

## A Study of Earthquakes in Bangladesh and the Data Analysis of the Earthquakes that were generated In Bangladesh and Its' Very Close Regions for the Last Forty Years (1976-2016)

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### Abstract

Bangladesh is a south Asian developing country which is used to struggle with various natural disasters and the earthquake is one of them. Bangladesh is of the most earthquake venerable countries of the world. Here we have tried to discuss about the risks of earthquakes in Bangladesh and the historical earthquakes that occurred in Bangladesh and its surrounding regions with some information. After that we have analyzed the earthquakes that were generated in Bangladesh and its very close regions (between 20.35° N to 26.75° N Latitude and 88.03° E to 92.75° E Longitude) for the last forty years. We have observed that under the area of concern most of the earthquake occurred were not devastating but the occurrences of those small magnitude earthquakes have been increasing significantly.

**Keywords:** Bangladesh; Earthquake; Tectonic plates; History; United states geological survey

### Introduction

Bangladesh, a geographically and geologically important country of south Asian region with an area of 1, 47,610 square kilometers, extends 820 kilometers north to south and 600 kilometers east to west, located between 24°0'0" N latitude and 90°0'0" E longitude, is often visited by many devastating natural disasters like flood, droughts, tropical cyclones, tornados, thunderstorms, excessive rainfalls, tidal bores, intense summer heat etc. On average Bangladesh is affected by the cyclones 16 times in a decade which are originated from the Bay of Bengal. But an even more lethal natural disaster "earthquake" has been threatening Bangladesh in the recent past. Though Bangladesh is located in a moderately risky territory and the density of population here and the infrastructural condition are been always a matter of concern here. As there is no technology developed to predict the time of occurring, makes earthquake a far devastating one. Recent earthquake in several parts of the world and the destruction occurred, clearly showing that Bangladesh has to take necessary steps to face the earthquake at any time in future.

Bangladesh is surrounded mostly by India, with some portion by Myanmar and the Bay of Bengal to the south. To the north of Bangladesh are the Himalayas, the world's largest mountain range. The fate of Bangladesh is vastly dependent on the Himalayas. Three major rivers the Brahmaputra, Ganges and Meghna-that were originated from the Himalayas and its neighbour mountains flow across the country. These gigantic rivers and their branches deposit huge amounts of mud and sand. All these elements formed the world's largest delta. The total area of Bangladesh can be divided into two regions. The first one is the broad deltaic plain covering 85% of land area of Bangladesh and the remaining one is the small hilly regions in some definite places. Bangladesh is one of the rainiest territories of this planet. During the monsoon the deltaic plain is frequently visited by the floods. But Bangladesh is not shaped by just rivers and flooding. It's also shaped by the incidents occurring beneath its surface, where tectonic plates are continuously changing their position. Bangladesh sits where three tectonic plates meet (Figure 1). These are the Indian plate, the Eurasian plate and the Burmese plate. In fact the whole Indian subcontinent is lying on the junction of the enormous Indian plate and Eurasian Plate. But living under the influences of third tectonic plate i.e. the Burmese

plate and it's junction with the Indian plate makes Bangladesh one of the most tectonically active regions in the world.

### Current condition of the tectonic plates related to Bangladesh

After detaching from the supercontinent Gondwana 110 million years ago, the Indian plate started its journey towards north and collided with Eurasian plate about 50 million years ago during late cretaceous period [1]. It was moving 20 centimeters per year before colliding, which was fastest among all other tectonic plates. The collision between the Indian plate and the Eurasian plate along the boundary between today's India and Nepal formed the Tibetan Plateau and the mighty Himalaya Mountains which are still rising [2]. Currently the Indian plate is moving in north east at a speed of approximately 6 cm per year.

The Eurasian plate's history is far older than relatively young Indian plate. It's the result of several collisions by many small cratons at different times in the past. It's a slow moving plate compared with the others. The whole Eurasia sits on the Eurasian plate. Currently the Eurasian plate is moving north at 2 centimeters per year. The Indo-Burman Mountain ranges mark the boundary between the Indian and Eurasian plates.

