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Latur - Killari Earthquake: An Overview Study

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Abstract: ***Indian subcontinent has suffered some of the greatest earthquakes in the world with magnitude exceeding 8.0. For instance, in a short span of about 50 years, Efforts have been made to relate earthquake intensity with values of peak ground acceleration at the site. However, this can at best be only approximate, because intensity depends on many features of the ground motion including ground acceleration, ground velocity, duration of shaking, and frequency content of motion. India has had a number of the world's greatest earthquakes in the last century. In fact, more than 50% area in the country is considered prone to damaging earthquakes. The north eastern region of the country as well as the entire Himalayan belt is susceptible to great earthquakes of magnitude more than 8.0. Indian earthquakes have shown some remarkable features which have implications on strategies for reducing earthquake disasters in the country. On September 30, 1993 a magnitude 6.4 earthquake shook the area near village Killari in Latur district killing about 8,000 persons (GSI, 1996; Jain et. al, 1994; Seeber et al., 1993, 1996). The maximum intensity of shaking was about VIII to IX. Until this earthquake the area was considered non-seismic and placed in the lowest seismic zone (zone I) by the Indian code (IS:1893-1984). Most of the damage was contained in a relatively small area of 20 km x 20 km. The affected area did not have any modern towns, modern buildings or major industries. In some of the villages more than 30% of the population was killed. This earthquake will be known for outstanding rescue, relief and rehabilitation carried out for any earthquake in recent Indian history; perhaps outstanding by even international standards.***

Keywords: Seismology, Epicentre, Rehabilitation, Tectonic, Seismic Zones, Earth Crust, Disaster.

I. INTRODUCTION

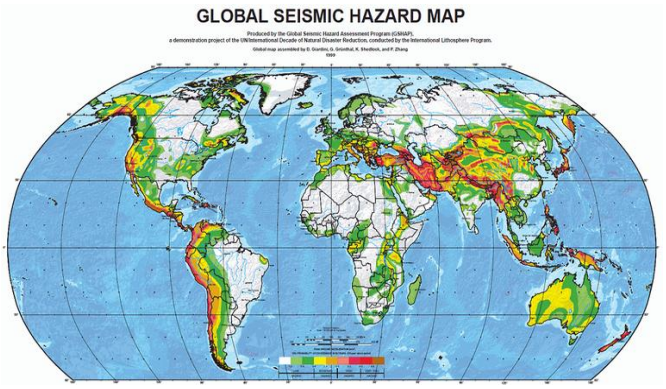

Figure 1: Global Seismic Map

Based on seismic data and different geological and geophysical parameters, the country is divided into five seismic zones. Of the five seismic zones, zone five is the most active region and zone one shows least seismic activity. (However, in 2003, the Bureau of Indian Standard (BIS) redefined the seismic map of India by merging zones I and II, so that India has four zones—II, III, IV and V.)

The entire north-eastern region falls in zone five. In fact, in the last 100 years, as many as five major earthquakes with a magnitude of 7.0 occurred in this region—Assam in July 1918, July 1930 and October 1943, Arunachal Pradesh-China border in August 1950 and Manipur-Myanmar border in August 1988.Besides the north-east, zone five includes parts of Jammu and Kashmir, Himachal Pradesh, western Uttarakhand hills, Rann of Kachchh (which includes Bhuj) in Gujarat, northern Bihar and the Andaman and Nicobar islands.One of the reasons for this region being prone to

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earthquake is the presence of the young-fold Himalayan mountains here which have frequent tectonic movements. Zone four which is the next most active region of seismic activity covers Sikkim, Delhi, remaining parts of Jammu and Kashmir, Himachal Pradesh, Bihar, parts of Uttarakhand northern parts of Uttar Pradesh and West Bengal, parts of Gujarat and small portions of Maharashtra near the west coast.

