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EARTHQUAKE CATALOGUE OF BANGLADESH

Munima Tahsin[1], Md. Abdullah Salman[2] and Dr. Syed Humayun Akhter[3]
[1,2]Department of Geology, Dhaka University, Dhaka-1000, Bangladesh
[3]Professor and Former Chairman, Department of Geology, Dhaka University, Dhaka-1000, Bangladesh
E-mail: munimatahsin@gmail.com, salmansadman126@gmail.com

Abstract: Bangladesh is vulnerable to earthquake being an earthquake prone country. Bangladesh lies in the three plate junction – Indian plate, Eurasian plate and Burmese plate. Different sizes and depth of Historical and Instrumental earthquake tells that how much risky area is Bangladesh and surroundings. So, Bangladesh is situated like a ring of earthquake. This information is very much clear from the existing and updated earthquake catalogue of Bangladesh. Earthquake catalogue shows the list of earthquake or serial of earthquake in a region. Here in this project work earthquake 1548 to 2015 has been descripted. From the earthquake catalogue in this region we can say that recent Nepal earthquake, 2015 which was devastated and magnitude was 7.8 was same devastating like 1934 Nepal-Bihar earthquake. As scientists say that every 50 to 100 years there can be bigger earthquake in a region because of accumulation more energy. So, earthquake catalogue can give us the knowledge of earthquake nature and recurrence interval in a region. And thus population of an area can be have some knowledge about nature's calamity like earthquake. The main prospect or finding is Earthquake Hazard Analysis in Bangladesh by using this catalogue and the upcoming hazardous situation in the country. In a nutshell, this catalogue will help in Disaster Response and will create an awareness in the county and worldwide. And at last we can say a proverb that "Prevention is better than cure".
Keywords: Earthquake catalogue, Faults, Subduction zone, Megathurst, Blind fault.

Introduction

An earthquake is a sudden, rapid shaking of the Earth caused by the release of energy stored in rocks. Bangladesh is a very disaster prone country. Different types of hazard frequently visits Bangladesh. Among them Earthquake is like a guest disaster in Bangladesh and the surrounded region. Though its occurrence period is less than a minute, it is a dangerous one. Earthquake catalogue shows the review of previous earthquake.

This Earthquake catalogue shows that, in recent years or last decades no previous earthquake did not affect so much Bangladesh as before. For example: Recent Nepal earthquake 2014 felt horribly in Bangladesh, people were panicked but there was a little disastrous situation luckily. Though many earthquakes among them 1548, 1762, 1787, 1822, 1869, 1885, 1897, 1918, 1923 are largest of all (Akhter, 2010). The 1762 mega thrust earthquake in Chittagong-

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Arakan coast generated tsunami in Bay of Bengal. Most of the earthquakes, historical and instrumental, are poorly recorded and are not readily available for earthquake hazard analysis. Tectonic framework of Bangladesh and adjoining areas define that Bangladesh is suited adjacent to the plate margins of India and Eurasia where severing earthquakes have occurred in the past (Bolt,1985). Non-availability of earthquake, geological and tectonic data posed great problem in earthquake hazard mapping of Bangladesh in the past. But historical seismic data reveal that Bangladesh has been affected by earthquake disasters since ancient times e.g. 1664, 1828, 1852 and 1885 are shown to have Dhaka as epicenter area (ISET, 1993). Bangladesh lies on the northeastern Indian plate, close to the edge of the Indian craton and at the junction of three tectonic plates e.g. the Indian plate, the Eurasian plate and the Burmese micro plate. That is the main reason of active seismicity of Bangladesh. The 62,159-sq-km area, along what is called the "Indo-Burmese arc", which runs through India, Bangladesh and Myanmar, is where the Indian tectonic plate–a raft of the earth's crust that bears the subcontinent–is diving obliquely under the Sunda plate in Myanmar, at around 46 mm a year. The Indian Plate is moving towards the north with slip rate of 6 cm/year, and subducting under the Eurasian Plate (Akhter, 2016). Large earthquakes were generated along the plate boundary under the compressive condition.

