Bhookampan Vol. 2, pp.35-40, December 2014
http://bhookampan.co.in/index.php
Journal of Indian Society of Earthquake Science
ISSN:2320-6217

Publisher ISES

Tsunamigenic Vulnerability on East Coast of India

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Received: 22/03/2015; Accepted: 07/07/2015

Abstract

The length of the rupture of fault during the tsunamigenic earthquake has certain relation between the direction of tsunami waves and the energy of tsunami waves. Based on actual readings from the 26 December 2004 tsunami a formula has been developed for east coast of India. The energy and amplitudes of the tsunami waves travelling at right angles to the rupture is highest while those in the direction of rupture are minimal. In addition, the submarine mud volcano activity off Arakan coast in 1924 is also discussed. This has increased the turbidity of Bay of Bengal. It had caused lot of navigational problems.

Key words: Tsunamigenic earthquake, fault rupture, energy of tsunami waves, mud volcano

1. Introduction

Tsunami is a rare transient event caused by a large magnitude earthquake near shore. The Bay of Bengal had experienced some tsunami events due to earthquakes in Indonesia, Andaman and Myanmar. Few major tsunamis have hit the Indian coastal regions. The first available record is from Madras Port Trusted (now Chennai Port Trust). The explosion of biggest volcano Krakatoa in Indonesia in August 1883 had generated huge tsunamis. At Chennai the recorded height of Tsunami was about 2.0 meters. Earthquakes on 4th January 1907 in Indonesia and Earthquake on 26th June 1941 in Andaman had also given rise to Tsunamis and their height was about one meter. The return period of tsunami is very long, of the order of few decades or more for east coast of India. The tsunamigenic earthquake is mostly of magnitude more than 7.5 or so. Though tsunami is a product of earthquake, there are two different scales to measure these events. The earthquake scale for long period was open ended Richter scale. However, it has now been changed to MKS system .The tsunami scale is known as Iida and Imamura scale (1963) the scale is reproduced as reported by Murty (1977) in Table 1.

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Table: 1. Iida Imamura tsunami scale

Grade Scale	Significance
-1	Minor tsunami with max. wave height less than 0.5 m
0	Height (h) is of the order of 1.0 m; no damage
1	H of the order of 2.0 m; house damage along coast, ships washed ashore
2	H is of the order of 4.0 to 6.0 m; some destruction of houses; considerable loss of life.
3	H is of the order of 10.0 to 20.0 m; damaged area along coast about 400 km
4	H is greater than 50 m; damage area along coast more than 500 km

2. Paleo and Historical Tsunamis on Indian Coast

The earthquake catalogues for India and surrounding countries are available for last few centuries as reported by Bapat et. al. (1983). However, the catalogue and references of tsunami are very few. The long return period of tsunami could be a possible reason for this. Table. 2 gives a short list of historical and Paleo-tsunamis on Indian Coast. There is one nice paper on Paleo-tsunami by Sarkar et. al. (2012). This paper has discussed some ancient and the latest tsunami. The paper also gives photo of ancient tsunami deposits.