In the past few years, Uttarakhand, Maharashtra and Madhya Pradesh have had a number of severe earthquakes. These include the devastating Uttarkashi (Uttarakhand) earthquake of 6.6 magnitude in October 1991, Latur-Osmanabad (Maharashtra) quake in September 1993, Jabalpur (Madhya Pradesh) in May 1997 and Chamoli (Uttarakhand) in March 1999 all of a magnitude of over 6.Zone three comprises Kerala, Goa, Lakshadweep, remaining parts of Uttar Pradesh and West Bengal, parts of Punjab, Rajasthan, Maharashtra, Madhya Pradesh, Chhattisgarh, Orissa, Andhra Pradesh and Karnataka. The remaining states with lesser known activity fall in zones one and two.

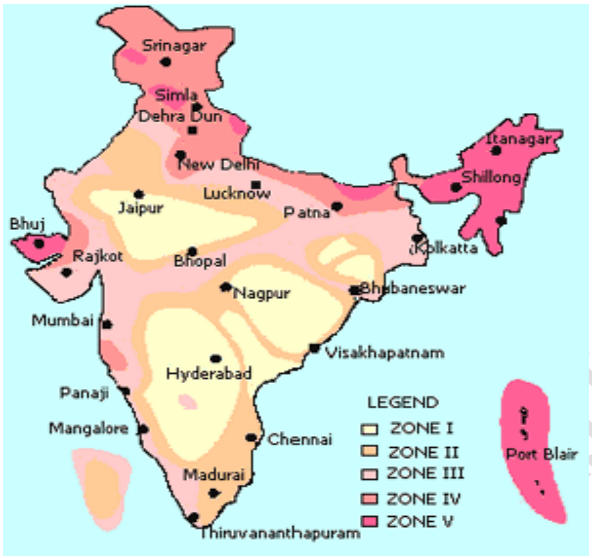

Figure 2: Seismic Zones of India

Delhi's Vulnerability to Earthquakes: Delhi is the most earthquake-prone metro in the country. It lies in the seismic zone four. The capital has been rocked by many earthquakes, some even more than six on the Richter scale though there has never been any loss of life or property. The last major quake was more than 30 years ago. In fact, since 1994, there has been a marked cessation of seismic activity. It is shown that stresses, which were being released periodically, are now stored in rocks like a spring. If this continues, these stresses will one day release and will lead to an earthquake. In spite of the knowledge, Delhi is perhaps the least prepared city for earthquakes. With an over 50 per cent rate of population growth and 85 per cent of people living in high density areas (about 22,399 persons per square kilometre), the availability of space per person is actually less than five square metres—a detail which often decides the final casualty figures. Moreover, according to analysts, 50 per cent of the houses are built privately, hence there has been an absolute laxity in enforcement of seismic building codes. According to experts, considerations of the soil where citizens live, the structure of buildings and the settlement pattern, roughly decide the place and the extent of the damage. The depth of the alluvial soil (sediment deposited by flowing water) plays a crucial role in determining risk. For instance, the Naraina-Patel Nagar road section and the Yamuna river-bed section (basically the trans-Yamuna area), extending till Noida and Faridabad, are more vulnerable to damage even in a moderate quake because they are located on alluvial soil which is up to 200 metre deep. Experts also state central business districts like Connaught Place and high-rise group housing schemes are high-risk areas.

Reasons of Earthquake in India Earthquakes happen due to movement of the Earth's crust. The movement releases enormous energy. This energy is spread outwards. The source of the movement is termed as the epicenter. Earthquakes can cause mass calamity. They are more dangerous in urban regions where high rise buildings are common. In thickly populated cities, Earthquakes can be devastating. There are multiple causes or reasons of earthquakes in India. *The following are the top ten reasons for Earthquakes in India.*

A. VOLCANIC ACTIVITY

Exploding volcanoes release tremendous energy which offsets the Earth's crust. This is the reason many earthquakes happen in and around volcanic regions. Earthquakes happening due to volcanic eruptions are called volcanic earthquakes.

B. FOLDING AND FAULTING

When a fracture occurs in the plane on which the Earth's crust resides, an earthquake can happen. This type of earthquake is caused either by vertical or horizontal displacements. The movement of rocks along these fractures causes the movement of earth's crust.

C. PLATE TECTONICS

The Earth's surface is comprised of plates. These plates are always moving. When these plates move, their margins become sites of earthquakes. That is why earthquakes are found to be frequent in plate boundaries.