The Burmese plate located in the Southeast Asia is a minor tectonic plate or Micro-plate. It's in a highly tectonically active region. In the past it was a part of the Eurasian plate. It was separated from the Eurasian plate when the Indian plate collided with Asia. It's now surrounded by the Indian, Sunda, Australian and Eurasian plates. These plates gave the Burmese plate a quite strange shape due to convergences. It's a very slow moving plate and there is debate over the plate's motion.

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Figure 1: Geographical location of Bangladesh in terms of tectonic [2].

The Indian Plate is subducting beneath the eastern facet of the Burma plate formed the Sunda trench causing it to move 46mm per year. The devastating 2004 earthquake and tsunami in Sumatra occurred along the boundary between the Indian and Burmese plate. [3]

### Fault zones of Bangladesh

Bangladesh is surrounded by a number of tectonic blocks responsible for many earthquakes in the past. Calcutta, Assam, Tripura are the three very earthquake prone regions that are joined to Bangladesh in the borders in the Northern, Western and North-Eastern part respectively. If we consider the tectonics and geology, five major faults are significant for the occurrences of devastating earthquakes and these are

- Bogra Fault Zone
- Tripura Fault Zone
- Shilong Plateau
- Dauki Fault Zone
- Assam Fault Zone

Bogra fault is a normal or gravity fault (Table 1). It is very close to the Bogra town and Jamuna River. It might be associated with flexure of the basin along its western margin. It was active in Palaeogene and Neogene times. Movement along the Bogra fault led to the deposition of a large amount of sedimentary pile within the Bogra graben [4].

Sl. No.	Fault zone	Maximum magnitude
1	Bogra fault zone	7.0
2	Tripura fault zone	7.0
3	Shilong plateau	7.0
4	Dauki fault zone	7.3
5	Assam fault zone	8.5

Table 1: The maximum magnitude of the earthquakes that can be produced from the fault zones.

Tripura is one of the states of India surrounded by Bangladesh and two other states Mizoram and Assam of India. The area is surrounded by Kopili fault; Kaladan fault etc. which have produced many earthquakes. The Tripura-Naga orogenic belt is a zone of highly faulted tertiary deposits which has witnessed earthquakes of moderate magnitudes [5].

Shilong plateau is characterized as a seismically active and geologically complex region located on the collision boundary between

Indian and Eurasian plate in the Meghalaya state of India. The general altitude of the Plateau is about 1,500 m. The plateau is composed of the Precambrian Metamorphic rocks and the Tertiary and Quaternary deposits are limited on the southern foothills of the Shilong Plateau indicating the successive uplift of the Shilong Plateau and the process started from the Pliocene time [6]. The 1897 Ms. 8.0 Great Assam earthquake is well-known as a historic earthquake that occurred below the Shilong Plateau. The Shilong plateau presently behaves like a rigid body tied to the Indian Shield at a velocity of  $46.5 \pm 1$  mm/a toward N  $51^\circ$  E. [7,8]

Dauki fault zone is a 300 km long north dipping reverse fault along the Meghalaya-Bangladesh border and inferred to go through the southern margin of Shilong plateau (Figure 2). It has a major role in deforming the surrounding areas. The Dauki fault is believed to be active in the past and it is most likely the fault associated with the magnitude >7 earthquake in Sylhet (Shilchar) known as Cachar earthquake (10 January 1869) [8]. Though it is inactive in the recent times still it is considered as one of the major threats for Bangladesh for the occurrence of devastating earthquakes (Figure 2) [7].

But there are more reasons to worry. A recent study reveals the existence of subduction zone of about 250 kilometers that can produce an earthquake of magnitude 8.2-9.0 [9]. After setting two dozen ground-positioning (GPS) instruments linked to satellites, capable of tracking tiny ground motions and analyzing the ten years of data the scientists have shown that eastern Bangladesh and a bit of eastern



Figure 2: Dauki fault zone [2].

