Recent tsunami and earthquake devastation

The Indian Institute of Technology (IIT), Kanpur organised a reconnaissance study of the affected areas of the recent earthquake and the tsunami with a view to document the scientific, engineering and disaster management lessons from this tragedy. A total of 13 investigators were divided into six groups with independent responsibilities: each of the groups spent about eight days in the field, during January 1 to January 13, 2005, as per *Table* 1.

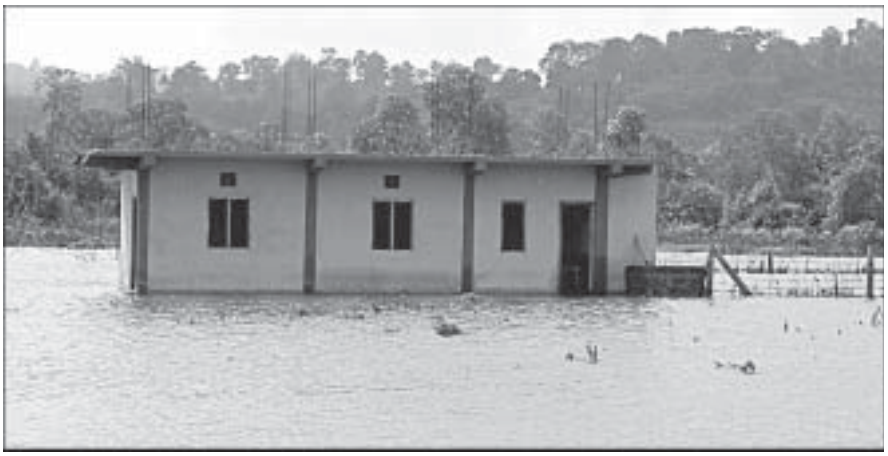

Fig 1 Sea water level at Port Blair with respect to land has gone has up by about 1 m. Hence many areas are now flooded during high tide (Photo: Sudhir K Jain)

General observations

Due to the subduction of the Indo-Australian plate under the Eurasian plate, the Andaman and Nicobar Islands experienced uplift on the western coast and subsidence on the eastern coast as seen from the field evidence. At Port Blair, located on the east coast, water level has risen by about 1 m, *Fig* 1. Western coast of the middle Andaman islands showed emergence of new shallow coral beaches suggesting an uplift.

Damage to buildings and other structures were primarily due to tsunami (as against due to ground shaking) on the mainland India. In Little Andaman and other islands south of it;

Table 1: Group investigation

Group	*Investigators*	*Activity*
1	Prof Sudhir K. Jain, IIT, Kanpur Mr Hemant Kaushik, research scholar, IIT Kanpur	Coordination, Areas around Port Blair, Meetings with administrators in Andhra Pradesh in Andaman and Nicobar islands
2	Prof C V R Murty, IIT Kanpur Prof Javed Malik, IIT Kanpur Mr Suresh Ranjan Dash, M Tech scholar, IIT Kanpur	Islands south of Port Blair; Meetings with administrators in Tamil Nadu
3	Prof Durgesh C Rai, IIT Kanpur Mr Gautam Mondal, research scholar, IIT Kanpur	Areas north of Port Blair
4	Ms Alpa Sheth, seismic advisor, Govt. of Gujarat, and consulting engineer, Mumbai Ms Pratibha Gandhi, research scholar, IIT Madras	Areas along the coast from Cochin to Chennai
5	Mr Arvind Jaiswal, consulting engineer, Hyderabad Ms Snigdha Sanyal, senior project associate, IIT Kanpur	Areas along the coast from Visakhapatnam to Chennai
6	Lt Col J S Sodhi, M. Tech student, IIT Kanpur Lt. Col G Santhosh Kumar, M. Tech student, IIT Kanpur	Car Nicobar island

Fig 2 Severe damage to Passenger Terminal Building at Port Blair (Photo: Sudhir K Jain)

Fig 3 Collapse of a stilt plus one-storey house in reinforced concrete near Port Blair (Photo: Sudhir K. Jain)

and structural damage in islands north of Little Andaman were primarily due to ground shaking.

Damages on the Andaman and Nicobar islands

Tsunami created giant waves as high as 10-12 m; in several instances, objects were found on top of the trees after the tsunami. In the islands of Great Nicobar, Car Nicobar, and Little Andaman, buildings constructed on the coast were washed away by the great waves, while those located on high grounds survived. When a number of rows of buildings existed on the coast, buildings in the first row from the sea suffered extensive damage while those in the rear rows did better due to the shielding provided by the front row. In general, constructions that were circular in plan (for example, circular water tanks, light house) did better under the onslaught of tsunamis as the water could easily flow around such objects. At Car Nicobar about 100 personnel of air-force (including the family members) lost life or are missing. However, the operational area and the airstrip survived enabling rescue and relief operations by the air force after the event.