D. NUCLEAR BOMBS

Human beings test nuclear bombs underground. The explosion releases shock waves. This situation can cause a minor earthquake. The overlying rocks become unstable. They shift their position. It induces a mass chain reaction of shifting rocks.

E. CONSTRUCTION ACTIVITIES

Blasting of rocks for construction work is common. Rocks are needed for construction. Blasts release energy and render the Earth's crust unstable. In mountainous regions, rocks that were lying for millions of years could shift. A small shift releases outward energy that renders the whole region unstable. In this event, an earthquake happens.

F. UNDERGROUND MINING

Deep underground mining creates big gaps beneath the Earth's surface. This does not do much for the stability of the Earth's upper layer. Also, mining involves the use of explosives and bombs to blast open rocks. Similar to nuclear bombs, and construction related bombs, explosions for mining release shock waves.

G. DAMS AND RESERVOIRS

Water held in dams and reservoirs exerts tremendous pressure on the ground surface. The ground surface spreads this pressure across to sustain itself. This is a natural phenomenon. But over a period of time, water disturbs the equilibrium of the Earth's surface. The pressure could build up in a way so as to produce mild tremors. Over a period of time, a full-fledged earthquake can happen.

H. LANDSLIDES

Avalanches and landslides disturb the equilibrium of the Earth's crust. They cause the Earth's crust to send shock waves as a means to release and distribute energy. Landslides exert tremendous force on the Earth's crust, which can even cause a full-blown plate movement several kilometers below the Earth's crust.

I. INJECTING LIQUID WASTE INTO THE GROUND

In many parts of India, certain industries inject waste into the ground's surface as a means of disposal. This process causes instability of the Earth's crust and could lead to earthquakes.

J. CREATING HIGH RISE BUILDINGS ON INAPPROPRIATE LAND

The creation of high rise buildings on land that is not capable of withstanding such pressure can cause Earthquake

The *Latur, India earthquake* was the most destructive earthquake in 1993. It occurred on September 30, 1993. The main reason for its lethality was the fact that it occurred at 3:45 AM, while the entire area was indoors and asleep. The earthquake struck in Southeastern India, in the state of Maharashtra. The two districts which were decimated by the earthquake were the districts of Osmanabad and Latur. The coordinates of the earthquake's epicenter were N18.07 and E76.62. (www.timesrelieffund.com) This was very close to Latur, and consequently, it suffered the most damage. *The earthquake measured 6.2 on the richter scale*, with its focal point 12 meters beneath the surface. Unlike the Latur earthquake, most earthquakes occur along fault lines, where two plates meet.

