

# SCENARIO OF SEISMIC HAZARD IN ASSAM

## INTRODUCTION:

Geomorphologically, NE India is located in an earthquake prone zone (zone V) of the Indian subcontinent. In this region earthquake comes with landsliding flood and along series of smaller magnitude earthquakes.

Here earthquakes of upto MM intensity IX can be expected. According to a hazard map by the Global Seismic Hazard Assessment Programme, the state can expect to have a peak gravitational acceleration (PGA) of 0.24g to 0.48g. The region where the highest PGA can be expected is along the state's border with Meghalaya, the site of the Great Indian earthquake of 1897.

## EARTHQUAKE HISTORY

Much of Assam lies in the Bramaputra River Valley, except for a few southern districts. The northern and eastern parts of this valley are bounded by the Himalayan Frontal Thrust (HFF). In the eastern parts along with the HFF, there is the arc of the Lohit and Naga Thrusts. Among the large earthquakes in this region were the events in 1897 and 1950. The 1897 earthquake is well known for the dramatic accounts of violent upthrow during the shock.

## SIGNIFICANT EARTHQUAKES IN ASSAM

Both instrumented and non-instrumented events may be listed below. Reported magnitudes are listed for instrumented events while the maximum observed intensities are listed for non-instrumented shocks. Some of the latter might also have magnitudes assigned to them by various authors, in which case the reference is stated.

**EARTHQUAKES DURING NON-INSTRUMENTAL PERIOD IN ASSAM 1548, 1596, 1601, 1642, 1663, 1696, 1756, 1772, 1838, & 1841.**

**EARTHQUAKE DURING INSTRUMENTAL PERIOD IN ASSAM 1869, 1897, 1923, 1930, 1943, 1947, 1950, 1985, 1984 & 1988.**

## 1869 - Cachar (Assam), India, M 7.5

Date	10th January 1869
Epicentre:	9.4 kilometers N of Kumbhir (Assam), India
Latitude:	25.00° N
Longitude:	93.00° E
Origin Time:	11:45 UTC / 17:15 IST
Magnitude:	7.5
Max. Intensity:	VIII



Kachar (Bengal) India earthquake

The earthquake that struck Cachar, Assam on 10th January 1869 caused heavy damage in the region. Though the IMD places the epicentre of this earthquake in the Cachar region of Assam, other catalogs place the epicentre, further west, in the Dhubri area.

The impact of the shock was felt over 6,50,000 square kilometres. There was heavy damage in the towns of Cherrapunji, Silchar, Shillong and Sylhet and also in Manipur. Fissures opened on the banks of the Surma river and sand vents threw up great amounts of sand and water. The epicentral tract was 30 - 45 kilometres long and 5 - 6 kilometres wide lying on the northern border of the Jaintia Hills. The hypocentre had a depth of 50 kilometres.

## 1897 - Near Rongjoli, Assam, India, Ms 8.7

Date	12th June 1897
Epicentre:	14 kilometres ESE of Sangsik (Meghalaya), India
Latitude:	25.50° N
Longitude:	91.00° E
Origin Time:	11:41 UTC / 17:11 IST
Magnitude:	Ms 8.7



Bent rails at Rangapara,  
Tezpur-Balipara Tramway



All Saints' Church, Shillong



Sand vent at Rowmari



Ground effect in  
Shillong Plateau

This was one of the most powerful earthquake in the Indian sub-continent and probalblyone of the largest known anywhere. The quake wreaked havoc across south-west of the present states of Assam, Meghalaya and Bangladesh. 1542 people were killed and hundreds more hurt. Damage from the earthquake extended into Kolkata where dozens of buildings were badly damaged or partially collapsed. Shaking from the event was felt across India, as far as Ahmedabad and Peshawar. Seiches were also observed in Myanmar.

It had a magnitude estimated variously between Ms 8.7 and Mw 8.. The earliest report of extreme ground acceleration is recorded for this earthquake, where stones on the roads of Shillong as said to have "vibrated like peas on a drum". Recent studies also indicate that this might have been a blind earthquake, therefore making it the largest blind earthquake ever known.