Fig 4 Collapse of a stilt plus one-storey house in reinforced concrete near Port Blair (Photo: Hemant Kaushik)

Fig 5 Collapse of a reinforced concrete scooter stand at Port Management Board office in Port Blair (Photo: Hemant Kaushik)

Fig 6 Collapse of three-storey reinforced concrete frame building at Port Blair (Photo: Sudhir K Jain)

on stilt columns, not complying with the codal requirements, collapsed, *Fig* 6.

A number of jetties collapsed or were severely damaged in a number of islands, *Fig* 7. This has severely affected the sea traffic and hence the relief operations.

A new bridge between north and middle Andaman had to be closed to even the light vehicles. The superstructure has moved on the substructure by a substantial amount. As a result, currently one has to cross from one island to the other by foot and leave the vehicle behind. More interesting part of the story that Dr C.V.R. Murty and Dr Durgesh C Rai of IIT Kanpur had visited this region two years back after a moderate earthquake on September 14, 2002 and in their published report had expressed

Fig 7 Collapse of the 80-m segment of the approach to Great Nicobar island jetty at Cambell Bay. This has adversely affected the relief work (Photo: CVR Murty)

Fig 8 Ravaged houses at Nagapattinam due to poor construction (Photo: Alpa Sheth)

Due to the ground shaking, the wooden buildings have performed very well as compared to the more modern RC frame and concrete block masonry buildings. The latter sustained large damages wherever the seismic codes were not complied with. For instance, the passenger terminal building at the Phoenix Bay in Port Blair was recently constructed but did not comply with the seismic codes. This rather expensive building has been irreparably damaged, *Fig* 2. At least two houses built by local people using reinforced concrete but without proper engineering supervision and seismic detailing collapsed, *Figs* 3 to 5. A three-storey apartment building in Port Blair

Fig 9 Foundation failure in Kerala due to scouring of rather shallow foundation (Photo: Alpa Sheth)

Fig 10 Complete loss of the four span of a RC bridge at Melmannakudi (Photo: Alpa Sheth)

Fig 11 Small mechanised boat sunk into harbour basin being pulled out of water at Fishermen's Wharf, Chennai (Photo: Arvind Jaswal)

concerns about this very bridge as follows:

> *"Inadequate seating of bridge deck over piers and abutments is a serious concern for its safely during a stronger earthquake in future. The bearings are simple neoprene pads which are far from satisfactory for a bridge located in seismic zone V. Bridge deck restrainers are the minimum that need to be provided to ensure that the spans are not dislodged from the piers in future earthquakes."*

A free copy of the report can be requested by sending an e-mail with complete postal address to the National Information Centre of Earthquake Engineering at IIT Kanpur at nicee@iitk.ac.in.

Damages on the mainland

The fishing community living along the shore suffered the maximum damage: to its housing, to its boats and fishing equipment, and in terms of loss of life, *Fig* 8. Most houses along the coast had been non-engineered. In general, quality of construction had a major influence on the level of damage sustained by the buildings. Buildings with low foundation depth, those with poorer building materials, poor integrity and poor workmanship were worst sufferers, *Fig* 9.

Several bridges suffered serious damages. The superstructure of all four spans of a bridge at Melmanakuddi came off the sub structure and two of the spans washed away to large distances, *Fig* 10. A good connection between the superstructure and the substructure and the additional provision of restraining upstands — recommended features for seismic design — would have helped these bridges. Infrastructure in Nagapattinam district was significantly affected: a railway line on the shore, telecommunication tower and control panel room were irreparably damaged. Compound walls upto 300 m inside the shoreline were very extensively damaged.

In ports and harbours, major disturbance was caused by vessels parting their ropes and becoming loose and hitting other vessels and causing damage. Small boats and ships were tossed astray onto the land by the incoming wave and thereby damaging them. Some boats were sunk to the basin due to the returning giant waves, *Fig* 11.

Breakwaters generally did well, and helped reduce the impact of waves. Beaches shielded by landmass or by rocky cliff sustained less damage. Seawater intrusion was less in area covered with thick vegetation as compared to those with bare lands. Sand deposits due to tsunami in delta areas have damaged standing crops and affected fertility of the land.

— NICEE press release

• • •