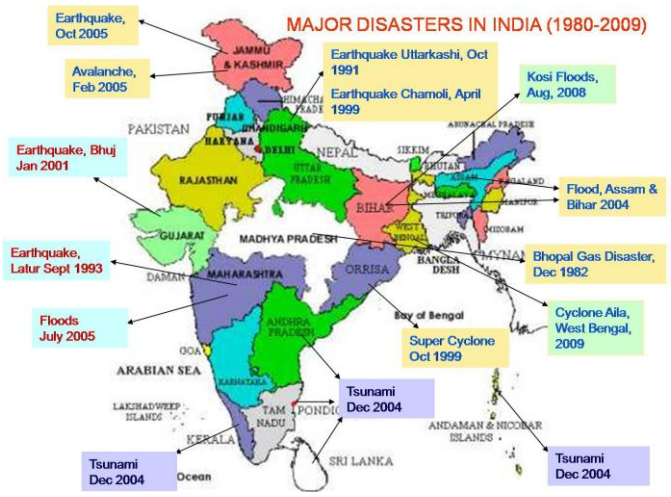

Figure 3: Disaster in India

II. WHAT CAUSED IT TO HAPPEN?

The Latur earthquake was one of a very rare type of earthquakes. It was what is referred to as a SCR, or a stable continental region earthquake. Most earthquakes are a result of interaction between two plates, whether they be sliding, colliding, or forming a subduction The distinguishing feature of the houses in the village is that they are constructed out of white earth and stones. The walls and roofs are 4 feet thick. The houses of masonry do not have strong foundations. The land on the banks of the Terana river is ex-tremely fertile; no hard rocks are found over the terrain even if you dig 10 feet deep. The foundations of houses are not strong enough with the soil being so loose. The effect of the seismic tremors zone., in this instance, the cause is very complicated. The Latur earthquake was an intraplate earthquake, or it occurred in the middle of a plate, as opposed to a plate boundary. The earthquake's epicenter was very far from any fault line. The cause of this earthquake is still in speculation. Some scientists claim that it was a result of the force released from the continuous crumpling of the Indian plate against the Eurasian plate. Others claim that it was a consequence of the pressure built up as a result of the reservoir construction on the river Terna. The theory which most scientists agree on is that the many leniaments, or mini faults within plates, in that region contributed to the build up of pressure and its consequent release.

The tragedy struck in the small hours of the morning. Many people had returned home late in the night and were enjoying a sound sleep About 20 villages were completely destroyed, resembling the mounds of stones and earth. About 70 to 80 per cent of the population of these villages have fallen victim to this calamity. Many of those who survived are as good as dead. There was the same pathetic sight everywhere—heaps of corpses, masses of debris, pyres arranged out of wooden beams of houses, smells of burning and decomposed bodies filling the atmosphere, the limbs of men and women peeping out of mountains of debris and rubble, dogs unearthing the dead bodies and devouring them, feeble wailing voices, grief-stricken eyes dried of tears.

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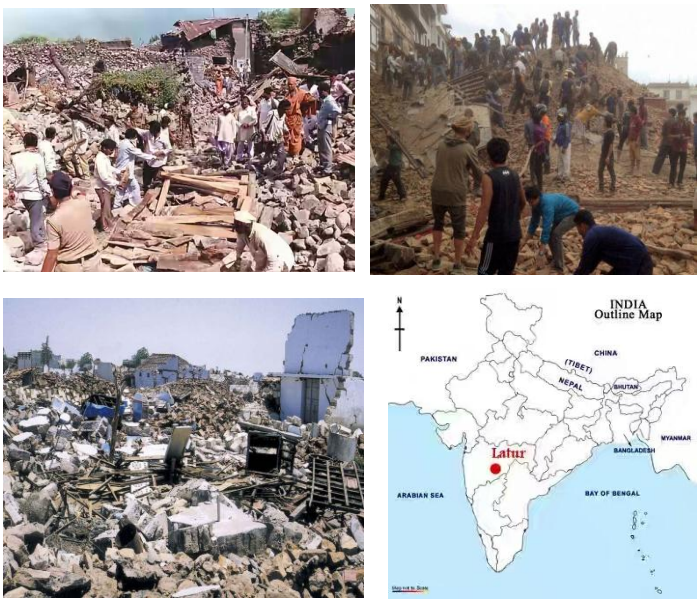

Figure 4: Killari Earthquake Impact Photos

Latur earthquake was one of the deadliest earthquakes Maharashtra has seen till date. The earthquake struck at about 3:45 am on September 30, 1993. In the intraplate earthquake about 52 villages were destroyed, over 30,000 were injured and approximately 10,000 were killed. The earthquake left a huge hollow at Killari, which was also the epicentre, remains in place till date. Facts you should know about the deadliest earthquake in the history of Maharashtra:

The earthquake in Maharashtra mainly affected the districts of Latur and Osmanabad. About 52 villages were demolished in the intraplate earthquake The earthquake measured 6.2 on the moment magnitude scale Over 10,000 people died, whilst another 30,000 were injured The area of Latur was densely populated so, the toll of those who were killed and injured was very high Since the earthquake's focus was 12 kilometre deep, the shock waves caused more damage The epicentre of the quake was Killari. The large crater can be seen at the place even today Several foreign and local donors reacted immediately to the tragedy by sending relief teams and rescue workers

The first convoy of over 120 trucks loaded with relief material such as tents, blankets, food and clothing, medical supplies and temporary shelters were given by international donors. The Indian Army, State Reserve Police Force, Central Reserve Police Force and other law enforcement agencies too reacted immediately and rushed their personnel to the earthquake hit area. The earthquake hit at about 4:00 in the morning so, the villagers of Latur and nearby areas had no warning and many of them were crushed to death under the wreckage of their houses which collapsed as a result of the quake. The number of deaths included many women and children After the damage was understood in numbers, World Bank also offered assistance and funding for the reconstruction at Latur.

