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LESSONS FROM RECENT EARTHQUAKES IN INDIA, INDONESIA AND PAKISTAN

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ABSTRACT:
Every earthquake has its own signature and every earthquake teaches some new lesson. The 26 January 2001 Bhuj Earthquake in India, 26 December 2004 Earthquake and Tsunami in Indonesia and 08 October 2005 Kashmir Earthquake in Pakistan has taught several new lessons. These are from different fields such as structural engineering, bridge engineering, telecommunication engineering, military engineering, coastal engineering etc. These lessons could be used in designs of future similar activities not only in the epicentral regions but also at other locations. The main lessons are (a) Damage of structures due to Raleigh Waves at far distance from the epicenter (b) Collapse of Military Bunkers in the highest Isoseismal intensity (c) Good Performance of Bailey bridges (d) Direction of Propagation of Destructive Tsunami waves (e) Animal Precursors of Tsunami. Some coastal towns have expanded and cities have become mega cities. The seismic and Tsunamigenic vulnerability of such locations needs planning for next few decades. These lessons would be useful for this purpose.

KEYWORDS: Engineering Lessons, Earthquakes in India, Indonesia and Pakistan

1.0 INTRODUCTION: The destructive earthquakes are paradoxically, highly informative and educative. Though these earthquake cause heavy damage, they are capable of teaching some new lessons. These are useful in future planning. During January 2001 to October 2005 India, Indonesia and Pakistan have experienced the following destructive earthquakes.

Date	Magnitude	Location	Name	Death
26 Jan. 2001	7.7	23.41 N 70.23 E	Bhuj, Gujarat, India	20,023
26 Dec. 2004	9.1	03.31 N 95.85 E	Sumatra, Indonesia	2,27,989
05 Oct. 2005	7.6	34.49 N 73.63 E	Kashmir, Pakistan	1,20,000

Table 1. Earthquakes of magnitude more than 7.5 in this century in India, Indonesia and Pakistan. (Indonesian earthquake death toll includes people died due to Tsunami in various countries such as Indonesia, Thailand, Malaysia, India, and Sri Lanka etc).

The total death toll from these three earthquakes adds up to 368,012. This shows that that the average death rate was about 6456 per year. Apart from the gory happenings, and sad death, there have been several other types of damages such as to structures, bridges, roads, dams, lifelines etc.

The different types of damages in the above earthquakes have taught a number of significant lessons. The changes and damages are on mega scale. For example, the entire earth was set in vibration due to the Sumatran earthquake of magnitude 9.1.

2.0 Distant Damage: When a large magnitude earthquake (M > 7.5) occurs, it creates two types of damages. One is epicentral damage, which is within about 40 – 60 km radius from the epicenter. The area between 60 to 100 km radiuses may suffer some non-repairable damage of the engineered structures. Beyond this distance of 100 km the damage would depend up on the mechanical properties of rock (density, elasticity, compaction, geology etc). Between 150 km to 550 km range the Long Period Surface Waves (Raleigh Waves) are highly predominant. These waves have a period of about 12 to 18 seconds and they cause damage only to tall structures of height more than 17 meters and located within the above vulnerable distance of 150 – 550 km from epicenter. Such damage was observed for the first time in Mexico City. A powerful earthquake of magnitude 8.1 occurred on the Pacific Coast of Mexico on 19th September 1985 at a distance of about 500 km from Mexico City, which is based on a bowl shape lacustrine deposits valley. In Mexico City only tall structures (height more than 17 meters) have suffered heavy damage. Structures with two or three floors did not suffer any damage or the damage was minimal. After these happenings, the Mexican Seismic Codes were revised and suitable provision was introduced.

2.1 During the Bhuj (Gujarat) earthquake in India of 26 January 2001, a similar situation to Mexico City had developed. Singh et al (1988) and Lomnitz et al (2005) have discussed the damage at Mexico City due to this earthquake. Ahmedabad City is located at a distance of about 320 km from the epicenter Due to this earthquake; only tall structures in Ahmedabad City have collapsed. Other structures with one / two / three floors did not suffer any damage. This is due to the Long Period Surface Waves (Raleigh Waves). The epicenter of the Bhuj earthquake was at a distance of about 320 km west of Ahmedabad City. It was observed that the structures which were having their long in North South direction and the broad side was facing west have suffered more damage. This is due to the fact that the epicenter was west of Ahmedabad City and Seismic Waves arrived from west. The broad side was exposed to the attacking waves. It was also found that the structures, which were having end position towards west, have suffered less damage. Bapat (2008a) has discussed this type of damage at Ahmedabad.

2.1.1 Another type of damage observed at this location. Buildings up to two or three floors and standing on stilts had suffered total damage. Due to paucity of parking space, the ground floor is used for parking and the building is on stilts. The reason for severe damage to such structures is clear from simple calculations. Suppose a structure has three floors and is standing on columns. Under such conditions, the about 32.3 per cent of built up area would account for each floor and about 3.0 per cent area of the building would be touching the ground. When the building starts shaking under seismic load, a stress wave would be starting from the top of the building and travel downwards. It will be traveling through a uniform cross section per floor from the top to the first floor. When it reaches the stilt level suddenly the cross section is reduced to about 3.0 per cent of the total area of the building. As a result buckling or breakage of the columns occurs. Instead of stilt if there I ground floor then the wave path would be through a uniform path and the building would not suffer any damage as seen for other similar buildings.

