FIELD SURVEY OF THE DECEMBER 26, 2004 TSUNAMI AT KANYAKUMARI, INDIA

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Abstract

The tsunami of 26th December 2004 in the Indian Ocean impacted the town of Kanyakumari at the very southern tip of India. On a coastline of about 4.8 km in length, the tsunami amplitudes varied from about 1.5 m to about 9.5 m. The horizontal extent of inundation ranged from a few meters to about 1,000. The large tsunami run-up variations over such a short distance were caused by wave convergences and divergences due to local shoreline geometry, its orientation and the near shore bathymetric gradients. Apparently, the physical process of quarter wave resonance amplification also played a significant role in enhancing the tsunami run-up at certain locations. The present study reports on the results of the field survey as well as on information gathered through eyewitness accounts.

Figure 1. The Tamil Nadu State in Southeast India.

1. Introduction

The magnitude 9.3 Sumatran Earthquake of 26 December 2004 generated a huge tsunami and caused extensive destruction in Indonesia, Malaysia, Thailand, India, Sri Lanka and other countries bordering the Indian Ocean. The east coast of India was severely affected. Coastal locations as Nagapattanam, Kaddalur were severely affected, while the coastal region of Kanyakumari was struck by a moderate size tsunami. Kanyakumari is a popular tourist destination; therefore it is essential that a suitable tsunami disaster mitigation and management plan be drawn to avert future impact. The National Safety Council (NSC) of India authorized our team to examine this issue and devise suitable scientific measures. The present report details the field survey that was conducted at Kanyakumari from 16 to 20 December 2007. Respectively, Figures 1 and 2 show the Tamil Nadu State in South India and the town of Kanyakumari.

Figure 2. The Town of Kanyakumari in the State Tamil Nadu.

2. **The Inundation Survey**

The extent of inland inundation by tsunami waves is an indication of the level of destruction they can inflict. The collection of such data helps with plans for future mitigation measures. For this reason 4.8 km of the coast of Kanyakumari were surveyed. Survey locations were selected at 50 m intervals along the coast and positioning was determined by GPS (Table 1). Whenever possible, interviews were conducted with eyewitnesses that had been present at that location during the 2004 tsunami event. The details of the interviews are given in Annex I. The collected data were analyzed and summarized with graphs. Figure 3 shows the heights of the tsunami at different locations. Figure. 4 depicts the horizontal extent of inundation.

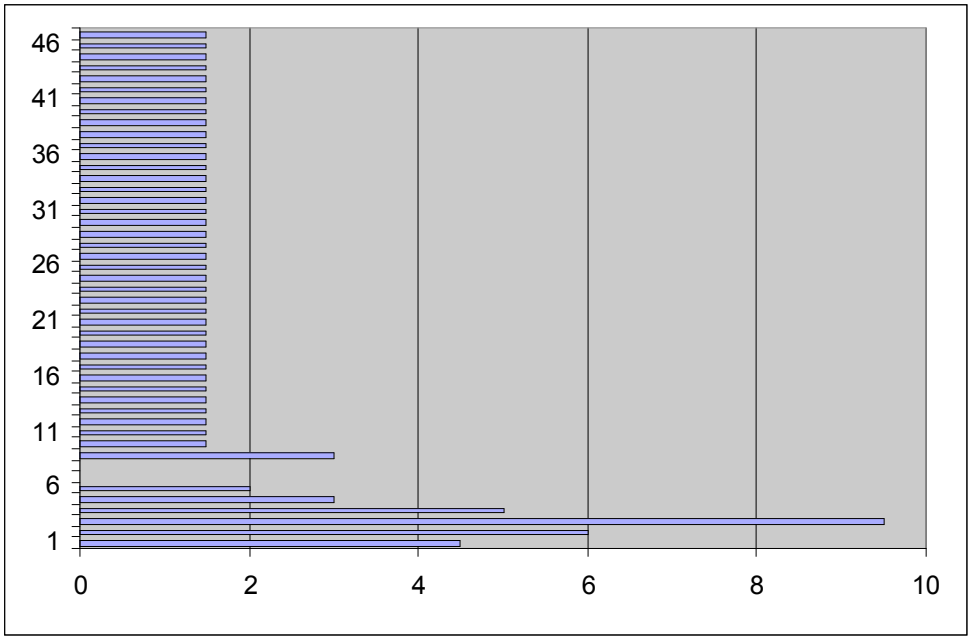

Figure 3. The height of Tsunami at different locations. Observation Points on Vertical axis and Tsunami height (m) on horizontal axes