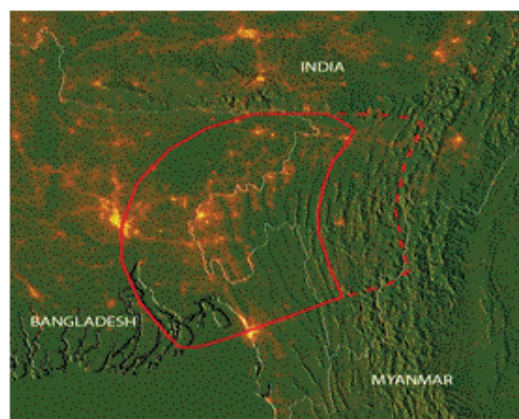


Figure 3: The most probable quake zone. Solid line representing the area under influence and dashed line represents a scenario in which the slip might take place along a separate fault [10]

India are pushing diagonally into western Myanmar at a rapid clip-46 millimeters per year or about 1.8 inches. After combining with the existing GPS data from India and Myanmar, the measurements show that much of the resulting strain has been taken up by several known, slowly moving surface faults in Myanmar and India. But the rest of the movement-about 17 millimeters, or two-thirds of an inch per year is shortening the distance from Myanmar to Bangladesh which is inferred as a subduction process going on. This shortening of distance is building pressure and that also a few kilometers below the surface and this process is going for a long time. The most uncomfortable reason is Dhaka, one the most densely populated territories and also the capital of Bangladesh is also under the range of this zone (Figure 3) [10].

## Major earthquakes in Bangladesh and its Surrounding Regions

When we talk about the history of earthquake in Bangladesh or Indian subcontinent there are always lack of evidences. We even don't have specific information about the earthquakes occurred around 500 years ago except some historical evidences which are not enough to specify the exact intensity or magnitude of the earthquakes. There are evidences of terrible earthquakes felt in Sylhet, Chittagong and Dhaka in 1548, 1642, 1663, 1762, 1765, 1812, 1865, 1869 but we do not have any information about their magnitudes. At most we can deal with their impact. It is reported that the 1663 earthquake in Assam and Sylhet lasted about half an hour. The 1765 earthquake was so devastating that it raised the Coast of Foul Island by 2.74 m and the northwest coast of Chedua island by 6.71 m above sea level and also caused a permanent submergence of 155.40 sq. km near Chittagong. The earthquake took 500 lives in Dhaka. [11] We have much clear data of earthquakes occurred more than two hundred years in this region. Here are some major earthquakes with some information.

### Cachar earthquake

**10<sup>th</sup> January 1869:** This earthquake occurred in the Sylhet region (Silchar). The epicenter of the earthquake was 250 kilometers away from the current capital city Dhaka. According to the estimation by Braseys and Douglas the magnitude of this earthquake was 7.39 [12]. The Dauki fault is believed to be responsible for this earthquake. The earthquake was not a single shock rather it lasted, on and off and some shocks lasted for about five minutes. Most of the houses were down. But the number of casualties is not reported [8,11,13].

### Bengal Earthquake

**14<sup>th</sup> July 1885:** The 1885 Bengal Earthquake, also known as Manikganj Earthquake had the magnitude 7.0. It's possible epicenter was at Kudalia in Satura (Manikganj) which is 170 kilometers away from the capital Dhaka. This event was generally associated with the deep-seated Jamuna Fault. The earthquake was so strong that it was felt by the people of Bihar, Sikkim, Manipur (India) and Burma (Myanmar).

Destructions of Buildings and losses of lives were reported from Dhaka, Mymensingh, Sherpur, Pabna etc. There is probability of recurrence of this kind of earthquake in this region from 2015-2020 [8,14,15].

### Meghalaya Earthquake

**10 January, 1889:** There is not much information about this earthquake occurred in 1889. The possible epicenter of this earthquake was Jaintia Hills in Meghalaya State of India. The magnitude of the

earthquake was 7.5. It affected the Sylhet town and its surrounding regions. No losses of lives were reported [11].

### Great Indian Earthquake

**12<sup>th</sup> June 1897:** It is also known as the Shilong Plateau earthquake. The magnitude of that earthquake was 8.0 [8]. The earthquake raised the northern edge of the plateau about 10 meters. The epicenter was 230 kilometers away from Dhaka. More than thousand people died in that event and most of the buildings in the affected region were damaged [11,13].

