Impact of Tsunami and Earthquake On Traditional Huts of Car Nicobar Island

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SUMMARY

The Sumatra earthquake of December 26, 2004 (Ms = 8.6 IMD; Mw = 9.3 USGS) and the tsunami that followed took a heavy death toll (240,000) on the rim of the Indian Ocean. In stark contrast to this dismal scenario, response of traditional huts in Car Nicobar Island was observed to be almost exemplary in the earthquake and in the tsunami. It was observed that the traditional practice of house making, which has evolved over time, incorporated all known elements of earthquake engineering. Due to the recent restriction on use of timber as a construction material and due to several other reasons, this traditional building practice has changed gradually. This paper deals with the practice of traditional hut making in Car-Nicobar, recent adverse changes observed in this construction practice, and response of these to the earthquake and the inundation and run up of the 15 - 30 m high tsunami.

Keywords: Car Nicobar Island, Nicobarese Huts, tribal huts, tsunami

1. INTRODUCTION

The great Sumatra earthquake of 26 December 2004, M_s = 9.0, M_w 9.3, (USGS), originated in the Indian Ocean, off the west coast of north Sumatra. Its epicenter was about 250 km south east of Banda Aceh and north of Simeulue Island, on a convergent plate margin. Parameters of this earthquake are given in Table 1.

Table 1 Parameters of the great Sumatra earthquake of December 26, 2004, as given by India Meteorological Department (IMD) and USGS.

Agency	Latitude (North)	Longitude (East)	Origin Time	Magnitude	Depth of Focus
IMD	3.34°N	96.13°E	06:29 (IST)	8.6 Ms	-
USGS	3.27° 3.09°	95.82° 94.26°	00:58:49 (GMT), (07:58 local time)	9.0 M_W 9.3 M_w	m

1.1 Geographical Extent of Disaster

This great earthquake was followed by a disastrous tsunami in coastal regions of the entire Indian Ocean. The tsunami caused extensive damage in an area that was much wider than that directly affected by earthquake shaking. Countries that bore the brunt of devastation included Indonesia, Sri Lanka, India, Thailand, Maldives, Malaysia, Myanmar and Seychelles. The tsunami spread to the east coast of Africa and affected coastal regions of Somalia, Tanzania and Kenya. Devastation was mostly confined to a narrow coastal belt; about 500-1000 m wide in most places, and extended further inland where the coast was almost flat or where the tsunami went inland due to inlet of a river, or resonated in a bay.

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As coastal areas and beaches on the rim of the Indian Ocean were recently developed, the tsunami that followed the earthquake negated all this development by destroying coastal structures. In India, coastal regions of Tamil Nadu and Andaman and Nicobar chain of islands were devastated, (Shankar et. al., 2005, Wason et. al., 2006). Impact of the disaster was severe in all the islands of Andaman and profound in all the islands of Nicobar, as the latter were closer to the epicenter, consisted of smaller islands with flatter beaches, and experienced high run ups and excessive inundation.

1.2 Car Nicobar Island

Car Nicobar is the district headquarters of the Nicobar group of islands. Because of its strategic location in the Indian Ocean it was recently bestowed with rapid development. These existed in terms of urban facilities and infrastructure like electricity, water supply, and communication, etc. Transport facilities were very well developed, in terms of air, sea and road link. A tarred coastal road circled the entire island, and all interior places were connected to it by small link roads. Many tribal societies existed on this and other islands of Nicobar, and some lived in tribal Nicobarese huts.

2. IMPACT OF THE EARTHQUAKE AND TSUNAMI AT CAR NICOBAR ISLAND

The tsunami arrived at Car Nicobar (epicentral distance almost 600 km) within minutes of the earthquake. The sea receded immediately after the earthquake, well below the normal low tide. This unusual phenomenon attracted many curious tourists who were savouring the beaches, to venture seaward. The succeeding crest of the sea wave that arrived minutes later proved to be fatal for these, and for several thousand others in similar situations in other coastal areas on the rim of the Indian Ocean, and claimed a heavy death toll. Almost 6000 casualties were reported in this island of 23,000 inhabitants, all due to the tsunami alone. Initially five to seven waves were observed every 5 minutes apart, and then the tsunami appeared as a deluge. Survivors described tsunami waves as high as coconut trees. Height of a coconut tree can be as much as 25 m.