As Bangladesh is one of the most densely populated country in the world, any future earthquake will affect more people per unit area than any other seismically active regions of the world. Both of the above factors call for evaluation of seismic hazard of Bangladesh so that proper hazard preparedness and mitigation measures may be undertaken before it is too late.

Objectives

- The main objectives of the study are to produce a comprehensive catalogue of earthquakes in Bangladesh and adjoining areas and to make an atlas of the major and great earthquakes that affected Bangladesh.
- The objectives of the study is to explore and reconstruct the present scenario of the tectonically active zone of Bangladesh and adjacent areas. Then to supply important source of information about occurring earthquake.
- It is an important source of information for the quantification of future seismic hazards.
- The earthquake zoning map also help us in hazard analysis and the affected areas near future.

- A reliable catalogue of earthquake events in conjunction with active faults and tectonics will serve to prepare effective hazard map of Bangladesh.
- Frequent earthquake occurs in the part of our country. To know the tectonic reason of these earthquake and possibility of hazards seismic gap can also help me in my earthquake hazard analysis.
- To identify the active faults that are present in Bangladesh and adjoining areas and the occurring earthquake from this faults in different times.
- To identify which parts of the faults are locked and unlocked from this earthquake catalogue.

Study Area

The study area is whole Bengal basin and the adjoining areas of Bangladesh. The Bengal basin is located in the northeast corner of the Indian Shield and at the junction of three tectonic plates – the Indian plate, the Eurasian plate and the Burmese micro plates. It occupies the total lower drainage of the Ganges-Brahmaputra-Meghna River. It covers an area of approximately 300,000 sq. km, and the area under investigation lies within the latitudes 16°N to 29°N and the longitudes of 86°E to 96°E (Fig. 1).

Bangladesh is surrounded by the regions of high seismicity which include the Himalayan Arc and Shillong Plateau in the north, the Burmese Arc, ArakanYoma anticlinorium in the east and complex Naga-Disang-Jaflong thrust zones in the northeast (Akhter, 2010) (Fig. 1). The south and southwest of the area is open to the main part of the Bengal basin. It is also the site of the Dauki Fault system along with numerous subsurface active faults and a flexure zone called Hinge Zone. Shillong Plateau is located in the north of Bangladesh and the E-W trending Dauki Fault goes through on the southern fringe of Shillong Plateau. The subduction fault on the eastern edge of the Indian Plate is partitioned into two fault system, the northern extension of the subduction fault and the Sagaing Fault System for a right-lateral fault, from off Sumatra.