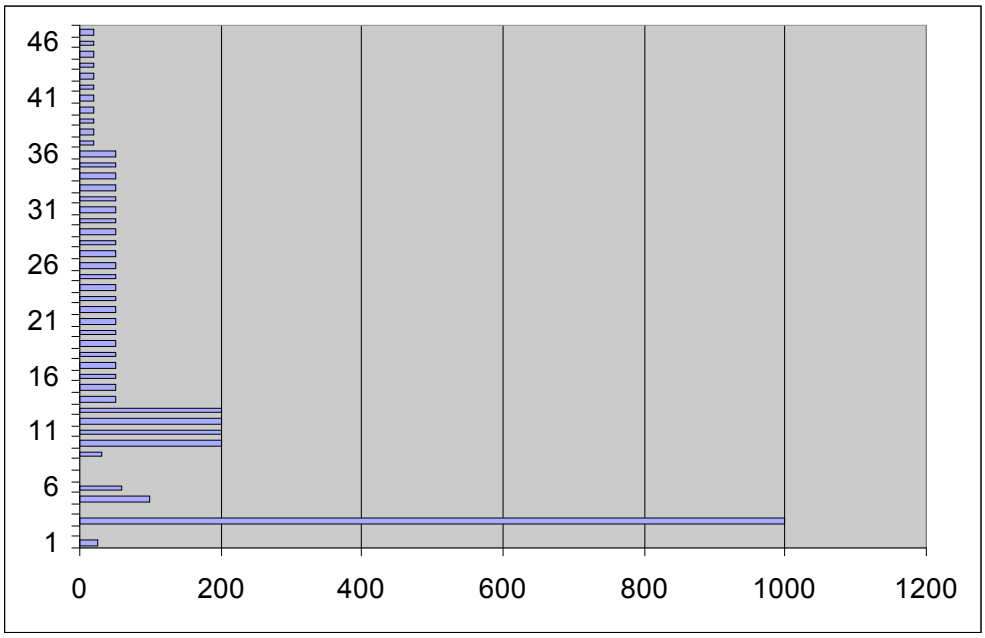

Figure 4. Horizontal extent of Inundation at different points. Observations Points on vertical axis, inundation (m) on horizontal axis.

3. Discussion and Conclusions

The Table, figures and photos (shown in the appendix) provide detailed information about the physical characteristics of the tsunami on the coast of Kanyakumari. The main results from this survey are:

(a) The tsunami run-up height at the majority of the points along the Kanyakumari was about 1.8 m.

(b) At locations 1 to 9 the tsunami run-up heights ranged from 3 to 9.5 m.

(c) The Kanyakumari shoreline appears to have experienced minimum tsunami amplitude of 1.5 m. The Vivekananda Rock Memorial and the Thiruvalluvar Statue might have given partial protection. The tsunami waves hit these two locations first and then arrived at Kanyakumari shoreline.

(d) The horizontal extent of inundation varied from 50 m to 1000 m. It was about 200 m at locations 14 to 36 and about 50 m at points 37 to 46. At some locations where the tsunami height was up to 1.5 m and inundation extent was about 200 m, is an area where numerous of fishermen live and a large number of fishing boats are anchored. At these two locations and other similar locations where extensive tsunami inundation was observed, Gabions could be placed to protect the coastline.

(e) During the survey, the team observed a young coconut tree with color markings on the trunk that clearly indicates the tsunami's height (Photo 1).

(f) Mrs. Muttama Palmani, a 50-year old lady, was struck by the tsunami and got stuck up on a tree. Her nephew Selvaraj was also washed away and got stuck up on another tree (Photos 2 and 3). These observations were useful in determining the height of the tsunami at this location.

(g) A church (shown in Photo 4) has been subsequently repaired. However, the height reached by the tsunami at that location was obvious.

