Viewpoint

Tsunami rehab

Not just four walls and a roof

An architect's thoughts on reconstruction and design of projects in the wake of a tsunami

Our knowledge of the destructive nature and force of tsunamis is limited and is only still being developed. Even standards of earthquake-resistant design are being constantly revised to incorporate new developments in the field.

Tsunami loads are far too great and it is costly and impractical to design normal structures that are resistant to all tsunamis. There is no point in making new houses extra safe, when they cannot resist all tsunamis. What about the buildings and areas that were not affected by the last tsunami? The next tsunami could affect them as well.

To calculate the potential damage to structures, several factors must be considered, including the characteristics of the particular tsunami, the exposure of the coastline, the configuration of local bays and harbours, and the area of inundation of the coastal zone. According to Diane Pierzinski (*Tsunamis*, California Geology, Vol. 34, No.3, 1981), one of the major causes of tsunami damage is surge-carried debris piled on to the shore.

Although the distance from the sea plays a significant part in damage mitigation (the energy of the waves gets dissipated with the distance), the elevation is a more critical factor.

Section 7.2.2 of the Coastal Construction Manual published by the Federal Emergency Management Administration in United States states that:

"Tsunamis have been known to damage some structures hundreds of feet inland and over 50 feet above sea level. Coastal construction in tsunami hazard zones must consider the effects of tsunami runup, flooding, erosion and debris loads. Designers should also be aware that the 'rundown' or return of water to the sea could also damage the landward sides of structures that withstood the initial runup."

To reduce tsunami damage, the layout of new villages should consider the following aspects:

- Placing houses behind a barrier, which can be a reinforced cement concrete wall or dense vegetation.
- Elevating the buildings to allow water to pass through.
- Providing maximum spacing between the buildings.
- Providing greater mass, as with some structures that have survived the tsunami (for example, the Tranquebar Fort and the Shore Temple at Mahabalipuram), which may, however, prove very costly by present standards.

The strategy to adopt is to ensure that the structures do not collapse all of a sudden, and the occupants are able to run to a place of safety.

Expensive options

Seawalls, dykes and so on may reduce the damage, but they are very expensive and may adversely affect the environment. According to the 2001 Regional Tsunami Hazard Scoping Project Report prepared for the Wellington Regional Council by Geo Environmental Consultants, such structures constructed in Japan met with limited success as the tsunami wave heights were not accurately predicted and subsequent waves overtopped the barriers. Protective measures such as

these may be used in areas that contain essential infrastructure, such as the Kalpakkam Nuclear Power Plant in Tamil Nadu, India.

Trees that are deep-rooted, and grow with branches high off the ground, are very resistant to tsunamis. They can be used as effective barriers to partially dissipate the tsunami and catch the debris carried in the wave. The major advantage of dense vegetation over sea walls is that the former does not affect the wind movement along the coast. The planting of appropriate coastal species of vegetation would create functional and productive use for the local populations; the product yield and protection thus gives a twofold justification for implementation.

One of the best ways to do buildings is on stilts because they let the water through. If the epicentre of the earthquake is not far away, the time gap available between the warning and the real tsunami is very small, and the only way of escape is to go vertical. The houses can be made two-storeyed of reinforced cement concrete framed construction and the villagers can build around it using the normal construction practices according to their requirements.

The height of the elevated structures could be 10 feet from the ground level. There is no sanctity about this 10 feet measurement, but based on the experience of tsunamis so far, we can say that most tsunamis cause the sea to rise no more than 10 feet. Special structures such as hospitals and shelters that come very close to the sea can be built up to a height of three storeys. Building standards for common facilities such as hospitals, schools and community centres should be made very stringent, to resist even the worst of tsunamis.

The positioning of the buildings should be such as to allow the energy of the tsunami waves to get dissipated, rather than try to be a physical barrier. Giving a large plot of land for each family will facilitate a layout that will be able to resist tsunamis better.

As far as possible, the new houses should be built in the same location of the existing village. As the villagers have developed a social bonding with the places, it is very difficult to shift to a new locality. In the case of Banegaon, in Latur, India, which was hit by a 6.3 magnitude earthquake on 30 September 1993, the new village was built on the other side of the existing village. In the case of Chapredi village in Bhuj district, 125 families refused to move into a new site which was 1 km away. So we built the houses in their old plots.

New locations

Whenever a village is relocated, for some people at least, their agricultural fields become distant, and their places of work

and worship far away from their houses. In most cases, the new location of the site is never discussed with the villagers, and the decision is taken by a few government officials.

Different strategies have to be developed for villages, towns and cities, based on the cost of land. The damaged houses might have been of various sizes and belonged to people of different economic strata. The extent of land required for each has to be worked out separately.