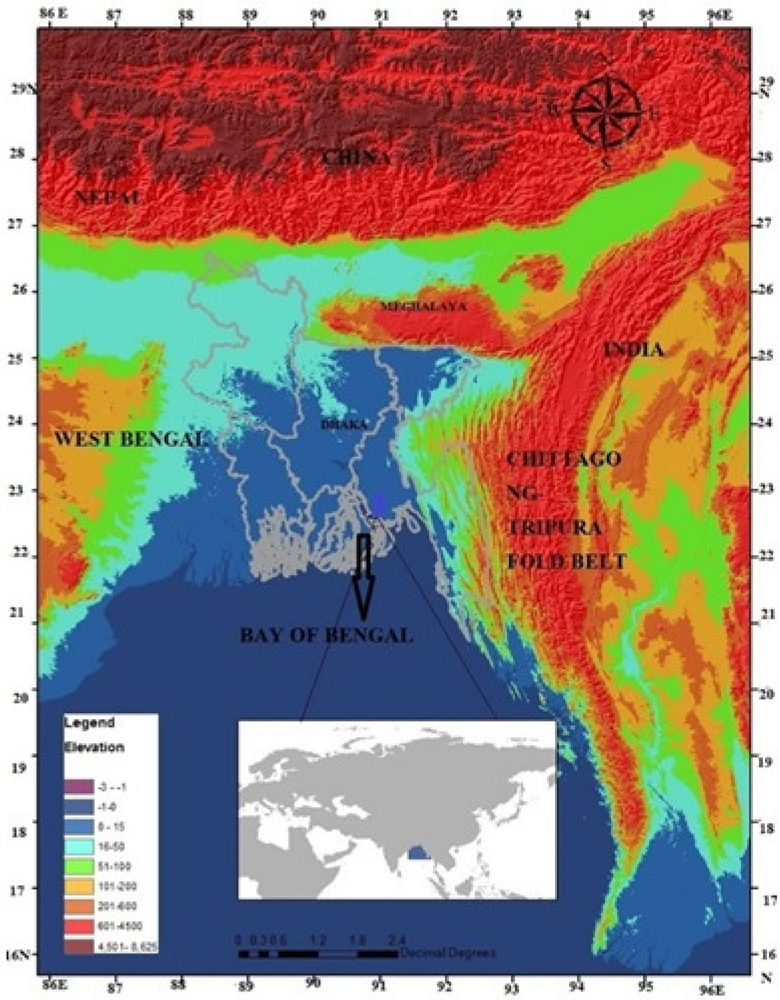

Figure 1: Study area of Bengal Basin.

Methodology

- Acquiring Earthquake data from USGS, IRIS, ASC, DUEO and ISC-Gem website from 1964 to present. (location only form 1548 to 1963)
- Sorting, removing duplicates and cataloging Earthquake data.
- Converting the cataloged data to shape file using ArcGIS-10 environment.
- Preparing Seismic occurrence map of the area in ArcGIS-10 environment.
- Creating the focal depth profile across Indo –Burma Subduction Zone.

Tectonic Framework

Bengal Basin is situated in the northeastern corner of the Indian subcontinent, is one of the largest (33700 sq.km Offshore and 57000 sq.km on land) delta in the World (Neogoi et.al., 1993). It is limited on its north by the Shillong Massif & Himalaya and on the south by the open Bay of Bengal. On the eastern side, it is bordered by Indo Burma fold-belt & Tripura fold-belt and on the west by the Indian Peninsular Shield.

Neo-tectonic Concepts: Neo-tectonic play a major role to identify the rate of compression or upliftment of seismic hazard of an area.Bangladesh has affected several active and inactive faults. To describe various type of faults;

Basement Faults

A zone of deep seated normal faults in the basement complex is conventionally thought of as representing the separating line between the Indian platform and the Bengal Foredeep. This zone is seismically active and the focus of earthquake possibly originating with this zone have depth ranges from 70 – 150 km (Fig. 2). Reverse/thrust faults are commonly associated with the anticlinal folds of the eastern fold belts. However, the eastern fold belt of the Chittagong-Tripura is a fold thrust belt owing its origin to the subduction of the Indian plate beneath the Burmese plate (Fig. 2).

Quaternary and Tertiary faults

Thrust, Strike slip and En-echelon faults are included in this quarternary and tertiary faults. In Bangladesh most of the high hilly areas are under tertiary faults system. Madhpur fault is under quarternary faults system. Kaladan fault covers a distance of almost 270 km marked the eastern boundary of the Mizoram-Tripura-Chittagong folded belt. It is a strike-slip fault.

Active faults zones

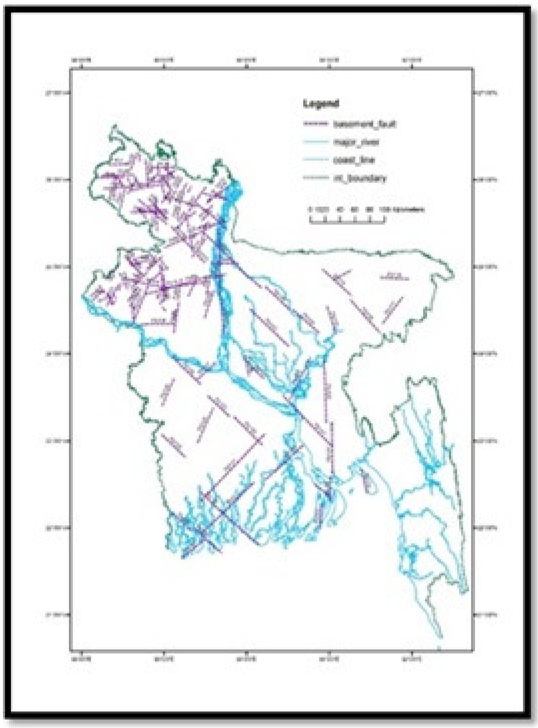

Figure 2: Basement faults of Bangladesh (After Hunting)