(h) In addition to the placing Gabions, suitable pre-tsunami warning mechanism may be worked out. In addition to the announcements on radio and television, it would be most effective if the tsunami warning were sent by SMS. At present it is possible to send SMS by one operation to about 3000 to 5000 Cell phone users. Suitable mechanism may be worked out with cell telephone companies.

(i) Creation of awareness about tsunami may be taken up as a part of school and community learning activities.

(j) Kanyakumari is about 130 to 150 minutes away from the probable epicentral locations in Indonesia as far as tsunami travel is concerned. If a Tsunamigenic earthquake occurs in Indonesia, it will be known through various websites and through telephone contacts almost immediately. The Tamil Nadu state Disaster Management should establish contacts with Andaman and Nicobar (A & N) Administration. Indonesian Tsunami may hit Andaman within about 20 to 30 minutes. The A & N should immediately inform the District Collector of Nagercoil, which is the headquarters of the district in which the town of Kanyakumari is located.

(k) Periodic assessment of the situation may be routinely undertaken every six months. This will help in reviewing the progress and also help in modifying the mitigation measures. A suitable permanent committee for this purpose may be formed.

Table 1: Location of observation points, GPS Position, tsunami height, inundation and remarks.

Location No.	Latitude (N)	Longitude (E)	Tsunami height (m)	Horz. Inundation (m)	Remarks
01	08° 04.714′	077° 31.895′	4.5	25	Sun set Pt
02	08° 05.403′	077° 29.035′	6	On back water	Keelamanakudi Bridge
03	08° 05.416’	077° 28.588′	9.5	1000	Sothavilai Beach
04	08° 04.761′	077° 32.430′	5	Nil	Old Beach Road
05	08° 04.678′	077° 33.067′	3	100	16 Pillar Mandapam
06	08° 04.896′	077° 33.165′	2	60	Boat Jetty
07	08° 06.134′	077° 32.952′	-	-	Kumarisalkulam. (Panchayat limit on North side)
08	08° 07.577′	077° 33.914′	-	-	Vattakottai (For Ref.)
09	08° 05.654′	077° 33.835′	3	30	Chinnanuttym Muttom (CM)Tample. (KKTP limit Starts on East Beach)
10	08° 05.541′	077° 33.840′	1.5	200	50 m from CM
11	08° 05.525′	077° 33.814′	1.5	200	100 m from CM
12	08° 05.520′	077° 33.789′	1.5	200	150 m from CM
13	08° 05.510′	077° 33.766′	1.5	200	200m from CM
14	08° 05.505′	077° 33.743′	1.5	50	250 m from CM
15	08° 05.498′	077° 33.718′	1.5	50	300 m from CM
16	08° 05.491′	077° 33.694′	1.5	50	350 m from CM
17	08° 05.483′	077° 33.672′	1.5	50	400 m from CM
18	08° 05.477′	077° 33.650′	1.5	50	450 m from CM
19	08° 05.469′	077° 33.630′	1.5	50	500 m from CM
20	08° 05.463′	077° 33.609′	1.5	50	550 m from CM
21	08° 05.453′	077° 33.588′	1.5	50	600 m from CM
22	08° 05.438’	077° 33.568′	1.5	50	650 m from CM
23	08° 05.423′	077° 33.549′	1.5	50	700 m from CM

