of the line ABC, the epicenter may be very close to the structure itself. From the figure, it is observed that 07 earthquakes bigger than 7.75 in magnitude have occurred in the past in the region, but other smaller size shocks have been located in the same areas. Therefore, frequency of occurrence is high and no important structure can be safe without suitable allowance being made for an earthquake of this size. It may be mentioned that although the frequency of a shock of size ‘08’ is perhaps not more than about one in a century in a certain area, yet a structure shaken by even smaller shocks again will not be able to stand them indefinitely. It therefore appears to be essential that the classification of the zones may be made on the basis that a shock of magnitude ‘08’ could occur anywhere on the line ABC in the life time of all important structures.

iii) Heavy damage may be expected where the maximum ground acceleration is 30% of gravity and above in an earthquake of magnitude ‘08’ occurring somewhere on the line ABC. It may be stated that this acceleration is the maximum value and may last for a very short duration. The moderate damage may be expected where the maximum ground acceleration is between 10% and 30% gravity. Light damage may be expected where the maximum ground acceleration is less than 10%. The Deccan Plateau as shown in figure may be considered to suffer earthquakes of damaging size.

VII. BASIC DESIGN REQUIREMENTS

i) The most important requirement of an earthquake resisting structure is that every part of a structure should be designed to withstand a horizontal force. The overturning moment of building should be kept within 50% of its moment of stability. It is necessary to aim at symmetry both in plan and elevation. If this is not possible, provision should be made for the resulting torsional effects. The torsional effect can be avoided in unsymmetrical buildings by dividing it in to separate parts and considering each part as separate structure.

ii) Cracks of any magnitude due to any cause, e.g. expansion or contraction, must be guarded against as such cracks will present planes of weakness during an earthquake. Additions and alterations to the structure should be avoided. If additions are essential, the new portion should be treated as a separate structure and 'Crumple sections' introduced at the junction with the existing structure. All parts of the structure should be tied together adequately so that the structure is effectively in one single rigid unit. The building should preferably be designed as a reinforced concrete rigid frame structure and each part of the building as a unit should be designed to resist the bending moment and shears caused by the horizontal seismic force.

iii) The earthquake resistant structure should be monolithic. There are a number of methods of designing indeterminate structures in reinforced concrete, i.e. strain-energy method, slope-deflection method, moment-distribution method etc. The last method is recommended as it is the simplest and provides a degree of accuracy commensurate with the accuracy of the seismic force which is based on experience rather than on scientific observation.

iv) The length of a building should not be as far as possible more three times its width. If a longer building is necessary, it should be divided into separate structures by crumple sections. The center of gravity should be kept as low as possible. Bents of columns should be straight and should run right through the building in both directions.

v) Dog-legged columns are uneconomical and weak. Weakness should be avoided by staggering openings. Internal partition walls should meet at a common vertical. Parapet walls, cornices, ornamental details etc. should be avoided. If used, they should be firmly tied to the structure so as to form and integral part of it.

VIII. CONCLUSION

Knowing more about the direct or indirect effects of earthquakes helps us to understand the mitigation steps that must be taken to protect a community from a seismic event. There is an urgent need that prevailing standard codes of practices for earthquake resistant design and construction should be adhered to, and wherever these provisions are deficient, detailed studies should be undertaken to evaluate and improve them. Buildings should not only meet the functional requirements of occupants but also essential requirements for sound earthquake resistant design and construction. Seismically deficient structures need to be strengthened to reduce their vulnerability.

IX. REFERENCES

[1]. Bhudaia P.D., Bhandari P.D. and Pindoria K. (2001), "Repair and strengthen guide for earthquake damaged low rise domestic buildings in Gujrat", Gujrat Relief Engineering Advise Team (GREAT) Publication, India

[2]. Bowles J.E. (1988), "Foundation Analysis and Design", McGraw Hills, New York

[3]. "Indian Standard Criteria for Earthquake Resistant Design of Structures: Part-1-General Provisions and Buildings", (2002), Bureau of Indian Standard, New Delhi

[4]. Jayasinghe M.T.R., (1997), "Load bearing brickwork construction for Sri Lanka", STRAD Consultants Pvt. Ltd., Colombo

[5]. Krishna J., (1959), Seismic Zoning of India, Proceedings of Earthquake Engineering Seminar, Roorkee

[6]. Kumar S.L., (1933), Theory of earthquake resisting design with a note on earthquake resisting construction in Baluchistan, Punjab Engineering Congress

[7]. Nowak A.S. and Collins K.R., 92013), "Rliability of Structures", CRC Press, New York

[8]. Pulinets S.A. and Boyarchuk K.A., (2004), "Ionospheric Precursors of Earthquakes", Springer, Berlin