Previously this earthquake was thought to have been caused by a slip alongs north dipping fault that forms the plate boundary under the eastern Himalayas. New studies show that it originated on a south-south-west dipping fault, named the Oldham Fault, bounding the north-western section of the Shillong Plateau. During the event, the total slip

on this fault, amounted to 16 metres, which is among the greatest for any known earthquake. Geodetic observations indicate that the rupture extended upto 35 kilometres into the crust and might have even cut through its base, which in this region, lies at a depth of 43-46 kilometres. The rupture of the Oldham Fault terminated at a depth of 9 kilometres from the surface of the earth, implying that this event was blind. This makes the 1897 earthquake the largest blind earthquake ever known. Post-earthquake surveys mapped large fault scarps on the western edge of the Shillong Plateau, most notably the Chedrang and Samin fault scarps. The former, which follows the Chedrang River, resulted in numerous sag ponds and waterfalls as the drainage was disrupted. The maximum offset recorded here was 35 feet. These faults were the result of large scale secondary faulting that accompanies blind earthquakes, which is often observed and sometimes misinterpreted as the primary rupture. The high ratio of slip to fault length implies a high static stress drop at the high end of the observed range and this is consistent with the violence of the shock, where observations indicative of accelerations in excess of 1g were noted.

The earthquake caused great destruction to many towns in Assam and Meghalaya. Most often referred to is Shillong, where most of the structures like the Telegraph House, were demolished. Landslides were reported all across the Garo Hills. The towns of Dhubri, Goalpara, Guwahati and Kuch Bihar in Assam and West Bengal was heavily damaged. Earthquake fountains, some 4 feet high, were reported from Dhubri. The Jolboda and Krishnai bridges were also ruined. At Goalpara, a 10-foot wave from the Bramaputra (possible subsidence), swept into the area, destroying the bazaar and many pukka buildings. Ground waves were reported from Nalbari, where the observer saw rice fields rise and fall as the waves passed under them. At Guwahati, the earth subsided along the Bramaputra and several sand vents were formed. The Bramaputra is also reported to have risen by 7.6 metres and even reversed its flow during the shock. Large scale subsidence was also reported from Muktagacha, Bangladesh. This town was constructed on man-made ground. The earthquake formed frozen earthwaves of "jinamis" in a rice field in lower Assam, where the crest to trough difference was between 2 to 3 metres. Fissures and sand blows occurred over a wide area of Assam, Meghalaya, West Bengal and northern Bangladesh. Fissures and sand blows were also reported from some parts of Bihar.

The earthquake affected both Dhaka and Kolkata, which are presently the most densely populated cities in the region. At Dhaka, most of the buildings were heavily damaged and many collapsed. Sand vents also occurred at many places in the city. Kolkata, was also badly affected, though to a much lesser extent than Dhaka. Walls and parapets came off many buildings, and the steeples of some churches, like the Free Kirk of Scotland, on Wellesley Street, were broken off. Damage was reported from Bardhwan, Bhagalpur, Behrampur, Comillah, Chittagong, Jamalpur, Jessore, Khulna, Monghyr (Munger), Murshidabad, Naokhali (Maijdi) and Purnea.

Shaking effects of the mainshock were experienced over a wide area of the subcontinent as far as Himachal Pradesh, Myanmar and the present-day Indo-Pakistan border. At towns like Lucknow and Allahabad, the shaking was strong enough to displace crockery. At Kathmandu, trees and free standing objects swayed and people ran outdoors. To the south it was felt at Bezwada in Andhra Pradesh and in the west upto Sehore, in Madhya Pradesh. Chandeliers and lamps oscillated at Piploda and Khandwa. It was not felt in Mumbai, though instruments did pick up the disturbance. Long period effects such as water oscillations were also reported. At Ahmedabad, water in a tank was set into motion and it spilled over partitions in the tank. In Myanmar, on the Theingale River, near Tagaung, no tremors were felt but water in an old river course was "lapping along its banks" and at Thayetmyo, water in a tank began to oscillate back and forth for about three minutes, rising 18 inches on the side of the tank. Hot springs at Sitakund became more active following the quake, while those at Rajgir discharged coloured water for three days.

