SOUTH PACIFIC ENGINEERS ASSOCIATION

Policy

Issued July 2010

Resilient Infrastructure and Disaster Management

1. Geohazard and climatic events need not be catastrophic

On Thursday 4 March 2010, whilst launching the South Pacific Engineers Association in Suva, the President of Fiji, His Excellency Ratu Epeli Nailatikau said:

The countries in our region, like countries in other regions, are very much at the mercy of the wrath of the forces of nature in its various forms like earthquakes, tsunamis, hurricanes, drought and sea level rise.

Our very survival depends on us having the means to resist the forces of nature and protect the safety of our people, our homes and the systems we depend on for our food and our livelihood. All too often countries, and particularly those in our region, are faced with major damage to be remediated. As we all are familiarly aware of, much of that has to be repaired or completely rebuilt. This is expensive and consumes the resources we would prefer to be able to use for advancing the standards of living of our people.

Good-quality engineering is one of the primary means to resist the forces of nature. Well-engineered structures resist high winds so less rebuilding is needed. Well-engineered transport systems suffer little damage and enable us at will, to move people and resources to places where they want to go or where they are most needed. Well-engineered water supply and sanitation systems are vital just for ordinary everyday living and these are critical issues in post-forces-of-nature times of relieving human misery. Well-engineered power supply and telecommunications will also survive much better and will enable a quick recovery.

The President was very much referring to the concept of resilience – ensuring that important systems for the support of people are able to withstand the stress brought on by natural disasters (but also those that can arise through human mistakes) and able to continue to deliver sufficient if not full service throughout the time of stress. **Figures 1** and **2** show examples of failure occurring in climatic events of a size that occurs every few years in the Pacific region. In **Figure 2**, the different performance of a number of buildings is evident. Eliminating failures except in major events is vitally important to the economy of Pacific nations.

In designing infrastructure, for it to be resilient, the four key principles of disaster or emergency management must be considered: risk reduction, readiness, response at the time and then recovery. They are sometimes known as the four Rs.

Figure 1: A tower which failed in Tropical Cyclone Tomas in 2010.

Figure 2: Differing degrees of building damage in Tropical Cyclone Pat in 2010.

2. Reduction

Reduction of risks in the context of creating resilient infrastructure is very much achieved by applying good engineering standards as an ongoing long-term process. Risk reduction should be applied not just to publicly owned infrastructure, but also to private infrastructure – particularly building and water supply systems. The key elements for infrastructure that arise from identifying and analysing risks, trying to eliminate them, and at the very least reducing their potential impact, are listed below.

- Identifying a suitable worst-case load condition that must be tolerated – designing for too infrequent events adds unjustified cost, but if the design event threshold is too low then the infrastructural system may fail. In the absence of any better information, climatic information from northern Australia and earthquake information from New Zealand might be applied to determine the worst-case load arising from climatic or geohazard events.
- Select a technical design standard suitable for meeting the worst-case load condition – care is needed in this step because sometimes combinations of circumstances that arise in tropical marine climates (e.g. corrosion resistance to overcome the salt load in wind and wind speed) may be more demanding than in other countries for the same design event. Donors of infrastructural projects may not be aware of this issue and may inadvertently under-design assets for the service conditions in the participating nation.
- Enforce the requirements rigidly during construction – it is vital that the actual construction quality fully meets the design specification. This can be a problem with poorly trained labour, or with labour imported specifically for the project. Further, inspectors need to have a high level of technical skill, and maintaining that skill level requires government commitment.
- Inspect and maintain the asset regularly – this needs a systematic programme of inspection and repair carried out by qualified persons.
- Where the infrastructural assets are publicly owned, initiate and maintain an asset management plan (AMP) over the top of these activities – the application of the principles of asset management will assist to ensure that appropriate financial provisions are made, and management systems put in place.

If these steps are taken, then the assets will have the maximum possible resilience to withstand the forces of nature. Whenever an event below the design threshold (which might be an event not likely to occur more than every 50 to 100 years) occurs, the asset will suffer little or only minor damage and the service loss will be minor, and the nation will not suffer major economic loss through the need to rebuild.

Another aspect of risk reduction is the development of hazard maps and utilisation of these to assist in siting infrastructural assets. It is important that the land topography is understood so that the potential inundation zones arising from either tsunami, or from storm surge generation can be identified. Inundation zones from rainfall-induced flooding also need to be considered. Many countries have an urgent need to define at-risk zones through investment in mapping – even identifying all areas that are (say) less than 10 metres above sea level and treating these as risk areas would be a major advance.

Critical bridges, road sections and transmission lines can then be sited away from these risky zones. Because bridges often carry other services like water and wastewater pipes, it is particularly critical that special attention be given to their siting. Even if embankments leading to or from them are damaged, the bridge and the services it carries should not be at risk through inundation. If siting within an inundation zone cannot be avoided then strengthening and protection works need to be considered.

If there is future sea level rise through changing climate then work of this nature will prove even more critical.

The principles above extend to private housing. Without attention to proper siting and then good construction standards, housing may well prove uninsurable because the insurer assesses it as too at risk and insufficiently resilient to common weather events. Case studies in which it is demonstrated that the extra costs of ensuring a low-risk site is selected and a house built to good standards is constructed are far less than the ongoing costs of recovery/rebuilding would be extremely helpful to convince local people to change. Additionally, in developing and implementing planning rules and construction standards, the government or local authority needs to stand firm on allowing exceptions to good practice.