2.1.2 This is an important lesson and could be used for design of future buildings. Cities located at the vulnerable distance range of 150 to 550 km from the potential epicenters of large magnitude earthquakes should make suitable provisions in the seismic codes. The vulnerable cities are New Delhi, Kolkata, Mumbai (Bombay) in India, Dhaka and Chittagong in Bangladesh, Lahore and Karachi in Pakistan. The Gulf countries are not known to seismically active. But

Long Period Seismic Waves (Raleigh Waves) generated by large magnitude earthquake in Southern Iran could cause severe shaking of tall structures in Gulf Countries such as Dubai, Bahrain, Muscat, Kuwait, Qatar etc. The tall structures in these areas are vulnerable to seismic waves from Iran and Iraq. In addition to these countries some cities have become Mega-Cities and the vulnerability of these Mega-Cities to earthquake and tsunami damage needs to be examined seriously. These are: Santiago, Lima, Bogotá, Caracas, Mexico City, Sao Paulo, Los Angeles, San Francisco, Vancouver, Tokyo, Osaka, Kobe, Manila, Jakarta, Yangoon (Rangoon), Ankara, Istanbul etc. As the population density is very high in these Mega-Cities the loss of lives could be very high. Efforts should be made to mitigate the disaster on the basis of microzonation.

3.0 Military Engineering: The natural calamities such as earthquake and tsunami also attack military establishment. A bunker is supposed to be the safest place for a soldier in battlefield. Even powerful penetrating bombs dropped on the bunkers do not cause any damage to the bunker. But during the Kashmir earthquake of October 2005 a number of bunkers were totally destroyed. The bunkers were not designed to withstand any force from underground. Similarly, some airports were flooded with water during the tsunami attack and some airports sank below their level by a distance up to one meter. While designing the airport the likely sinking of land was not accounted. Future military engineering projects would be required to be examined from these points of view.

Performance of Bridges: It was observed during the Kashmir Earthquake and during the Sumatran earthquake and Tsunami that Bridges known as Bailey Bridges have performed well. Pore et al (2006) have reported that most of Bailey bridges have not suffered any damage. In Bailey bridges the superstructure is in the form of trough type trusses consisting of twin panel modules joined through pins and/or bolts. The typical span length is 15 to 30 m. These bridges have performed well due to their flexible nature. (This is a type of partially prefabricated military bridge is suitable for rapid assembly and named in honour of Sir D. Bailey the structural engineer). The ductility of the steel material introduces good element of ductility in the structure.

4.0 Tsunami Damage: The Sumatran earthquake had generated huge tsunami waves and it had caused heavy damage in several countries. As reported by Murty et al (2005) the energetic of the most destructive tsunami in historical time, and that of the under ocean earthquake that triggered this tsunami of 26 December 2004 in the Indian Ocean has been briefly reviewed. This tsunami has several other unique characteristics, besides being one of the worst natural disasters in human history. It is the first truly global tsunami after modern seismographic and sea level monitoring networks are put in place. After seeing the energetic of the tsunami some of the physical parameters need to be considered. One of the most important observations is that the maximum energy and amplitude of the tsunami waves is at right angles to the direction of rupture at the epicentral area. This is very important finding and may be used for Tsunamigenic safety of coastal areas in littoral countries of Pacific region where occurrence of tsunami is quite frequent. The Makaran Coast in Pakistan – Iran had produced a destructive tsunami of about 12 m height in 1945. Fault plane solutions of earthquake in Makaran coast would help in understanding the rupture mechanism of Makaran coast. Depending up on the fault plane solutions probable direction of propagation could be worked out using suitable computer models. For proper coastal planning and development proper tsunami mitigation plans are required. Inundation survey of tsunami affected areas help in getting minute details of the tsunami propagation. Bapat and Murty (2008) have conducted an inundation survey for the town of Kanyakumari (India).

5.0 Animal Precursors in Andaman before tsunami: Prediction of earthquake is yet to reach any perfection and the matter at present is not crystallized. It is not proposed to discuss the theory of earthquake prediction but an observations from Andaman needs to be examined from prediction point of view. The happening is from Hut Bay area in Andaman island group. The Tsunami occurred on 26th December 2004. 25th December was Sunday, holiday and Christmas day and people wanted to make some happy function. By afternoon some people gathered on a 100 m long jetty at Hut Bay and started preparation and arranging food, drinks and music system. By about 1500 hrs (Local Time) there was snake on the jetty. After half an hour there were about seven snakes on the jetty. By about 1700 hrs the jetty was full of snakes, toads, turtles, crabs and some fishes were jumping out of water towards land. This was most unusual and the organizers of the party left the jetty. The earthquake and tsunami occurred next morning around 0630 hrs. At present the mechanism of abnormal animal behavior before any medium to large earthquake is not accepted as reliable seismic precursor. But it is not fitting in the presently accepted norms of science. One of the probable reasons could be the presence of excessive and large charged particles in the atmosphere. Any loving organism when subjected to heavily charged particle conditions becomes extremely uneasy.

Conclusions: The present scientific and technological development is not able to stop the occurrence of any natural disaster. Earthquakes, tsunami cyclones etc would continue to occur. The agonies of human beings could be reduced by proper mitigation efforts and hazard reduction. Bapat (2008b) has discussed planning of earthquake disaster planning. If there are geological, tectonic, statistical, geophysical evidences about the possibility of occurrence of any earthquake then a suitable mitigation strategy could be worked out. The observations could be used for future long term planning and development of inland and coastal regions. In addition to engineering efforts and measures and codal requirements for construction, efforts should be made to create awareness about earthquake and tsunami. The areas and cities identified may be assigned proper priority for incorporating these observations in futuristic planning.

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