Landscape changes occurred on the periphery of the entire island. The sea transgressed, in some places, almost 3-km inland after the tsunami, indicating partial submergence of the coastline. The human habitat was completely obliterated within this narrow belt and the sea front human habitat turned into eerie ghost places. The tsunami washed out almost the entire Malacca area of its built habitat, jetty, and people. Mountains of debris of uprooted coconut and beetle nut trees, mud, mixed with scattered remains of houses such as tin sheets, timber, RCC hollow blocks etc., was all that was left after the tsunami. The six surviving double-storied government buildings on the same coastline were all that remained after the tsunami receded, though tilted and totally marooned, and continued to be battered by sea waves, see Fig. 2.1. As per local officials even in high tide the seawater never touched these buildings. The stench of decomposing organic material was overpowering in several regions in Car Nicobar.

Surviving cars and motorcycles were thoroughly battered by the inundation. Several oil storage tanks at the sea facing air force station were uprooted by the tsunami and floated far inland away from their original place of rest. Five of these large-diameter steel tanks were found entangled within a mountain of debris consisting of cars, building material, trees, etc. The journey of these cylindrical tanks sheared off a coconut forest *en route*, and their passage was stopped only after they got entangled in an upslope coconut grove. Five of these steel tanks were littered and scattered amidst debris, about 50 m away from each other. These cylindrical tanks were found 3 km inland, at a height of more than 30 m above mean sea level when located on Survey of India topographic sheet numbers 87 C/16, C/12, and C/15. This indicates the tremendous kinetic energy and uplift pressure generated by the tsunami that hurled material to such a large horizontal distance inland and to a height of 30 m above mean sea level. This observation led to an estimation of run up of almost 30 m and inundation of 3 km at the air force station and Malacca, (Sinvhal, 2011).

At Katchal, the police station was close to Malacca jetty. Kakana and Kimous are in low-lying areas south of the Air Force Station. Nearly 400-500 human lives were claimed in these two villages alone. Lapathy was a newly developed up market shopping centre and all needs of the privileged were fulfilled here. Everything either turned into mounds of debris or was swept away by the tsunami. The coastal road around the Car Nicobar Island was scoured, dumped with debris, or washed away at many places in the eastern part of the Island, like near the Air Force Station, Lapathy, Malacca, Kakana and Kimous.

Figure 2.1 Surviving government building in Malacca was marooned by the tsunami.

The interior of Car Nicobar Island was slightly elevated, maximum elevation of this island is 65 m above MSL, was sparsely populated with neatly laid out government offices and houses made of hollow brick masonry. Consequently, damaging effects were in stark contrast to that witnessed in coastal areas. In addition, as traditional dwellings of local tribal communities, located in the interior of the island, were unscathed by the tsunami and the earthquake, their construction practice was studied in some detail.

3. CONSTRUCTION PRACTICE OF TRIBAL HUTS

The tribal families of Nicobar live like a traditional Indian joint family. The traditional housing consisted of a hut, which was circular in plan and was made entirely of timber. This was a single room with one tall central post to support the dome shaped roof. A traditional timber house consisted of two structurally independent blocks; one was used for living and the other as the kitchen. With gradual urbanization a third block became necessary for toilet and bath purposes.

The traditional Nicobarese hut, shown in Fig. 3.1, was lifted six to eight feet above the ground. It was supported on 6 to 8 vertical timber posts. These were very sturdy, each of almost 4 inch diameter. The floor of this raised hut was usually a wooden platform, and consisted of a stiff mat with perforations. This was supported on horizontal timber members, running in two mutually perpendicular directions, which were supported on vertical peripheral posts. The timber skeleton of walls was covered with another mat. A tall central post supported the dome shaped roof. The domical skeleton was formed from local thin stems of wood. The skeleton was covered by thick dry bushes and grass, locally known as '*Bhent*'. For horizontal and inclined members coconut tree stems were used. Structural detailing of timber material was elegant. A timber ladder was attached to climb up and go into the hut at night.

