

PART VI
Appendix B

Local Geology, Tectonic Features and Earthquake Occurrence in the Region

B.1 Seismotectonics and Earthquake Occurrence in and Around Bangladesh

B.1.1 General

Earthquakes are closely related to plate tectonics. Bangladesh is located in a tectonically active region close to the plate boundaries of the Indian plate and the Eurasian plate. The plate boundaries lie to the north and east of Bangladesh. The collision of the north-east moving (around 4 cm or more annually) Indian Plate with the Eurasian plate (Figure 6.B.1) is the cause of frequent earthquakes in the region comprising North East India, Nepal, Bhutan, Bangladesh and Myanmar.

Major thrust faults exist to the north (at the foot of the Himalayas) and to the east (in the Indo-Burma mountain ranges) of Bangladesh. Geologic evolution of the Bengal Basin is related to this collision. Bangladesh constitutes the major portion of the Bengal Basin. The collision perhaps started in the late Cretaceous and the Bay of Bengal and the Bengal Basin attained its present configuration at the end of middle Miocene orogeny.

Tectonically Bangladesh is divided broadly into three divisions: (i) Stable Shelf (in the northwest) (ii) Bengal Foredeep (in the Central) and (iii) Chittagong-Tripura Folded Belt (in the east). In addition there is a SW-NE trending 25 km wide hinge zone separating the Bengal Foredeep from the Stable Shelf.

The Stable Pre-Cambrian Shelf in the northwest consists of relatively thin sedimentary strata over bedrock. In Madhyapara area of Dinajpur the basement is only 130 m deep from the ground surface and is overlain by Dupi Tila Sandstone and Madhupur Clay of Plio-Pliocene age. The basement plunges gently from Madhyapara towards the southeast up to the Hinge Zone. Seismic contours on top of limestone in Bogra show regional dip of 2-3° besides revealing a number of NE-SW trending faults. The hinge zone is characterized by the sharp change in the dip of the basement rocks associated with deep-seated displacements in faults and is reflected on the gravity and magnetic anomalies. In the hinge zone, the depth of the limestone increases from 4000m to 9000m within a narrow zone of 25-km. Hinge Zone is connected with Bengal Foredeep by deep basement faults that probably started with the breakup of Gondwanaland. The SW-NE trending Hinge Zone turns to the east near Indian border in Jamalpur and seems to be connected with the Dauki Fault, probably by a series of east-west trending faults. Bengal Foredeep occupies the vast area between Hinge Line and Arakan Yoma Folded System in the east. The Bengal

Foredeep consists of very thick basin-fill that overlies deeply subsided basement of undetermined origin in the south and east. Thickness of sediments increase toward the south and east to more than 16 km. The huge thickness of sediments in the basin is a result of tectonic mobility or instability of the areas causing rapid subsidence and sedimentation in a relatively short span of geologic time. The Bengal Foredeep consists of some Troughs and some relatively high lands. Faridpur Trough situated adjacent to Hinge Zone is separated from the Sylhet Trough (in the northeast) by the Madhupur High of Pleistocene origin where the basement is relatively uplifted. East-west trending Dauki Fault with 5 km wide fault zone near Bangladesh-India border forms the contact between Shillong Massif (India) and Sylhet Trough. Eastern part of the country is represented by the Chittagong-Tripura Folded Belt. The folded belt in the east consists of narrow, elongated N-S trending folds in Sylhet and Chittagong Divisions of Bangladesh, Tripura, southern Assam and Mizoram states in India and also Myanmar territory. The elevation of these elongated anticlinal folds in Bangladesh ranges from 100 -1,000m. Some of the structures are faulted and thrust and the intensity of folding increases gradually from west to east.