Location No.	Latitude (N)	Longitude (E)	Tsunami height (m)	Horz. Inundation (m)	Remarks
24	08° 05.412′	077° 33.531′	1.5	50	750 m from CM
25	08° 05.402′	077° 33.508′	1.5	50	800 m from CM
26	08° 05.391′	077° 33.486′	1.5	50	850 m from CM
27	08° 05.379′	077° 33.467′	1.5	50	900 m from CM
28	08° 05.366′	077° 33.449′	1.5	50	950 m from CM
29	08° 05.351′	077° 33.425′	1.5	50	1000 m from CM
30	08° 05.341′	077° 33.405′	1.5	50	1050 m from CM
31	08° 05.331′	077° 33.383′	1.5	50	1100 m from CM
32	08° 05.313′	077° 33.362′	1.5	50	1150 m from CM
33	08° 05.297′	077° 33.338′	1.5	50	1200 m from CM
34	08° 05.274′	077° 33.319′	1.5	50	1250 m from CM
35	08° 05.254′	077° 33.299′	1.5	50	1300 m from CM
36	08° 05.233′	077° 33.282′	1.5	50	1350 m from CM
37	08° 05.209’	077° 33.272′	1.5	20	1400 m from CM
38	08° 05.184′	077° 33.259′	1.5	20	1450 m from CM
39	08° 05.168′	077° 33.213′	1.5	20	1500 m from CM
40	08° 05.072′	077° 33.143′	1.5	20	1550 m from CM
41	08° 05.039′	077° 33.137′	1.5	20	1600 m from CM
42	08° 05.010′	077° 33.142′	1.5	20	1650 m from CM
43	08° 04.985′	077° 33.139′	1.5	20	1700 m from CM
44	08° 04.957′	077° 33.130′	1.5	20	1775 m from CM
45	08° 04.934′	077° 33.125′	1.5	20	1850 m from CM
46	08° 04.908′	077° 33.117’	1.5	20	1925 m from CM
47	08° 04.759′	077° 33.083′	1.5	20	2000 m from CM
48	08° 05.286′	077° 32.819’	-	-	Railway Station (For Ref.)
49	08° 05.235′	077° 32.672′	-	-	Pillar Hospital Road (For Ref.)
50	08° 05.539′	077° 32.610’	-	-	South Kundal Village (Panchayat Border)
51	08° 06.092′	077° 32.456′	-	-	Microwave station (For Ref.)
52	08° 06.135′	077° 32.491’	-	-	Nagarcoil KKRoad
53	08° 06.287′	077° 32.393′	-	-	KK Fire Station
54	08° 05.733′	077° 31.683′	-	-	Railway Crossing
55	08° 04.918′	077° 32.586’	-	-	KK Bus Stand
56	08° 04.911′	077° 32.660′	-	-	St. Michel Community Center for Shelter
57	08° 04.896′	077° 33.021’	-	-	Panchayat Office

Appendix - I

The team begun the tsunami field survey on 17th Dec 2007. The survey was confined to the municipal limits of Kanyakumari and its immediate shoreline of about 4.8 km.

The survey commenced at Sunset Point (GPS Location 08° 04.714′ N and 077° 31.895′ E), identified as KW001. The following information was deduced from interviews with eyewitnesses.

Mr. J. Anthony, age 75, fisherman.

(a) The first tsunami wave arrived at 0930 (Indian Standard time, 5 hours 30 minutes ahead of Universal time) and then the sea receded by 4.0 to 5.0 km.
(b) His boat was washed away by the waves.
(c) The tsunami wave inundated about 10 m from the high tide line, to a height 4 to 5 m above mean sea level.
(d) After the tsunami inundation, the remaining seawater had a bad smell and caused allergies with blisters to local residents.

Mr. Domni, age 40, Fisherman.

(a) A small wave arrived at 0800 hours. At 1000 the sea receded.
(b) The big tsunami wave arrived at 1015 with a height of 5 m.
(c) The previous day, there was high fish catch. In the days following the tsunami the fish catch was reduced.
(d) There was a continuous warning by local church authorities by ringing the church bell.
(e) There was a rise in skin diseases after the tsunami.

Mr.. Christraj Kennedy, Age 45, Fisherman.

(a) At 0800 hours, a slightly higher wave than normal arrived.
(b) At 1000 hours, the sea receded up to 2.5 km.
(c) At 1115 hours a large tsunami wave struck the shoreline.

The second point of observation was at Keelamanakuda (East Manakkudi, GPS Location 08° 05.403′ N and 077°29.035′ E). This has been identified as KW002. The observations here are as follows.

At this site there was a prefabricated bridge of two segments of 30 m length each resting on 4 pillars and the side bunds having a span of 15 m each. The two segments were dislodged by the tsunami. The western segment was thrown up to 30 m towards the western bank and the other was thrown to about 8 m on the eastern side. (Photo 5)

On the western side of the bridge, inside a house compound, a coconut tree had discoloration (Photo 1) up to a height of 6 m. This mark could be correlated to the tsunami height at that location (plus ground height of about 3 m).