Dozens of aftershocks were felt in the region. At the Bordwar tea estate, a week after the mainshock, the surface of a glass of water standing on a table was in a constant state of tremor. At Tura, a hanging lamp was kept constantly on the swing for 3 days. On June 13, at around 01:30 local time (LT) and again at 13:00 LT two severe shocks were felt. The earlier event was strong enough to be felt at Kolkata and as far as Sutna, which lies beyond Allahabad. Two more quakes, were felt at Kolkata, at 22:40 LT on June 13 and at 00:47 LT on June 14. Later, on June 22, at 07:24 LT, June 29, at 22:19 LT and October 2, at 20:58 LT, strong aftershocks were felt as far as Kolkata. The last event felt in Kolkata, occurred at 01:40 LT on October 9, 1897.

### 1923 - (Meghalaya), India, Ms 7.1

Date	9th September 1923
Epicentre:	South Meghalaya, India
Latitude:	25.25° N
Longitude:	91° E
Origin Time:	22:03:42 IST
Magnitude:	Ms 7.1

A strong earthquake shook parts of south of Meghalaya, Assam, West Bengal and Bangladesh on the morning of 9th September 1923.

The earthquake causes heavy damages at Mymensingh, Cherrapunji, Guwahati. The earthquake is also felt at Barisal, Chittagong, Nagrakata, Midnapore, Srimangal, Sivasagar, Tatung, Salonah, Borjuli, Narayanganj.

### 1930 - Dhubri (Assam), India, Ms 7.1

Date	2nd July 1930
Epicentre:	3.9 kms NNW of Dabigiri (Meghalaya), India
Latitude:	25.80° N
Longitude:	90.20° E
Origin Time:	21:03:34.4 UTC / 03:23:34.4 IST
Magnitude:	Ms 7.1

A strong earthquake shook parts of western Assam, West Bengal and Bangladesh on the morning of 2<sup>nd</sup> July 1930. Strong as it was the Dhubri earthquake most surprisingly but thankfully did not cause any fatalities, though a few were injured. This, in spite of the fact that it hit in the early hours of the morning. Most of the buildings in Dhubri and the surrounding areas were destroyed in this shock.

It was felt as far away as Kolkata, Chittagong, Dibrugarh, and Patna. It was felt nearly all over northern-eastern and eastern India. This earthquake was followed by six major aftershocks of magnitude 6. The first three were in the immediate epicentral region south of Dhubri. The next three were in the region southeast of Goalpara, on the Assam-Meghalaya border.

**1941 - Near Tezpur, Assam, Ms 6.5**

Date	21 January 1941
Epicentre:	Near Tezpur, Assam
Latitude:	26.50 N
Longitude:	92.50 E
Origin Time:	02:30:16.0 UTC
Magnitude:	Ms 6.5

**1943 - Near Hojai (Assam), India, Ms 7.2**

Date	23rd October 1943
Epicentre:	13.6 kms E of Hojai (Assam), India
Latitude:	26.00° N
Longitude:	93.00° E
Origin Time:	17:23:17 UTC / 22:53:17 IST
Magnitude:	Ms 7.2

At around 11 pm on the 23rd of October 1943, a major earthquake rattled northeast India. The shock had a magnitude of 6.9 (Mw). This would be the first of three powerful earthquakes that would hit the region in the next seven years.

Felt strongly in the region and in neighbouring Manipur. Not much is known about this earthquake as it occurred at the height of World War II when the threat of Japanese aggression on the eastern border of British India was extremely high.

Doug Warr, who was stationed with a medical unit near Dimapur, gives an eyewitness account of the events of that night. "At the time I was with a medical unit stationed on the Manipur road, seven miles from Dimapur. I was awakened in the night by violent shaking - so violent that I found myself clinging desperately to the charpoy to avoid being shaken off. There was a rumbling noise. I don't know how long it lasted - perhaps a few minutes - and then it subsided to occasional slight tremors. In the morning we discovered that there were fissures and great unevenness in what had previously been level ground, trees had fallen and buildings had been damaged. There was some damage to the Manipur road, I think to the bridges on either side

of my unit, but for security reasons a complete ban was imposed on the mention of any consequences of the quake so we never heard precise details. Of course, rumour was rife and we heard lurid accounts of fissures that had opened and swallowed men and vehicles but these were never substantiated and may have been figments of somebody's imagination. We shall never know". - Dong Warr.