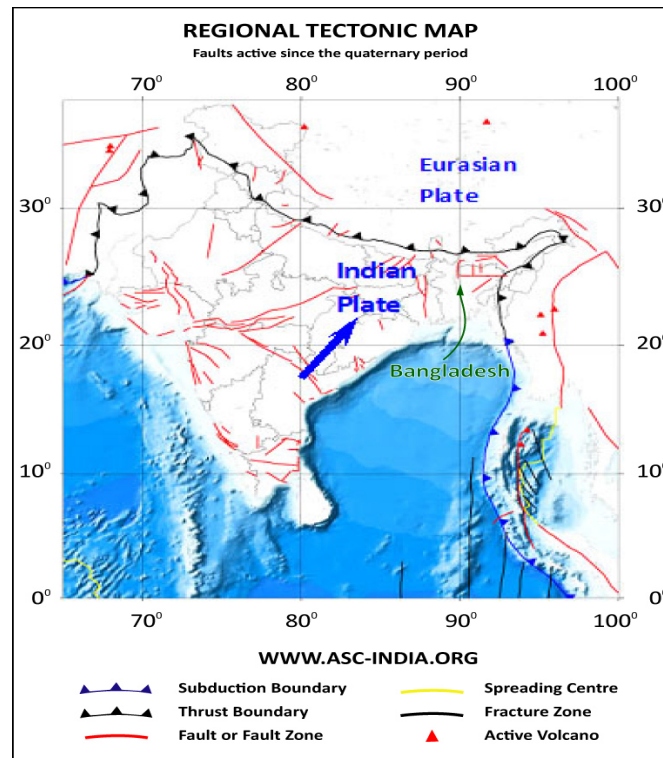


Figure 6.B.1 Movement of Indian plate relative to Eurasian plate

B.1.2 Earthquake Occurrence

Historically Bangladesh has been affected by five earthquakes of large magnitude ($M \geq 7.0$) during 1869 to 1930. One of the strongest earthquakes of the world, the 12 June 1897 Great Indian earthquake in Shillong, Assam had an epicentral distance of about 230 km from Dhaka, its magnitude has recently been reestimated to be 8.1. Two of these earthquakes had their epicenters within the country. The 14 July 1885 Bengal earthquake, measured as $M = 7.0$, originated near Bogra in Bangladesh. The 8 July 1918 Srimongal earthquake occurred in Sylhet region of Bangladesh and its magnitude was determined as $M_s = 7.6$. In addition, some historical reporting points out to the occurrence of a major earthquake ($M > 7$) near Chittagong in 1762. Table 6.B.1 gives brief information about these major earthquakes.

In recent years, the occurrence and damage caused by a number of earthquakes (magnitude between 4 and 6) inside the country or near the country's border, has raised an alarm. The Nov. 21, 1997 magnitude 6.0 earthquake at the Bangladesh-Myanmar border triggered collapse of an under-construction reinforced concrete frame building that killed several people in the port city of Chittagong. The July 22, 1999 magnitude 5.1 earthquake with its epicenter very near the island of Moheshkhali, near Cox's Bazar, caused extensive damage and collapse of rural mud-walled houses, as well as damaging column of cyclone shelter. The Dec. 2001 magnitude 4.0+ earthquake with its epicenter very near Dhaka city caused panic and injuries to prison inmates at the Dhaka central Jail. In the July 27, 2003 magnitude 5.6 Rangamati earthquake, in the village of Kolabunia, brick masonry buildings as well as mud-walled houses were severely damaged.

Table 6.B.1: List of Major Regional Earthquakes

Date	Earthquake name	Epicentre	Magnitude, M	Effects
2 April, 1762	---	Near Chittagong	>7.0	Some changes in landforms in the coastal area and liquefaction
10 Jan. 1869	Cachar	Cachar, Assam	7.5	Some damage occurred in Sylhet
14 Jul. 1885	Bengal	Bogra	7.0	Severe damage occurred to houses in Sirajganj and Sherpur (Bogra)
12 Jun. 1897	Great Indian	Shillong, Assam	8.1	Greatest damage in Rangpur including railway line and buildings; intense ground fissures and vents in Mymensingh, Jamalpur, Sylhet; damages to masonry buildings covering a major portion of Bangladesh including Dhaka