Figure 3.1 A tribal hut in Car Nicobar Island

Non-structural elements within the hut were also fully taken care of. An appropriate storage space was made in the floor mat for crockery so that it did not topple during the frequent strong earthquake shaking. Moreover, the indigenous islanders chose sites for constructing their houses very carefully. These were located in the interior of the islands, far away from the coastline and on high ground. Traditional Nicobarese huts are made of locally available light building material. Timber and bamboo are used in plenty together with coconut, melon tree wood, '*bhent*', bushes, stems, and grass, as revealed by residents of these huts. The huts are constructed by their occupants. Many such huts existed on the inhabited islands of the Nicobar archipelago. These indigenously designed huts are thoroughly ventilated in the hot and humid tropical climate, are very comfortable, eco friendly and earthquake resistant.

Figure 3.2 A comfortable and eco friendly interior of a hut that is rectangular in plan.

3.1. Changes Observed in Construction Practice

Due to the recent cap on use of timber as a construction material, with sudden urbanization and due to several other reasons, the conventional practice of making Nicobarese huts described here changed gradually. This included changes in the plan of the house; material used for making stilts, walls and roof, height of stilts and quality of construction.

The plan of the house changed from circular to either a square or a rectangle. Masonry walls were introduced in the newer houses. However, stilts and floors continued to be made of timber. Gradually, timber stilts were replaced by plain concrete stilts. Their size varied from 25 cm x 25 cm to 30 cm x 30 cm, Fig. 3.3, with a very shallow footing, only 90 cm deep. Quality of material used for making stilts also deteriorated. Poor quality concrete mix consisting of sea gravel (mostly of corals), sand and cement was used, in the ratio 4:6-10:1. Water was mixed without any measure, to make the concrete workable. No steel was used in these vertical members. Sometimes, the traditional timber house was built on top of these concrete stilts. Any structural connection between stilts and horizontal timber members was absent in many such huts.

Figure 3.3 A rectangular timber hut supported on plain concrete columns.

Gradually concrete walls were introduced in some houses. These were raised between the plain cement concrete columns described above. The wall was made in staging of about 45-60 cm in height, using plywood as side shuttering. The same concrete which was used for columns was also used for making walls. Sometimes instead of this type of wall, hollow type blocks were used. On top of stilts wooden rafters and purloins supported hipped roof with sloping G.I. sheets.

With so many alterations, the timber hut eventually became a concrete structure, as stilts and the super structure were made of concrete. The stilts got shorter, till gradually these disappeared altogether. Some houses were made on the ground, without stilts and without any platform. The use of low-rise RCC hollow brick masonry houses has also caught on with the modern Nicobarese. Both kinds of construction performed surprisingly well on high ground. Moreover, some of these newer houses, with a changed construction technique, were located closer to the coast. Some of these were razed to the ground at many places as an impact of the earthquake, and some others were adversely affected by the tsunami.

3.2. Impact of the Earthquake and Tsunami on Nicobarese Huts

A combination of several factors makes populations in island arcs, such as the Andaman and Nicobar Islands, vulnerable to damage due to earthquakes and tsunamis. High seismicity in a submarine environment on a convergent plate boundary is the largest contributory factor. Lack of appropriate structural measures, along an extensive and low-lying coastline with a soft and saturated sedimentary cover and bereft of all natural vegetation increases the vulnerability of the built environment. The earthquake carried out a prototype test and exposed all weaknesses of construction practice in all kinds of houses and choice of their site.

As the Andaman and Nicobar islands are subject to frequent large and moderate sized earthquakes, it seemed that the indigenous population was well aware of the twin disasters caused by earthquakes and tsunamis. This was amply manifest in their response to the earthquake, both immediate and long term. Indigenous islanders, on hearing the rumbling produced by the earthquake, sought safety in high ground, as they knew by long experience and through folk tales, that high-amplitude sea waves sometimes follow an earthquake and are disastrous in coastal areas, even if preceded by a trough.