Table 2: Paleo and historical tsunamis on Indian Coast

Historical Tsunamis On Indian Coast

a. 326 BC Kachchh region/Indus Delta

b. 1 April- 9 May 1008 Iran coast In Arabian Gulf

c. 1524 Off Dabhol coast, Maharashtra

d. 16 June 1819 Kachchh region, Gujarat

e. 19 June 1845 Kachchh region, Gujarat

f. 28 November 1945 Makran coast, Southern Pakistan

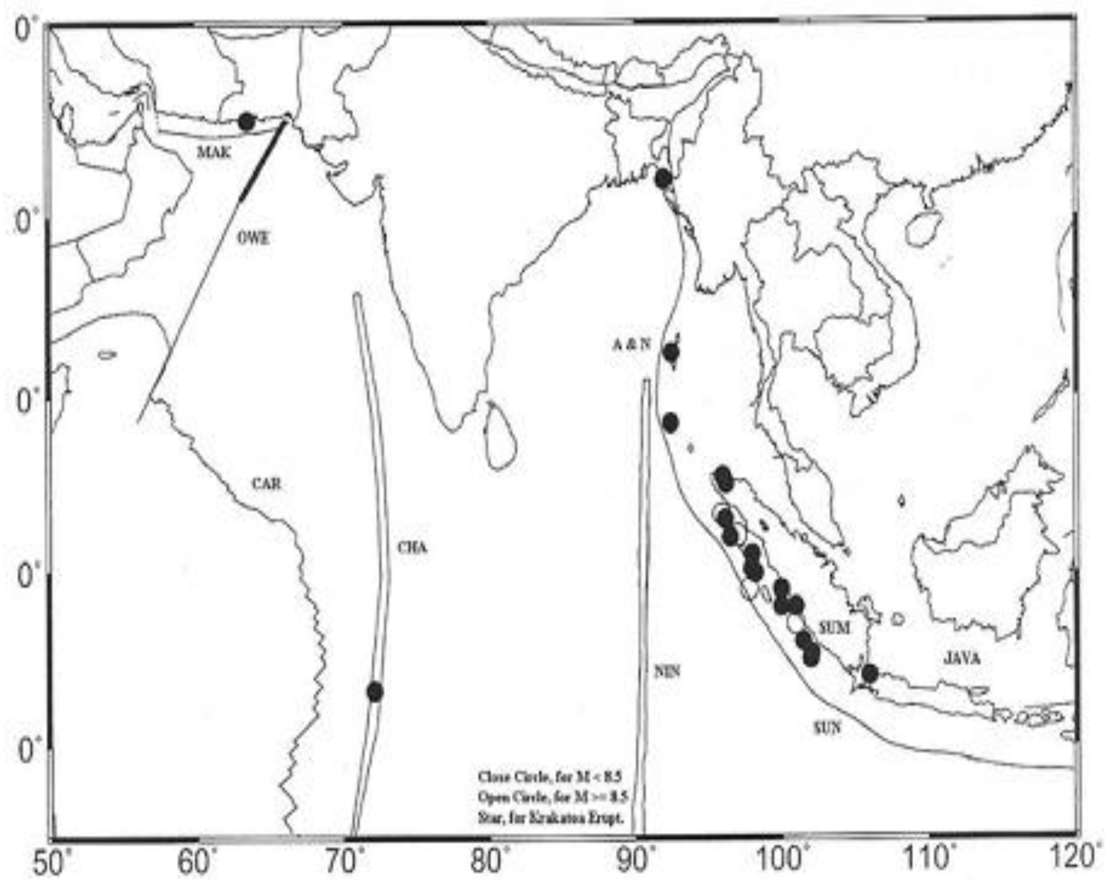

Fig.1 Tsunamigenic earthquake locations for Indian Coast (adopted from Rastogi and Jaiswal, 2006)

3. Tsunamigenic vulnerability of east coast and ports

After the 26 December 2004 tsunami the coastal authorities became aware of the rare event and started some work to protect the Ports, Harbors and other coastal infra-structures. It is fact that the highest tsunami wave of about 7 meters was observed at Nagapattanam (Singh et al., 2012). Taking this as clue to the highest tsunami, most of the ports on east coast of India have made arrangements to account for such tsunami attack. However, theoretical calculations do not support this observation.

When tsunami occurs, the tsunami waves start propagating in all 2π directions. Bapat (2013) has discussed these details. See Fig. 2. However, the energy and amplitudes of the waves is different. Nagapattanam and Thailand coast were hit by high tsunami, while Nagapattanam and Thailand coast were hit by high tsunami, the ruptured fault (Singh et al., 2012).

The east coast of India at Nagapattanam and Thailand had highest tsunami of about 7.0 meters; the Cocos Island recorded only 42 cms tsunami. Mathematical seismology tells us that during the rupture of fault, Cocos Island recorded only 42 cms tsunami.

While, waves travelling in the direction of the rupture have minimum energy and amplitude. This is the reason why Kolkata and Chittagong had very little effect of Tsunami waves. While working on tsunami protective measures for any port on east coast this may be kept in mind.