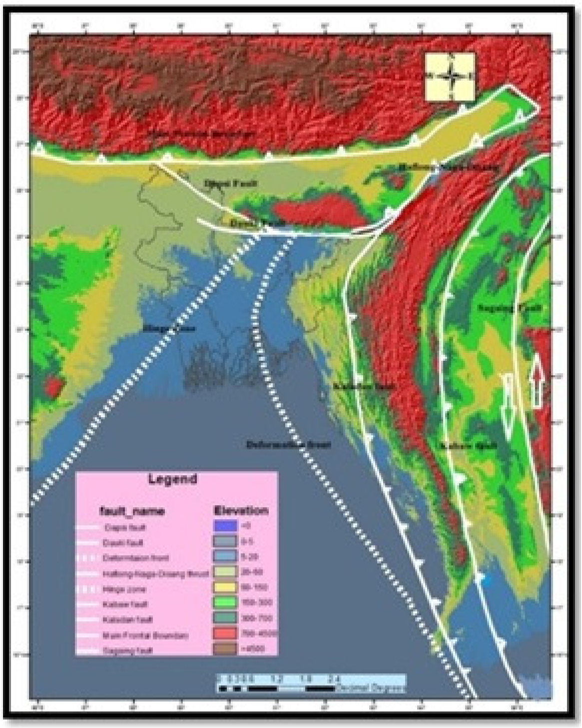

Figure 3: Active and major faults in and around Bangladesh

Dapsi thrust: The Dapsi thrust and the Brahmaputra faults are the two boundary faults of the Shillong plateau. Seismicity in the Shillong massif is probably related to the reactivation of the Dapsi Thrust. One end of the dapsi fault joined with the main frontal thrust and other side joined with daukifault (Fig. 3). North dipping Dapsi thrust are the northern and southern boundary of the 'Pop- up' tectonic model of Shillong plateau. There are evidence of several earthquake in this fault system i.e., 1843 Shillong plateau, 1923 Meghalaya earthquake, 1947 Arunachal earthquake.

Kabaw fault: Kabaw Fault is a fault situated in Myanmar. This is a strik slip fault. Kabaw Fault lies roughly parallel with the Indo-Burmese border near Mizoram at the foothills of the mountains separating the plains of central Myanmar with the Arakan Mountains, extending due south roughly 300 km (Fig. 3).1762 Arakan earthquake was due to rupture of Kabaw fault.

Sagaing fault: The Sagaing Fault is a major tectonic structure that cuts through the center of Myanmar (formerly known as Burma), broadly dividing the country into a western half moving north with the Indian plate, and an eastern half attached to the Eurasian plate (Fig. 3). The Sagaing Fault (SAH-gyne) links two very different, but equally active tectonic domains: the Andaman Sea in the south and the eastern Himalayan syntaxis in the north (Curray, 2005; Searle and Morley, 2011).

Kaladan Fault: Kaladan Fault marked the eastern boundary of the Mizoram-Tripura-Chittagong folded belt and give us the important clue about the folded active area (Fig. 3).It covers a distance of almost 270 km. This is also a transform fault.

Blind fault

Madhupur blind fault: A type of thrust fault, which does not appear on the surface. Cannot mapping by surface geological map. Hidden fault under the crust.

Although the Madhupur Tract is heavily eroded, the crests of the hill keep flat surfaces which are gently tilted. The straight low scarps are developed at the western edge of the Tract. The low scarps are estimated to be fault scarps, and the east-dipping Madhupur blind fault is inferred from these geomorphic features. The Madhupur blind fault is considered to be important for seismic hazard assessment of Bangladesh, since Dhaka, the capital of Bangladesh, stands ~40 km southeast from the fault. However, no deformation is identified on the young fluvial surface, so the low scarps may be eroded ones. The Madhupur Tract is uplifted by the activity of the Madhupur blind fault. However, the warping scarp is thought to be eroded.