3. Readiness

The concept of readiness is normally implemented through the development and ongoing review of an emergency response plan. For example, if the infrastructural system of concern is electricity supply, then the particular risks imposed by the cyclone seasons should be identified – holding stocks of wire and poles at their highest level at the onset of the cyclone season, having a plan by which the number of skilled linesmen that can be made available is sufficient, having diesel to fuel generators in more than one tank in more than one location, maintaining a high diesel inventory against the possibility that inwards shipments might be disrupted through port damage etc.

It is particularly important to recognise the critical elements of infrastructure and ensure these have the highest levels of readiness. These include backup generation plant (e.g. for hospitals and to keep the airport operational so supplies can arrive).

It should be recognised that following a natural disaster there are both immediate and longer-term medical concerns (dealing with injuries), medium- and long-term concerns with public health (safe water, sanitation), longer-term concerns with food supply and housing people, both immediate and longer-term needs to re-establish communications, and needs to restore power supply. All such matters need to be addressed in the emergency response plan.

Recognising any potential for cascading failure is vitally important. If one asset cannot operate without supply of a service from another then damage to one cascades to the other. The best example is loss of power supply – if that stops other services operating then a cascade failure has occurred. In a high state of readiness the potential cascades are identified and readiness plans put in place.

A high level of infrastructural resilience is a critical factor in maintaining readiness – response and recovery is much easier.

The question of putting in place early warning systems for climatic or geohazard events is more one for meteorologists and geohazard scientists than for engineers, but the importance of such systems is acknowledged.

4. Response

Response is the term given to the initial period following a natural disaster. Even after the application of the risk-reduction strategy and even with a high state of readiness in a major event, a critical element of infrastructure may still need repair. If the work on risk reduction and readiness as outlined above has been properly implemented then the on-the-ground response can be effective even if the overarching management systems cannot function fully effectively for some time after the event.

A major part of the on-ground response can be through community organisations. The major utility providers should have response plans to restore their own networks, but community organisations are often well-placed to act as a clearing house for information, can assist to assess local needs and can deal with local distribution of emergency supplies.

Engineers have a critical role in the early response phase. Whilst there are a wide variety of groups who can determine the needs of affected people in general terms, engineers are able to provide quantitative advice far better than other occupations. For example, if building materials are needed, what materials, if a water treatment plant need be sent, what size? Therefore engineers should preferentially be used for natural disaster assessment.

Although not as critical in the Pacific as in larger economies, structural engineers have a special role in determining the safety of structures after earthquake or other damage. Critical questions can be answered including – can a building be re-occupied, or just visited to recover critical property or should it not be re-occupied at all? Is a hydro- or water-supply dam still safe?

If a register of engineers with knowledge of particular infrastructural assets is maintained by the government disaster management office (DMO), it may be possible to deploy an engineer with specific knowledge of the asset being evaluated, which is even more valuable to the community and the nation.

Pacific nations are recommended to also record Australian or New Zealand engineers with specific knowledge of assets in their country – if a request for help is to be made to Australia or New Zealand, the assistance of these particular people can be specifically sought.

5. Recovery

In the recovery (rebuilding) phase it is vital that any damage is repaired back to a standard that fully restores the resilience of the asset, but also of the community it serves. This may mean accepting a temporary repair to restore service but it is vital that the temporary repair is not left in permanent service. If temporary repairs are allowed to become the permanent solution then future resilience may be placed at risk.

Much of the recovery phase will involve engineers – restoring electricity and communications, repairing transport assets such as ports, airports and roads, restoring water supply and waste management systems, and repairing buildings. A major risk factor for any nation during this period is not having sufficient engineering capacity to undertake the volume of work necessary. If this is the case, the work may not be well done, and future resilience will be compromised, with more-than-necessary damage occurring again. This wastes precious financial capital.

6. The critical role of engineers

Although health professionals also have a critical role of a different kind, engineers are the most critical profession to determine the success or otherwise of plans to improve infrastructural resilience and to manage disasters.

It is vital that governments involve their local engineering community actively in the development of both disaster management plans, in the installation, operation and maintenance of infrastructure, and in the enforcement of standards in the construction of privately owned assets. It can do this by working co-operatively with the national professional engineering body.

Government need not be the direct employer of all the engineers deployed in an emergency. Rather, if enduring contracts and arrangements are put in place with engineers working in the private sector, (but only activated upon demand) those engineers can be called on as required without there being ongoing cost. When an engineer is needed at short notice, the process of deployment should not be slowed by the need to negotiate terms of engagement – that can be pre-agreed. The national engineering body can have a major role in facilitating such arrangements.

7. Disclaimer

The South Pacific Engineers Association (SPEA) is the non-aligned association of national professional engineering bodies in the South Pacific. It seeks to contribute on matters of national and regional importance. One part of its contribution is to issue position papers, which give a learned view on important issues, independent of any commercial interest. Such notes are not consensus papers of the Association membership, although they have been widely peer-reviewed amongst the membership. Others are free to quote or use materials from this note.