The third point of observation was at Sothaivavilai Beach (GPS location 08° 05.416′ N and 077°28.588′ E). This has been identified as KW003. The observations are as follows.

Mrs. Mutthammal, wife of Palmani, age 48 provided the following observations:

(a) She was in a thatched shed, which accommodates 20 persons, where she serves breakfast and lunch.
(b) At 0610 hrs the seawater reached up to the road. At 0810 a slightly higher wave was observed. At 1100 hrs the sea receded up to 3 km.
(c) At 1120 hrs a huge wave struck. She was lifted, her head hit a lamppost and she lost a tooth by the impact. She became unconscious and was carried up to the top of a palm tree (Photo 2) situated about 10 m from her shop. Her sister's 30-year son Silvaraj was also washed away and got stuck up at a coconut tree located at about 25-30 m from the shop (Photo 3). Her husband was in bathroom and could not move out as he had suffered injuries. Both of them were in the hospital afterwards for 42 days (wife) and 45 days (husband).
(d) After about 20 minutes, the sea level came down. Selvaraj shouted for help and people came and rescued them. The heights of both trees positively indicate that the tsunami run-up height was about 7-8 m (plus ground to sea level of 2 m).
(e) The tsunami run-up height is corroborated by the corrosion of the electrical fittings on the nearby lamppost.
(f) The spiral staircase of the sun set view tower in that location was washed away and the water level was up to the bottom brim of the flooring. It is understood that a person who was on the top of the tower jumped into the water. His body could not be retrieved.
(g) In the Manakkudi village enroot to the beach, a Church located at about 2m above sea level has undergone repair about 6 m from ground through out the sea side wall (Photo 4).

The fourth point of observation was at 100 m east of KW001 (GPS location 08° 04.764′ N and 077°32.430′ E) near Kamaraj Mandapam. This has been identified as KW004. The observations at this point are as follows.

Mr. Perumal, age 35, street side goggle seller, had the following observations:

He saw waves at 0600 hrs, 0900 hrs and 1100 hrs. The wave at 0900 hrs receded about 2 km. The tsunami height at this location was about 5 m.

The fifth point of observation was at sixteen-piller mandapam (GPS location 08° 04.678′ N and 077°33.067′ E) near Kamaraj Mandapum. This has been identified as KW005. The local observations are as follows.

Mrs. Joyce Mery, age 39, fruit seller, reported:

(a) At 0700 the sea receded about 500 m.
(b) The first wave came at 0930 up to mandapam. The next wave came from the Thiruvalluar Statue to Bhagavati Amman Kovil (temple). The third wave came at 1200 hrs. The wave height was 3 m.

Observations of Mr. Krishna Pillai, President of Taxi Owners' Association:

(a) At 0900 on 26 December 2004 he saw people crying and running and their numbers were rapidly increasing. He saw crowds at the Vivekanand rock memorial from the Sea View Hotel. His relative and friends in Andaman and Chennai telephoned him that the sea was unusually rough.
(b) At around 0945 the sea begun to recede and there was no water between the jetty and Vivekanand Rock Memorial and the Thiruvalluar statue. A similar situation had never occurred in the past.
(c) Around 1100 large sea waves started hitting the coastline and destroyed a number of ships and other structures. The waves continued to hit for about 20 to 25 minutes. The whole event lasted for about two and half hours.
(d) One boat at Kanniyakumari jetty was swept away and was found after two months at Earnakulam.

Observations by Mr. C. Swarnapandian, Manager, Phoompuhar Shipping Corporation (Govt. of Tamil Nadu Enterprise):

(a) At around midnight on 25th December 2004, it was reported by the security guard that a powerful wave struck the coast and that small boats were damaged. (See Photo No.6 of damaged boat).
(b) His son informed him on the telephone about the rough sea conditions at Chennai. At about 0900 hrs he went out and saw that the seawater was highly muddier than normal and that the wave heights were higher than usual.
(c) He immediately stopped the ferry, which was about to start. The shipping corporation has two ferryboats.
(d) At 0945 hrs the first tsunami wave arrived from east. This was followed by several more waves of increasing heights. The most powerful wave of 8.0 m height occurred at 1110 hrs.
(e) Both ferryboats were lifted up by the tsunami waves and were placed on the jetty.