### The Srimangal Earthquake

**18<sup>th</sup> July 1918:** This earthquake's epicenter was at Srimangal in Moulavi-Bazar (Sylhet) which is about 150 kilometers away from Dhaka with a magnitude of 7.6. The earthquake occurred in the afternoon and for this the losses of lives was not reported. The earthquake was felt in Myanmar and North East of India. The brick built houses in Srimangal were seriously damaged but minor effects were observed in Dhaka [11,16].

### Meghalaya Earthquake

**9<sup>th</sup> September 1923:** This earthquake with a magnitude of 7.1 shook the south of Meghalaya, west Bengal (India) and Bangladesh in the morning. It caused heavy damages in Mymensingh, Cherrapunji and Guwahati. It was also felt in Chittagong and Barisal [13].

### The Dubri Earthquake

**3<sup>rd</sup> July 1930:** The epicenter of this earthquake was in Dubri, Assam with a magnitude of 7.1. It shook Assam, west Bengal and Bangladesh early in the morning. Heavy damages occurred in Assam, many people were injured but fortunately there were no losses of lives as it occurred early in the morning. This earthquake was followed by six major aftershocks of magnitude 6. The eastern part of Rangpur district in Bangladesh was the worst sufferer of that earthquake. [11,13].

### The Assam Earthquake

**15<sup>th</sup> August 1950:** One of the largest earthquakes of 20<sup>th</sup> century with a magnitude of 8.7 killed about 1500 people in India. Heavy damages were observed. It also shook Bangladesh, Myanmar and a part of China but no significant damages were reported in those regions. [11,13].

### The Bay of Bengal Earthquake

**11<sup>th</sup> August 2009:** The epicenter of that earthquake was located at the North Andaman Islands of the Bay of Bengal and seacoast of Myanmar with a magnitude of 7.5. It was strongly felt from Dhaka but fortunately no heavy damages occurred [11].

### The Myanmar Earthquake

**24<sup>th</sup> August 2016:** The epicenter of this earthquake was in 25 kilometers west of Chauk in Myanmar with a magnitude of 6.8. It was strongly felt in Chittagong and Dhaka. 3 people died in Myanmar but in Bangladesh, no casualties were reported but 20 people were seriously injured [17].

With the help of Google map and GPS Geoplaner (A web based application that provides several GIS and GPS utilities) we have generated an image that is showing the approximate location of the epicenters of the earthquakes (Figure 4).

## Data Analysis

Now we are discussing about the earthquakes those generated in between 20.35° N to 26.75° N latitude and 88.03° E to 92.75° E longitude for the last forty years (1976-2016). The area we have chosen covers the area of Bangladesh and it's very nearby regions. The necessary data are taken from United States Geological Survey (USGS). The data contains the depth of the epicenters, magnitude of the earthquakes, time of the event occurred and some others related data. We have found 284 earthquakes occurred in that concerning area (Figure 5).

## Results

The diagrams below are showing the characteristics of those earthquakes. Here we have represented 283 earthquakes with the depth of their epicenters and their magnitudes. We have also tried to represent the number of earthquakes occurred in every 10 years in this area from 1976-2016 (Figures 6-9) [20].