Date	Earthquake name	Epicentre	Magnitude, M	Effects
8 Jul. 1918	Srimongal	Srimongal, Sylhet	7.6	Collapse/ severe damage of buildings in Srimongal, damage to buildings in Habiganj, Moulvibazar
2 Jul. 1930	Dhubri	Garo hills	7.1	Damage to railway track in Lalmonirhat, damage to buildings in Lalmonirhat and Rangpur

Figure 6.B.2 shows distribution of earthquake ($M \geq 3.5$) epicenters for the period 1845-Feb.2010 in and around Bangladesh. This is indicative of the significant seismic activity in the region. There are earthquakes distributed all over Bangladesh. However the cluster of earthquakes appears to be quite dense in Chittagong. Although few in number, there are earthquakes occurring in south western Bangladesh including the sea. The large magnitude ($M \geq 7.0$) earthquakes have taken place within Bangladesh in Sylhet, Bogra, and Chittagong. Outside Bangladesh but close enough to cause damage in Bangladesh, major earthquakes ($M \geq 7.0$) have occurred in India to the north, northeast and northwest of Bangladesh particularly affecting Sylhet, Mymensingh and Rangpur region.

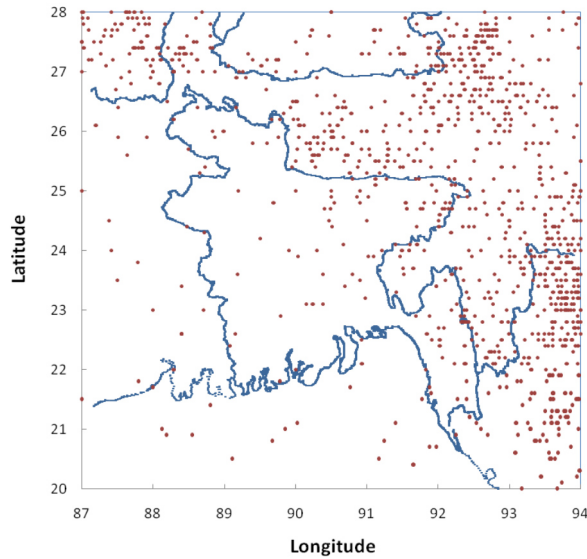


Figure 6.B.2 Earthquake ($M \geq 3.5$) occurrence in and around Bangladesh (1845-Feb.2010).

PART VI
Appendix C

Seismic Design Parameters for Alternative Method of Base Shear Calculation

Table 6.C.1: Spectral Response Acceleration Parameter S_s and S_1 for Different Seismic Zone

Parameters	Zone-1	Zone-2	Zone-3	Zone-4
S_s	0.3	0.5	0.7	0.9
S_1	0.12	0.2	0.28	0.36

Table 6.C.2: Site Coefficient F_a for Different Seismic Zone and Soil Type

Soil Type	Zone-1	Zone-2	Zone-3	Zone-4
SA	1.0	1.0	1.0	1.0
SB	1.2	1.2	1.2	1.2
SC	1.15	1.15	1.15	1.15
SD	1.35	1.35	1.35	1.35
SE	1.4	1.4	1.4	1.4

Table 6.C.3: Site Coefficient F_v for Different Seismic Zone and Soil Type

Soil Type	Zone-1	Zone-2	Zone-3	Zone-4
SA	1.0	1.0	1.0	1.0
SB	1.5	1.5	1.5	1.5
SC	1.725	1.725	1.725	1.725
SD	2.7	2.7	2.7	2.7
SE	1.75	1.75	1.75	1.75

Table 6.C.4: Spectral Response Acceleration Parameter S_{DS} for Different Seismic Zone and Soil Type

Soil Type	Zone-1	Zone-2	Zone-3	Zone-4
SA	0.2	0.333	0.466	0.6
SB	0.24	0.4	0.56	0.72
SC	0.23	0.383	0.536	0.69
SD	0.27	0.45	0.63	0.81
SE	0.28	0.466	0.653	0.84