The Handicapped persons were provided financial assistance of 46.55 lakh rupees 1,26,132 agricultural apparatuses were also provided to the farmers 299 beneficiaries have been provided cattle for the cattle lost in earthquake. The National Disaster Management Authority (NDMA) was also set up after the Latur earthquake. The surface of the Earth is made up of tectonic plates which are slowly but continuously in motion. When they move against each other the pressure builds up until it is released at a point called the epicentre. The resulting stress is transmitted in the form of seismic waves, or what is commonly called an earthquake. As the surface of the Earth buckles and bends great devastation can be caused to lives and property in the area. One such catastrophic event took place on 30th September, 1993, in Latur in Maharashtra state of Western India.

Early in the morning of 30th September, at 3.56 am a massive earthquake took place in Central India. The epicentre of the earthquake was in Killari in Latur district of Maharashtra. The impact was felt most in Latur and Osmanabad districts. The sleeping villagers of Latur and nearby areas had no warning and many of them were crushed to death under the debris of their houses which collapsed as a result of the quake. More than 10000 people were killed and about 30,000 were injured. Many of the injured had fractures or crushed limbs as a result of being trapped under heavy stones or beams from the walls and roofs of their houses. The death toll included many women and children.

The intensity of earthquakes are measured on the Richter Scale where (where 2.0 or less is a minor quake while 7.0 and above is classified as a major quake). The Latur earthquake was recorded as measuring 6.2 on the Richter Scale. Since the area was densely populated, the toll of those killed and injured was very high. About 35 villages were completely devastated, as all the houses were destroyed in the quake. Another 730 villages were damaged as a result of the tremor.

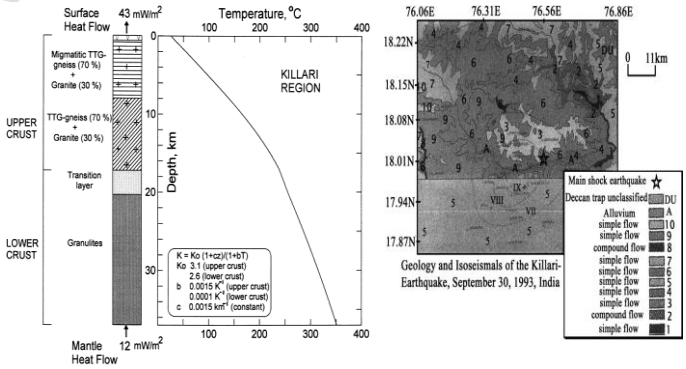

Figure 5: Graph showing Earthquake Data

III. REHABILITATION AND RELIEF TASK

The civil administration, the Central Reserve Police Force (CRPF) and the armed forces were pressed into disaster relief operations to rescue those trapped under the debris and provide the survivors with basic necessities. The Red Cross, the state health department and local hospitals were pressed into service to evacuate the injured and provide immediate medical help and rehabilitation. The most vulnerable, including young children, the elderly, women and the differently abled were given priority treatment. Basic necessities such as food, clean drinking water, clothing, blankets and tents for the survivors were organized and dispatched from central collection points. Villagers who had

survived but had lost their homes were provided compensation and temporary accommodation. NGOs and social service organizations also played a big role in the relief efforts and helped survivors rebuild some semblance of their normal lives as soon as possible.

As the debris was cleared, the question of how to respectfully dispose off the large number of dead bodies also emerged. This needed to be carried out soon in order to prevent the spread of infectious diseases in the area. The option of community burial of the dead was put to use and people of all faiths were buried in mass graves. Disinfectant agents were used in the area to prevent any outbreak of disease. A large number of livestock were also killed as a result of the quake or died shortly thereafter. Their bodies too were disposed off in a similar manner, keeping in mind the health of the community.