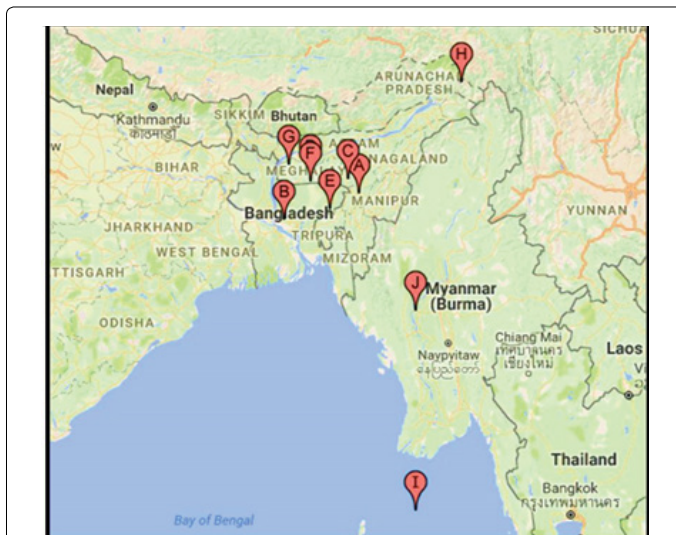


Figure 4: Epicenters (approximately) of the historical earthquakes in Bangladesh and its surrounding regions. Here A, B, C etc. are representing earthquakes, e.g. "A" signifies "The Cachar Earthquake (1869)" [19].

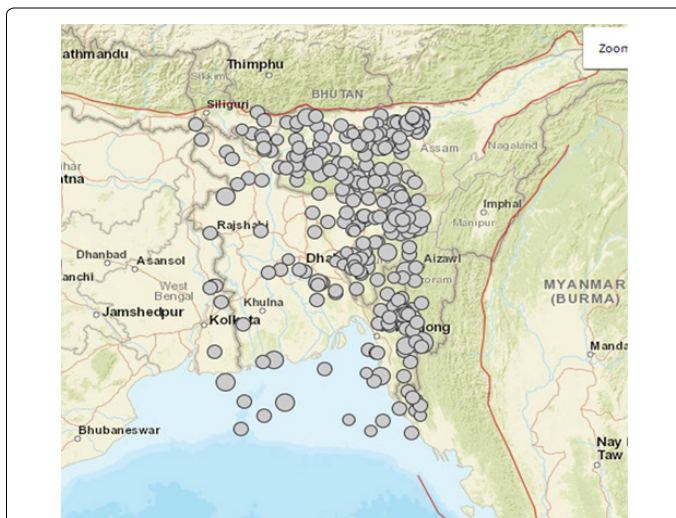


Figure 5: Earthquakes that were generated in the area of concern. The grey circles signifying the epicenters of the earthquakes and the size of the circle show the strength of the earthquake. The solid red lines are representing the plate boundary [18].

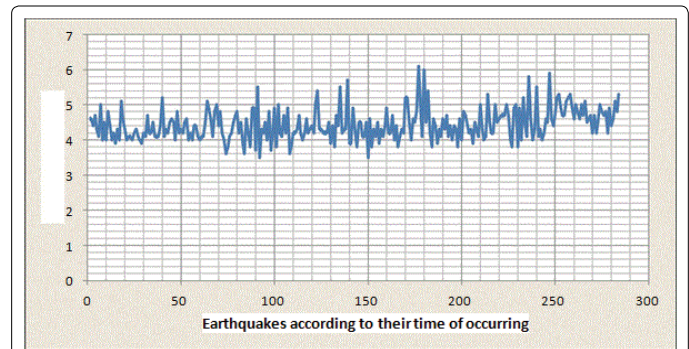


Figure 6: Earthquake magnitude vs. Earthquake according to their time of occurrence (i.e. 1 for the earthquake on 2016-11-15 or no. 291 for the earthquake on 1976-06-23).

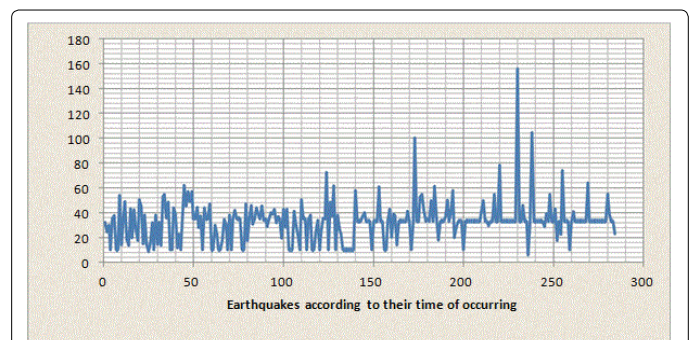


Figure 7: Depth of the epicenters vs. Earthquake according to their time of occurrence (i.e. 1 for the earthquake on 2016-11-15 or 291 for the earthquake on 1976-06-23).