It is believed that the 1885 Bengal earthquake may have been caused by the rupture of the Madhupur blind fault. However, there is no paleo-seismological evidence. The Madhupurblind fault may have a long recurrence interval of several thousands, since it is an intra-plate active fault.

Mega-thrust Fault: Recently, many geo-scientists e.g. Steckler et al. (2016 & 2008), Wang et al, (2014), Gahalaut, V.K. (2012), Cummins, (2007) and Vigny, C., (2005) have given some evidences and clue to have blind or megathrust fault linked to active subduction beneath Bangladesh (Fig. 3).

Steckler and Akhter (2016) strongly suggest that subduction in this region is active, despite the highly oblique plate motion (46 mm/yr) between Indian & Eurasian plates and thick sediments. In addition, about 21 mm/yr of shear motion is taken up along the Sagaing fault, on the eastern margin of the modeled deformation zone. It has been suggested that the remainder of the relative motion is taken up mostly or entirely by horizontal strike slip faulting and that has stopped. With the help of GPS measurement of Bangladesh, NE India and Myanmar regions, they reveal 13-17 mm/yr of plate convergence on an active, shallowly dipping and locked megathrust fault. They also suggest that the presence of a locked megathrust plate boundary representing an underappreciated hazard in one of the mostly densely populated region of the world.

Data processing, Result and Discussion

Process: At first earthquake catalogue data have been downloaded as excel file (.csv) from different sites, for example –USGS, International seismological centers, Incorporated Research Institutions for Seismology, DUEO etc. At first I have zoomed out my study area from the whole world's DEM image in the ArcGIS software from the reliable USGS website. I also showed the Hill shade effect so that elevation can be shown clearly. I have downloaded and input total 6000 data from all the websites from 1548 to 2015 and compiled them. Then removing duplicates and after omitting all the null and invalid files from the cell total 1871 data remains in the excel sheet. The excel file containing time, focal depth (the depth which have not been found replaced by 1), magnitude (the magnitude which has not be found is replaced by 1) etc. Then the excel file is opened in ArcGIS 10 software and converted to the shapefileand to create a map of earthquake catalogue with major faults (Fig 4)

Focal depth of Subduction zone

After the making of earthquake catalogue a cross section from Indian Craton to Sagaing fault has been drawn by (22 degree latitude from west to east) line. From the earthquake analyst tool the elevation profile has been drawn (Fig. 5).