In stark contrast to the disaster to the newly built habitat around the coastline, life went on as usual in Nicobarese huts. The long term solution was amply evident in their traditional mode of constructing their houses, popularly referred to as Nicobarese huts. Even the long stilts were not displaced in most cases and there were no visible signs of structural stress either. Moreover, as these were located far away from the coastline and on high and firm ground most of these were safe from the tsunami too. One such surviving hut is shown in Figs 3.1 and 3.2.

Some of the newer tribal huts, with a changed construction technique, were located closer to the coast. These lacked all earthquake resistant measures. As these could not resist seismic forces and because of their location these were razed to the ground at many places as an impact of the earthquake, and some others were adversely affected by the tsunami.

4. SEISMO TECTONIC FEATURES

Subduction of the Indian plate beneath the Eurasian plate in the Bay of Bengal manifests as frequent large magnitude earthquakes in the region. Most of these are concentrated between the Andaman trench and the Back Arc Spreading Ridge, rendering the Andaman and Nicobar archipelago as one of the most seismically active regions in the Bay of Bengal, (Sinvhal et. al., 1978). Significant earthquakes occurred in 1881, 1914, 1929, 1941, 1949 and 1955. The tsunami produced by the great earthquake of December 26, 2004, damaged almost the same areas as the tsunami of 1881 and 1941. As a consequence of this high seismicity, the Andaman and Nicobar Islands have been assigned to seismic zone V, as per the seismic zoning map of India, given by Bureau of Indian Standards (BIS: 1893–2002). This is the zone of highest seismicity and is vulnerable to earthquake damage pertaining to intensity MMI IX and above.

5. CONCLUSION

It was very surprising to observe that modern and large population centers, including government and defense establishments, offices, and houses, had developed recently all along the coastline not only in Car Nicobar Island but all along the rim of the Indian Ocean, totally oblivious of their vulnerability rendered by the seismo tectonic factors along the Sumatra Java Trench. Obviously, the tropical sun and sand makes the coast a coveted building site in all these islands. If the coastal regions were spared the building activity, the loss of human life would have been a very small fraction of what was actually claimed by this tsunami. Damage due to the earthquake alone was not as life threatening as demonstrated by a subsequent aftershock, a great event in its own right, in the same region (M_S = 8.3, March 28, 2005).

It seems tribal communities have learnt to live with earthquakes and tsunamis. This was amply manifest in the response of their built habitat to the twin disasters of earthquake and tsunamis. Also, they followed a construction practice that seemed to be primitive, but the effect of strong ground shaking on their dwellings was minimal, and because of site selection it was undamaged by the tsunami too. It was observed that their traditional practice of house making, which has evolved over time, incorporated all desirable elements of earthquake engineering: like site selection, foundation aspects, planning and architectural configuration, structural details, non structural elements, and construction material. Their traditional wisdom is passed on from one generation to the next. This aspect needs to be respected and harnessed for disaster mitigation.

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REFERENCES

BIS: 1893 (2002), Indian Standard Criteria for Earthquake Resistant Design of Structures, Bureau of Indian Standards, New Delhi, India.

Shankar, D., Wason, H. R., Sinvhal, A. and Joshi, V. H. (2005). Damage due to devastating earthquake (M_W 9) and tsunami of December 26, 2004 in Andaman and Nicobar, India: A perspective, *Proceedings of the Twenty Second International Tsunami Symposium*, 27--29 June, 2005, Chania, Crete, Greece, 221-232.

Sinvhal, H., Khattri, K. N., Rai, K. and Gaur, V. K. (1978). Neotectonics and time–space seismicity of the Andaman–Nicobar region. *Bulletin of the Seismological Society of America*, **28**, 399–409.

Sinvhal, Amita, (2011), Understanding Earthquake Disasters, Tata McGraw Hill Education Pvt. Limited, New Delhi, 286p, First Reprint.

Wason, H. R, Sinvhal A., Shankar D., Kumar A.and Joshi, V. H. (2006). Ground deformation observed due to the great Sumatra earthquake of December 26, 2004 and tsunami in and around Andaman and Nicobar Islands. *Proceedings of the Thirteenth Symposium on Earthquake Engineering*, I I T Roorkee, December 18-20 (2006), 228–237.