Dimapur was 74.5 kilometres SSW of the epicentre. Based on this account it is possible that the MM intensity near Dimapur was VIII to IX.

#### 1947 - Arunachal Pradesh, India, Ms 7.7

Date	29th July 1947
Epicentre:	Arunachal Pradesh, India
Latitude:	28.80° N
Longitude:	93.70° E
Origin Time:	13:43:20 IST
Magnitude:	Ms 7.7

The earthquake of 29th July, 1947, had a magnitude of 7.7 This earthquake is felt over larger region - Assam, Bengal (upto Kolkata) & Bihar (upto Purnea).

At Jorhat in Assam water overflowed riverbanks. At Dibrugarh, Jorhat & Tezpur cracks in walls & failure of electricity at Guwahati. The earthquake is also felt at Silchar, Kathmandu, Rajsahi, Krishnagar, Lasha, Cooch-Bihar, Mymensingh, Dhubri, Rangpur, Tezpur, Srimangal, Bogra, Kalimpong, Comilla, Darjeeling, Guwahati, Purnea.

#### 1950 - Arunachal Pradesh, India, Mw 8.7

Date	15th August 1950
Epicentre:	20.7 kilometers NW of Tajoobum (Arunachal Pradesh), India
Latitude:	28.50° N
Longitude:	96.50° E
Origin Time:	14:09:28.5 UTC / 19:39:28.5 IST
Magnitude:	Ms 8.7,





North Lakhimpur, Assam Bridge on Ranganadi Assam.



Saikoaghat,

This "Independence Day" earthquake was the 6th largest earthquake of the 20th century. Though it hit in a mountainous region along India's international border with China, 1500 people were killed and the drainage of the region was greatly affected. The resultant floods were the cause of most of the fatalities aftermath of this earthquake. The initial shock was followed by thousands of aftershocks, some of which were big earthquakes enough to be reckoned.

It had a magnitude of 8.7 and struck a relatively sparsely populated region along the Indo-China border. This earthquake is often referred to as the "Assam Earthquake of 1950".

The earthquake occurred at 19:39 pm on August 15, 1950. It was felt throughout north-eastern India and in many parts of eastern India. It was also felt throughout Bangladesh, Bhutan and Myanmar. Damage occurred in the entire region as far as Kolkata. It was felt across a wide area of the subcontinent, over an area totalling 4.5 million square miles.

There was widespread devastation in Upper Assam, the Abor Hills and the Mishmi Hills. The region that suffered the most damage to life and property was 15,000 square miles. This included the districts of Jorhat, Lakhimpur, Sibsagar and Sadiya, in Assam. Dibrugarh and Saikoaghat were among the worst affected areas. Railway communications were disrupted due to damage to tracks and bridges. However, the area that suffered damage and encompassed by the isoseist VIII was nearly 75,000 square miles. There were fissures in the earth, from which water and sand was emitted. These are called sand vents and represent liquefaction due to intense ground shaking. Vast areas of land either were elevated or subsided, altering the drainage of the region.

There were huge landslides in the mountains and these dammed tributaries of the Bramaputra River, like the Dihang, Dihing and Subansiri. The latter was dammed by landslides for several days and some worst liquefaction damage was reported from the area where the river enters the plains. These were breached a few days later and resulted in serious flooding. Most of the loss of life was as a result of the flooding and not directly from the earthquake. Pilots flying over the meizoseismal area reported great changes in topography; this was largely due to enormous slides, some of which were photographed. Alterations of relief were brought about by many rockfalls in the Mishmi Hills and destruction of forest areas. 1,526 deaths were recorded, out of which 600 were from Lakhimpur and Sibsagar districts alone. In the Arbor Hills 70 villages were destroyed with 156 casualties due to landslides. Dykes blocked the tributaries of the Brahmaputra; that in the Dibang valley broke without causing damage, but that at Subansiri opened after an interval of 8 days and the wave, 7 metres high, submerged several villages and killed 532 persons. Mathur concluded that at least  $5 \times 10^{10}$  cubic metres of material was involved in the sliding. This is about 30 times of the average load of detritus carried by the river Brahmaputra annually. Fig.1.