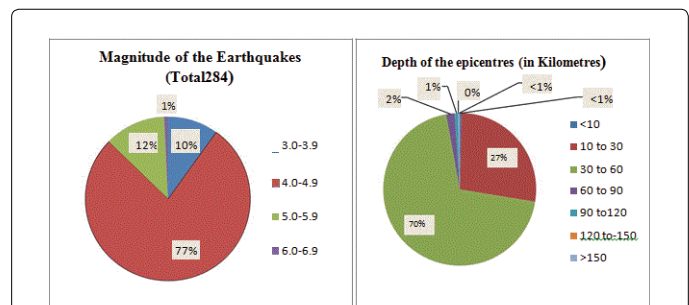


Figure 8(a): Earthquakes of different Magnitudes. Figure 8(b): Depths of epicentres of the earthquakes

Figure 8: Magnitude and depth of the earthquake for the last forty years.

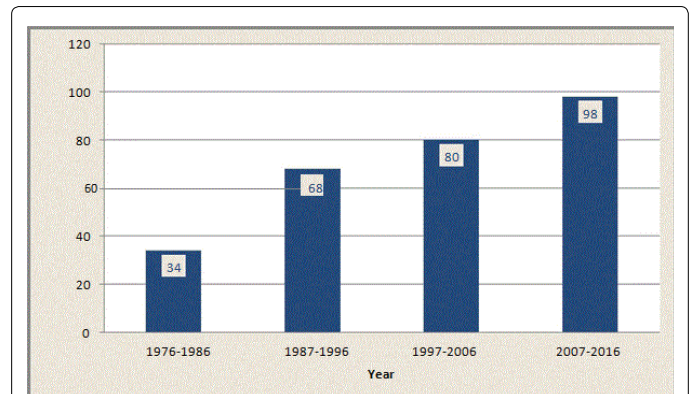


Figure 9: Frequency of the earthquakes.

## Conclusion

We have analyzed the data of the earthquakes occurred in the last forty years in Bangladesh and its very close regions (20.35° N to 26.75°N latitude and 88.03° E to 92.75° E longitude). From Figure 6 and 8a we have seen that most of the earthquakes occurred in the area of concern were not devastating. We have only two cases when the magnitude of the earthquake exceeded the 6.0 mark. Most of the earthquakes were ranged between magnitudes 4.0 to 4.9 (77%) which is not harmful enough and only 12% of them were ranged between magnitudes 5.0 to 5.9. Figures 7 and 8b have shown that depth of the epicenters varied between 8 kilometers to 155 kilometers beneath the surface of the earth. But in most cases (70%) the depth of the epicenters were ranged between 30 to 60 kilometers. About 27% of the earthquakes were generated 10-30 kilometers beneath the earth surface. We have only a single case when the epicenter is 155 kilometers beneath the earth surface. From Figure 9 we can see that the number of earthquakes generating in this area is increasing and for the last ten years it has increased significantly if we had taken more data of the earthquake for more twenty years in the past we might have a clearer picture about this.

This above analysis indicates that the earthquake occurred in the area of concern were not devastating. But it actually does not show the real picture of the risk of Bangladesh about the earthquakes. From Figure 4 suggests that if we had taken a larger area for study then few of the devastating earthquakes in the past would have come to our calculation as the earthquake prone zones are not so far from our area of concern. Besides we have studied only the history of forty years of earthquakes in this region. Forty years are not enough as compared to time of recurrence of a devastating earthquake in most cases.

The newly discovered subduction zone, the geological position and the historical earthquakes clearly indicates that the government of Bangladesh should put much emphasize on earthquakes and how to minimize its damage. Disaster management system should be more developed to cope with the requirement. The building codes should be followed by the citizens and the government should try to increase the awareness about the safety rules of earthquakes among the mass people.

## Acknowledgement

The data and the Figure 5 are taken from the website of United states

Geological survey's website. This agency provides data about the earthquakes. The link of the data: <https://on.doi.gov/2t1DCfJ>

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