Photo 1. Shows the tsunami mark on the coconut tree and metallic part on the electric lamppost, which have been corroded.

Photo 2. Trapped lady in center

Photo 3. Selvaraj was stuck up at the tree where he is standing. The distance between this tree and the tree on which Muttama was hanging is about 15 m.

Photo 4. The repairs on first floor indicate damage during tsunami and the level of Tsunami height.

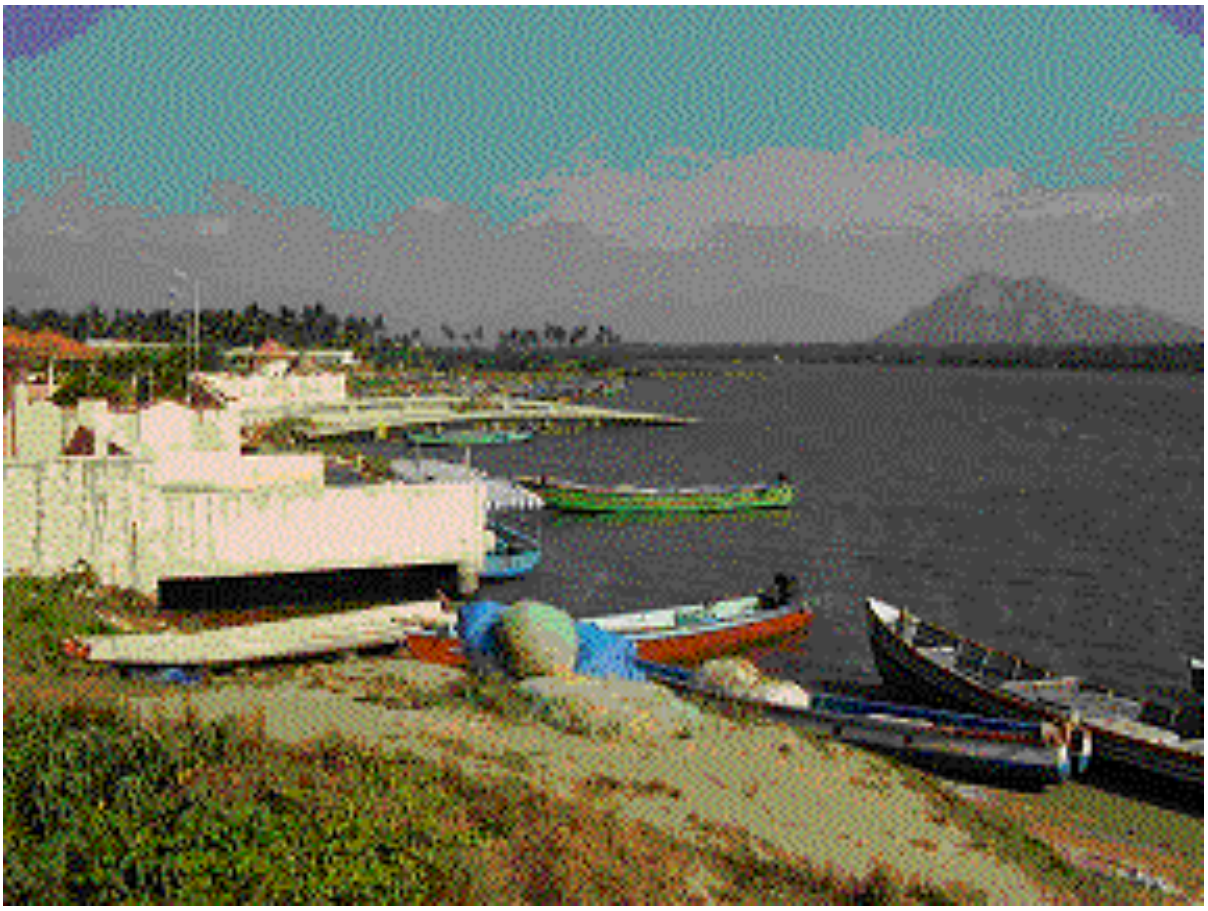

Photo 5. Damaged part of the bridge seen at left of center and boats.

Photo 6. Damaged bridge is seen at rear center. Bridge on right is the new bridge.