Heavy explosive sounds were heard by F. Kingdon-Ward, a botanical explorer at Rima, very near to the epicentre. These sounds were also heard at many places in India and Myanmar, at distances of over 750 miles. Though his primary concern was getting back to India, he did confirm violent shaking at Rima as well as extensive landslides. The term seismic seiche was coined by Anders Kvale in 1955 to describe oscillations of lake levels in Norway and England caused by the earthquake.

This earthquake was caused due to a slip on the Jiali and Po Chu Faults in southern Xizang, along the border with northeast India. The fault plane mechanism for this event indicates strike-slip faulting. Surface faulting is thought to have also occurred as a result of the quake. The earthquake was followed by a large number of aftershocks, most of which were of magnitude 6.0 or greater. These were very frequent following the earthquake and continued for many years after the main shock. Their frequency however kept on decreasing with the passage of time. The aftershock zone extended from 94 degrees east longitude to 97 degree east longitude.

**1954 - Arunachal Pradesh, India, Ms 7.7**

Date	21st March 1954
Epicentre:	Manipur-Burma border
Latitude:	24.2° N
Longitude:	95.1° E
Origin Time:	23:42:17 IST
Magnitude:	Ms 7.7

The shock has a magnitude of 7.7 and originating from Manipur-Burma border. The shock was felt widely over whole of Assam, Bengal & parts of Bihar & Orissa. Minor damages reported from parts of Assam.

**1957 - Arunachal Pradesh, India, Ms 7**

Date	1st July 1957
Epicentre:	Near Indo-Burma border
Latitude:	25° N
Longitude:	94° E
Origin Time:	19:30:20 IST
Magnitude:	Ms 7

This earthquake of 1st July, 1957 had the magnitude of 7.0 and it has the epicenter near Indo-Burma border. This earthquake is widely felt over Assam, Manipur, Tripura, East Pakistan and parts of West Bengal & Bihar. No report from Burma is available. According to the press, only Silchar (Cachar) reported minor property damage. The shock was felt at Tezpur, Halflong, Guwahati, Kailasahar, Silchar, North Lakhimpur, Rowriha, Kumbhirgram, Kohima, Dhubri, Luming, Pasighat, Imphal, Bindukuri, Shillong, Mazbat, Goalpara, Agartala.

**1984 - Silchar (Assam), India, Mw 6.0**

Date	31st December 1984
Epicentre:	SSE of Silchar (Assam), India
Latitude:	24.64° N
Longitude:	92.89° E
Origin Time:	23:33:37 UTC
Magnitude:	Mw 6.0

20 people were killed in Cachar District and a 100 were injured. This quake was "forecast" on the basis of a seismic swarm which was followed by a period of quiescence.

An area of about 250sq km was affected by this earthquake. Damage seem to be of moderate nature except around Sonaimukh Bazar area. The Sonaimukh bridge over the Sonai river, a few school buildings got severely damaged. The Sonaimukh bridge was dislodged from the abutment towards SE direction as a result the bridge was closed to traffic. Two furlongs away from the said bridge, the Nitya Gopal High School and the Sonai Senior Madrassa were severely damaged. These schools are housed in traditional Assam type buildings having walls made of ikra or bamboo strips being cement plastered. Unfortunately the half brick walls were resting on the floor rather than to the foundation. The wall fell towards north. The entire desk -bench were thrown haphazrdly over the floor, the ceiling fans got twisted, heavy almirah also tilted. The boundary walls of both the schools were raged to ground. A few furlong away two mosques were also affected and in one the bell tower was thrown to a distance of about 20ft. Numerous cracks developed on the floor and walls. The affect on the bridge over the Rukmini river was there.

### 1988 - India, Ms 7.3

Date	6th August 1988
Epicentre:	Indo-Myanmar
Latitude:	24.149° N
Longitude:	95.127° E
Origin Time:	05:03 IST
Magnitude:	Ms 7.3

This was a significant earthquake, which occurred on the Indo - Burma border Its hypocentre was at a depth of 91km. Widespread damage was there at Jorhat, Golaghat, Dirugarh and Manipur. However, because of its occurrence at a considerable depth the effect was comparatively low.