As the damage was assessed and reconstruction requirements understood, donor agencies such as the World Bank offered assistance and funding for the reconstruction projects. The central and state governments with the help of NGOs and donor agencies carried out a reconstruction programme. Along with houses, essential infrastructure such as local schools and health centres were also extensively damaged. The new buildings that were constructed incorporated earthquake proof engineering techniques and structural design elements that would prevent them from collapsing in the the event of a future quake. The authorities viewed the reconstruction as an opportunity to introduce positive health practices to the community In all 769 Hectares of land has been acquired for Rehabilitation and an amount of Rs. 43.63 crores has been distributed by way of compensation to land owners. The layous were prepared in consultation with the people. The advise of the Town Planner has also been taken into account. 1/3 rd space in the layouts has been reserved for afforestation. One who is resident of the damaged village and who is recorded as a owner of house as per village property register or one who is recorded as independent head of family in 1991 census or one who has a Ration Card in his name and a panchanama has been done in his name stating that his house has been damaged has been considered to be entitled for getting a house in the new gaothan.

While deciding the entitlement regard being had to the land holding of individual. Those residents who owned agricultural land admeasuring 7 hectares and above have been provided a plot of 5000 sq.ft. area and constructed house on that plot with 750 sq.ft. carpet area in the new village. Those residents who owned land between 1 hectare to 7 hectares have been provided plot of 2500 sq.ft. size and constructed house on that plot with 400 sq. ft. carpet area. Those residents who owned land less than 1 hectare or are landless have been provided plot of 1575 sq.ft size and constructed house on that plot with 250 sq.ft. carpet area. Those villages where the damage is more than 70 % but the soil strata below is hard BC soil is less than 2 mt. deep were found to be fit for reconstruction on the same site. The residents there were provided Rs. 62000/- grant for reconstruction by himself and the technical assistance was provided by the Govt.

A vast programme for repairs and strengthening of houses which suffered varying degrees of damages was taken up in 749 villages. Taking into consideration the extent of damage the house owner was provided a grant of Rs.17000 for minor damage and Rs. 34,500/- for major damage to repair and strength his house with technical assistance provided by the Govt. 1,03,240 beneficiaries have completed the work of R & S of their houses by using earthquake resistant technique.

The various techniques used in construction of houses are as follows.

- ✓ Precast Technique
- ✓ In-Situ RCC Construction
- ✓ Geodesic Dome
- ✓ R.C.C. Framed Structure
- ✓ Load Bearing Structure
- ✓ In-Situ Construction
- ✓ Retrofeiting of Existing Structure

IV. CONCLUDING REMARKS

When reviewing the past earthquakes it is important to have the correct perspective on earthquake magnitude and earthquake intensity: two terms often misunderstood. Earthquake magnitude is a measure of the size of the earthquake reflecting the elastic energy released by the earthquake. It can be seen from the graph that on an average about one earthquake of magnitude greater than 8.0 takes place every year as against about 96 events per year of magnitude range 6.0 to 8.0: a ratio of about 1 is to 100. If this trend were to be applicable to India, the Indian subcontinent should have had about 400 earthquakes of magnitude range 6.0 to 8.0 in the last 100 years since we had four events of magnitude greater than 8.0 in that period. Clearly, we have had far less number of moderate earthquakes. This illustrates an interesting aspect of Indian seismicity: India has relatively high frequency of great earthquakes and relatively low frequency of moderate earthquakes. Moderate earthquakes create awareness and lead to improvements in constructions at relatively low human costs, which could be very effective in the long run. Due to rather infrequent moderate earthquakes, the Indian.

Indian seismicity: India has relatively high frequency of great earthquakes and relatively low frequency of moderate earthquakes. Moderate earthquakes create awareness and lead to improvements in constructions at relatively low human costs, which could be very effective in the long run. Due to rather infrequent moderate earthquakes, the Indian earthquake problem does not receive the attention of the country that it deserves considering our overall seismic potential, and this is a tragedy. For a poor country, the focus of political priorities anyway remains on day-to-day problems of poverty, shelter, law and order, health, sanitation, and it is as such difficult to seek priorities to once-in-a-while problems of natural disasters. Nevertheless, just like one takes a life insurance policy for unexpected disasters, the country needs to invest a small fraction of priorities towards earthquake disaster mitigation; the consequences otherwise could be truly unimaginable should a major earthquake cause severe shaking in highly populated areas of the country.

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