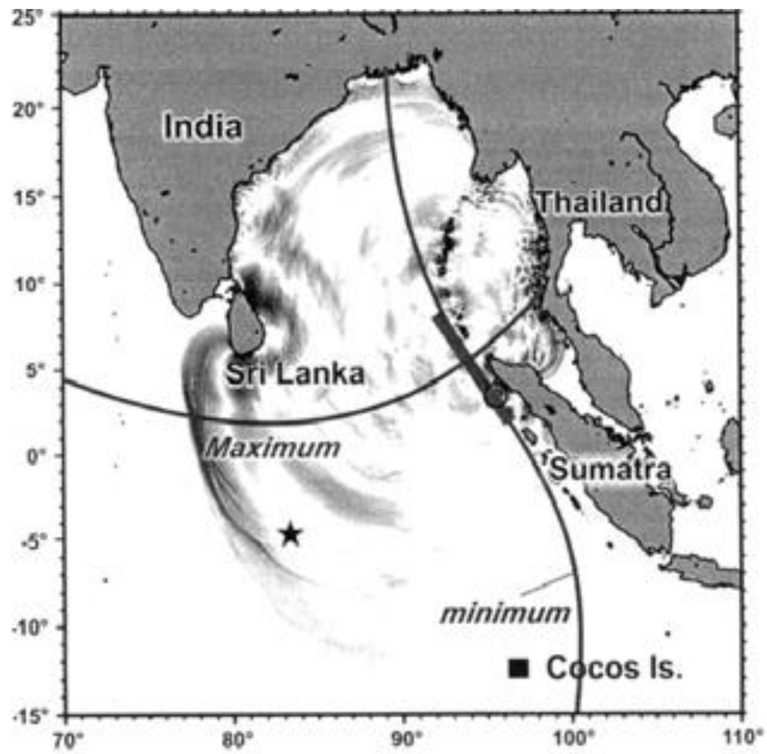

Fig. 2. Map shows direction and energy of December 2004, tsunami waves. The thick line shows actual rupture of about 1200 km. Two lines show the maximum and minimum energy vectors (modified after Bapat et al., 2013).

The distribution of energy in the direction of rupture and at right angles to the direction of rupture is shown in Fig. 3.

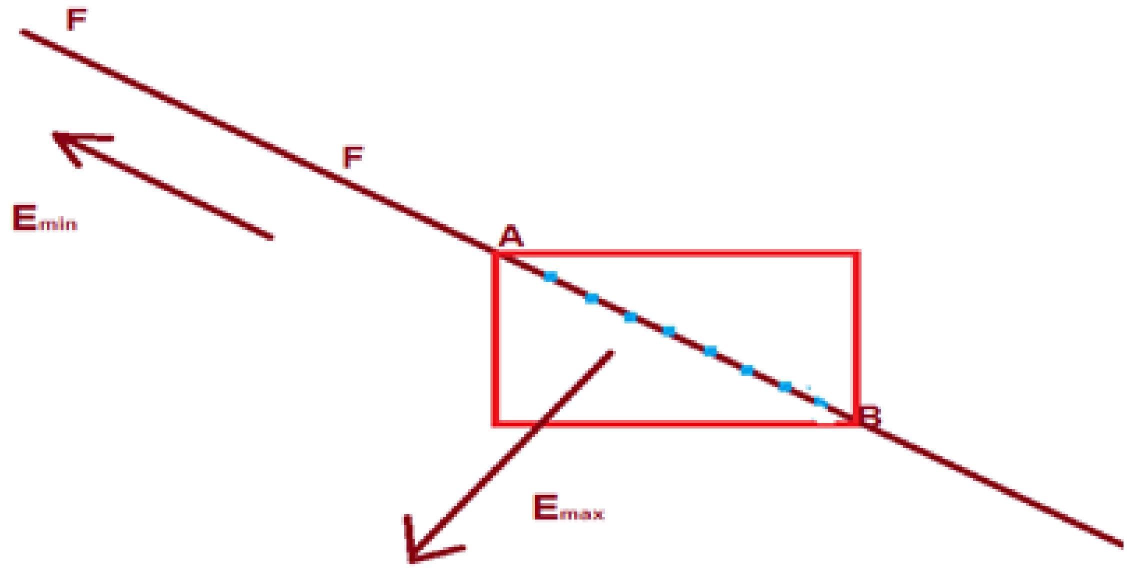

Fig. 3 FF is fault, AB is rupture length and two arrows show the maximum and minimum energy directions.

Another point for east coast is about 'Mud Volcano'. During 1923 – 1924 a submarine mud volcano erupted off the Arakan coast. Continuous flow of mud was erupting for about three months. As reported by Brown (1924). This had turned the water extremely muddy and it had poses navigational difficulties in the area surrounded by Kolkata, Chittagong and Rangoon. At present, a live mud volcano is active near Port Blair and is known as Bara Tanga. The mud volcano disturbs the navigation for long period. Moreover, the sea fish also experience difficulty in their movements and fish catch is considerably reduced.

Tsunami is known to have dissected rich alluvial mouth area. During the 1960 tsunami on Chile coast such incidence is reported from a place known as Chimbote. The delta was totally dissected. On east coast there are two delta regions as mouths of Krishna and Godavari. It is not unlikely that the alluvial mouth deposits of these deltas could suffer some damage due to tsunami.

4. Concluding Observations

Though tsunami events are rare with a very long return period, long term planning of ports, harbors and coastal infrastructures should consider the likely effect of tsunami on this establishment.

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