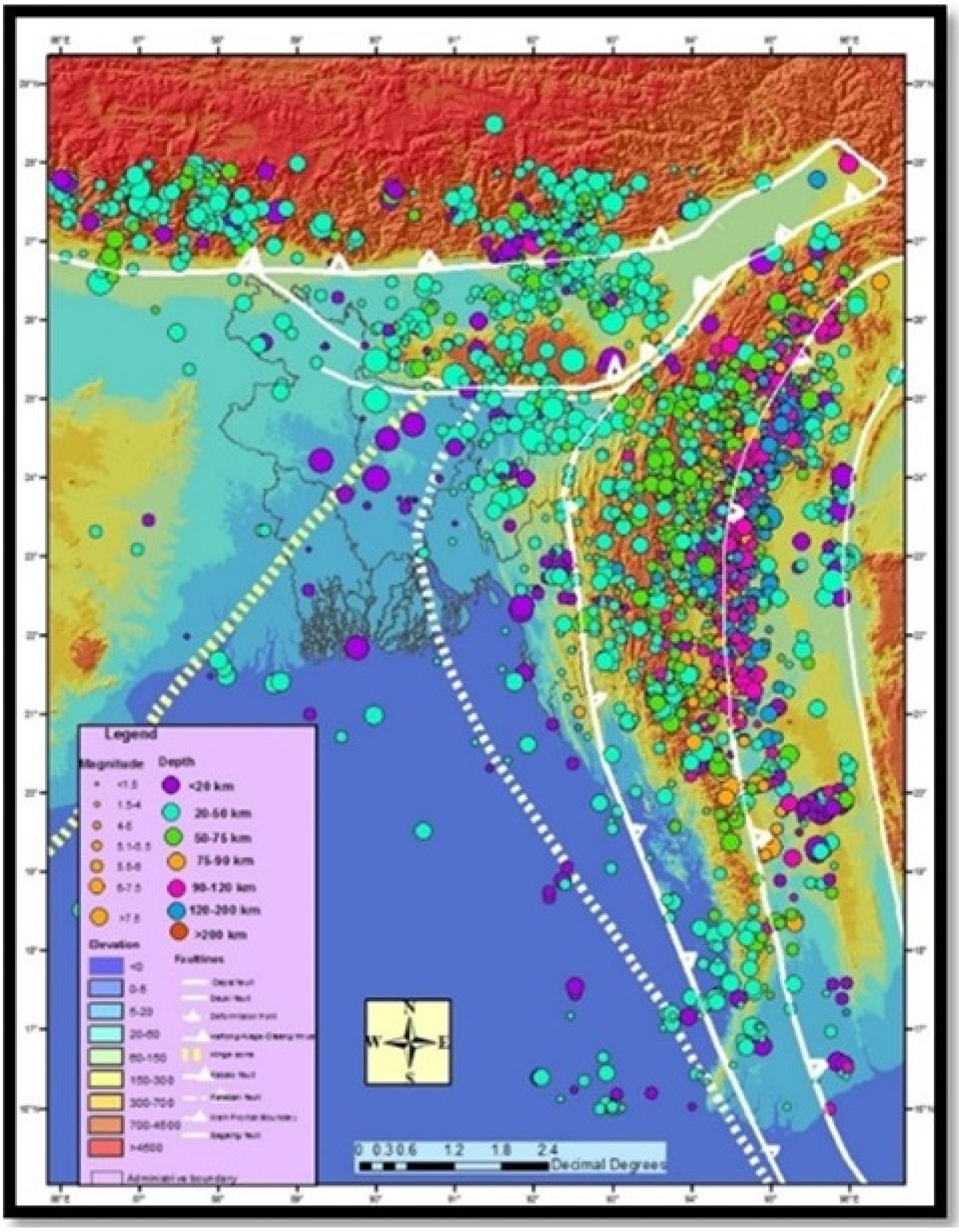

Figure 4: Earthquake catalogue of Bangladesh

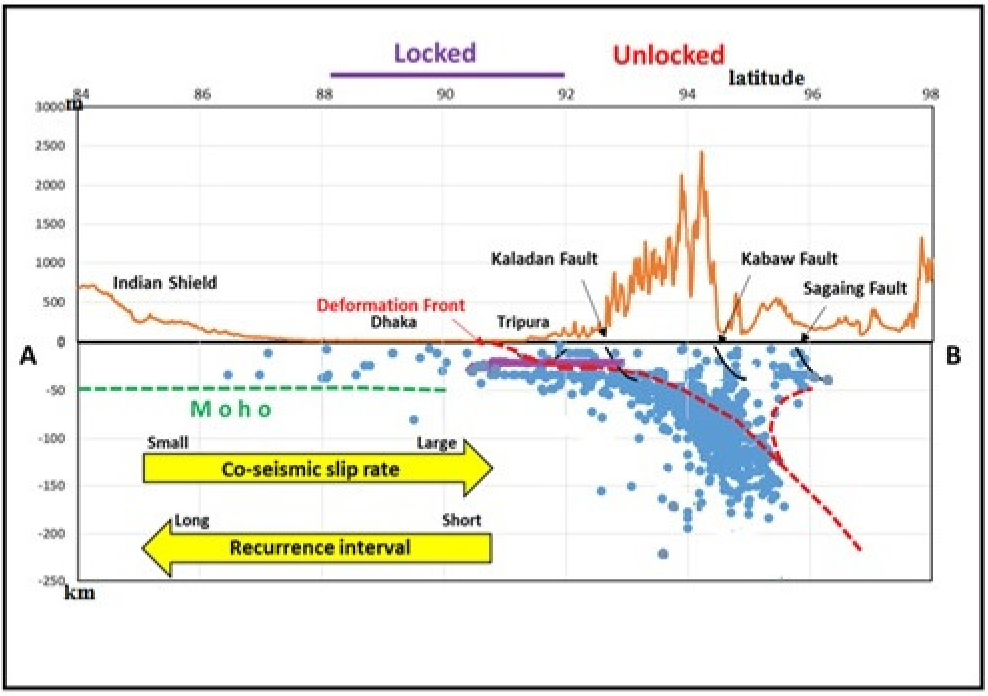

Figure 5: Cross Section of the Subduction zone

Result and Discussion

From the image of Earthquake catalogue we can see that Earthquake occurs more in the eastern side of Bangladesh. Besides, Northern part of Bangladesh is also in high seismicity. From the graph we see that if we go to the eastern part from western part then seismicity increases. From the Indian craton to subduction zone co-seismic rate increase (Fig. 5). The area of Myanmar zone is unlocked because of having different magnitudes earthquake but the area from Indian craton to Tripura region is locked zone (Fig. 5). As this area is not facing no earthquake from a long time. Most of the earthquake in this region is in shallow depth. The earthquake occurring in the area is having depth highest 250 km (Fig. 5).

As shallow to intermediate earthquake occurring most it is very vulnerable for Bangladesh and surrounding areas. Recurrence interval is shortest near the Indo-Burman Ranges. Where the imaginary deformation front lies we can say that as it is suggests as locked area so it is more vulnerable for earthquake (Fig. 5).

Impacts and Preparedness of Earthquake

Impacts

Ground rupture: It is the main result of an earthquake strike. Shaking of ground causes severe damage to the buildings or other structures on the ground including houses etc.

Landslides: Earthquakes causes instability of land results into landslides; this claims many lives at the effected zone.

Fire: Earthquake causes breaking of electrical power lines or gas supply lines which causes incidents of fires. Water lines also got ruptured and decreased pressure makes it impossible to control the spread of fire.

Soil liquefaction: When severe shaking occur then soil or sand loses their strength for a temporary period and gets converted from solid to liquid. This liquefaction causes sinking of buildings, bridges etc.

Tsunami and floods: when epicenter of an earthquake is located near sea, then the traveling of seismic waves below the sea causes generation of Tsunami waves, which can travel at a speed of 600-800 kilometers per hour.