In rural areas, the government should be able to allocate bigger plots for each family. The main advantage of this is that there will be less overcrowding in future and the villagers have more flexibility in extending their houses based on available resources.

If there is no flexibility for expansion, then another slum will be formed in the coming years. As families expand, the demand will rise for more units for the next generation. For the poor, who have very little resources left after meeting their food and clothing needs, land can be a major resource.

The old house damaged by the tsunami might have been overcrowded, and now is the time to give the affected family two houses in the new layout. Definite criteria have to be evolved to decide about the allocation of extra houses to overcrowded families.

A house located in the middle of a plot, with vacant space all around, might not suit the villagers' lifestyle. Flats and grid layouts could be disastrous. In deciding the final layout of the village, fishing communities need to factor in their relationship with the surroundings, and their occupational requirements regarding craft and gear, disposal of fish waste, and so on.

Any new housing scheme must provide each house with a lavatory of its own (communal lavatories rarely work) and with a cooking space designed so that smoke from the stove will not fill the entire house. The living and sleeping areas must be at least partially separated from each other.

One possibility is to provide a solid permanent core, or nucleus, of a house, around which the inmates can add their own rooms and living spaces, perhaps at first with only temporary materials such as mud and corrugated galvanized iron sheets and later with more permanent materials.

Common facilities

In many of the reconstruction projects, the thrust given for common facilities and infrastructure is low. Markets, a library, a community hall, schools, village council

office, and places of worship are some of the community facilities that can be added for a reconstruction project.

Water supply and sanitation plans are important. Many of the villagers might not have had toilets and bathing facilities in their old houses. The new layout can add water closet and bath and wash areas. Water storage facility is another important feature for each house. In many areas, tsunami inundation has caused salinity in the wells, which were the main source of drinking water.

One basic mistake we make in rehabilitation is that we want to give the villagers what we think is right. We never want to know their real needs. "People's participation" is an oft-repeated cliché; even where it does happen, it is only in the case of implementation, and not in the case of planning, design and choice of technology.

The villagers have to be convinced about the techniques and materials we use for reconstruction. In Banegaon village, in Latur, India, the villagers rejected stone for masonry walls because the same material had fallen over them during the earthquake. One of the buildings in the village which survived the earthquake was a building built with burnt bricks. Although brick is not a local material—it has to be transported from a distance of more than 70 km—the villagers' preference was for bricks. In Chapredi village in Bhuj district too, the villagers did not want stone for masonry walls, because many of them had collapsed. They agreed for cement-stabilized mud blocks for walls since the traditional mud structures had survived the earthquake.

One NGO had constructed houses in the shape of geodesic domes. The villagers could not relate with such shapes and they refused to live in those houses, which were eventually used for storing things.

Whatever the choice of technology for reconstruction, it is very important to make sure that the villagers and local masons are able to construct similar buildings in future. One major caution to be exercised here is that reinforced cement concrete framed structures, especially in a highly corrosive coastal environment, needs lot of care in construction and maintenance. If the quality of construction cannot be ensured, the maintenance of these structures over a period of time can lead to a serious crisis.

The quantum of construction activities which are going to take place in the tsunami-hit areas in the next one year is huge. There will be a tremendous shortage of construction workers, and migration of construction labour will occur. Wages will go up. Unskilled workers will become skilled masons overnight. Based on the experience in Bhuj and Latur, it is very difficult to ensure the quality of construction, which is very critical in the case of the structures that are going to come up.

When we built earthquake-resistant structures in Latur and Bhuj, we were quite convinced about the soundness of the structures. But the villagers always had doubts about the safety of such structures. It is very important that we bring them into confidence before, during and after construction. In Banegaon, we started living in one of the model houses. After one of those after-tremors, which was of moderate intensity, the villagers came running to the house where we were staying to check whether the structure had developed any cracks or damage.

To conclude, the housing problem is not a mere question of four walls and a roof. It is, in fact, a social problem, which has many cultural, economic, technical and political dimensions. The house as a microenvironment is very essential for the healthy living of individuals. We have to approach the problem in a holistic way, taking into account regional variations.

We can consider the following actions for the future:

- Producing inundation maps, which will help in the adoption of different criteria in the design of new buildings based on the data generated.

- Deploying tsunami warning systems. (Whether the dissemination of information can be done under the present

circumstances is still doubtful, since we need experience in responding to warning systems.)

- Locating and designing new buildings by taking into account the possibility of a tsunami in the future, and giving quality of construction extra importance.

- Providing tsunami-resistant structures that can function as shelters for people during a natural disaster, and finding alternative uses for them so that they can be justified.

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