Preparedness: Bangladesh is possibly one of the most vulnerable countries to potential earthquake threat and damage. An earthquake of even medium magnitude on Richter scale can produce a mass graveyard in major cities of the country, particularly Dhaka and Chittagong, without any notice.

Large scale mitigation measurement needs huge initial investment; however, to save human lives and properties, we should not hesitate to do so. Particularly strict control of building codes, enforcement of laws and orders, and development of people awareness has no alternatives.

However, some immediate measures are suggested below:

1. Make an inventory of all old buildings which are vulnerable to earthquake, and either repair or evacuate occupants from those buildings.
2. Make an inventory of houses, which are constructed at the foot of steep hillsides, particularly where hill slopes have been cut, even ten years back. Relocate those families to suitable places.
3. Make earthquake vulnerability atlas of major cities, which will show in detail the list of vulnerable sites, their possible consequences and possible measurements of mitigation at different scales of earthquake events.
4. Strict application of building codes for all newly constructed buildings, particularly all high-rise buildings.
5. Development of awareness program to educate people regarding the causes and consequences of earthquakes. And also to disseminate knowledge to them regarding their responsibilities before, during and after the earthquake through seminar, symposium and workshop, and also through non-formal education by GO and NGOs.

Conclusion

Earthquake vulnerability of any place largely depends on its geology and topography, population density, building density and quality, and finally the coping strategy of its people and it shows clear spatial variations. It is thus necessary to identify the scale of such variations and take necessary measurements to cope with that. This earthquake catalogue can help us in knowing the earthquake vulnerabilities in the area and in disaster management. Besides we are helpless to nature. So, it is our duty to cope with natural disaster like earthquake and take special preparedness and recovery after occurring disaster and become a resilient nation.

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