

1 Introduction

On January 31, 2005, ASCE sent a team of engineers to the west coast of Thailand to investigate and document damage resulting from the December 26, 2004 tsunami. This tsunami was caused by a magnitude (M_w) 9.0 earthquake off the coast of Sumatra, Indonesia southwest of Thailand. The team, led by Curtis Edwards, P.E., included members from ASCE's Technical Council on Lifeline Earthquake Engineering (TCLEE) and the Coast, Oceans, Ports and Rivers Institute (COPRI). In addition, the Institute of Civil Engineers (ICE) provided assistance (one of the first joint international collaborations by ASCE) along with local engineers from Chulalongkorn University.

The investigation covered about 150 km of the coastal region including the highly impacted areas of Phuket, Khao Lak and Phi Phi Don Island. Although approximately 10,000 fatalities were suffered, the team focus was to document damage to coastal lifelines and other coastal facilities incurred by the tsunami generated from 500 miles to the west.

Rugged cliffs interrupted by pocket beaches characterize the Phuket coastline. These beaches are highly developed and contain most of the resorts, commercial support, and resident housing for the communities. Many of these facilities are in close proximity to the beach and were subjected to the most destructive forces of the tsunami. The tsunami was generally characterized by a receding wave followed by three surging waves, depending on the location. The first wave was the smallest but still did a great deal of damage. As a result, the second and third waves contained large amounts of debris, such as trees, furniture, cars, glass, and rocks, that caused far more casualties and damage than the saltwater waves alone.

The sewer systems, electrical systems, roads, and bridges suffered significant damage. One of the more interesting findings of this investigation was the excellent performance of high-density polyethylene pipe (HDPE) which was used for both water and sewer systems. As the roads eroded exposing the pipe, the continuously jointed (butt weld joints) pipelines would simply conform to the new contours with very few separations. This allowed for rapid repairs and service restoration soon after the tsunami. Coastal steel water towers performed very well due to their slender nature and deep foundations.

In contrast, the debris-laden waves took their toll on many other coastal lifelines. On Phi Phi Island, the water system consists of many individual public/private wells, reservoirs, and tank systems. Those located in the low areas were completely inundated by the saltwater waves. Some systems were temporarily restored.

The lower lying portions of the sewer system in Patong Beach were completely flooded by the tsunami waves. This included large portions of the gravity sewer system and six of their 13 pumping stations. The waves introduced salt water into the system, which entered the activated sludge type treatment plant causing it to fail. All six of the damaged pump stations were still out of service at the time of the investigation, five weeks past the event. In addition, all six control panels were destroyed and each station (all submersible pumps) was filled with sand and debris causing them to fail. Only one of the six pump stations had a temporary pump and panel installed since there are no spare panels available in the area.

Many of the electrical power systems were disrupted along much the tsunami-affected areas. Thailand uses reinforced concrete power poles, which have been known to do very well during earthquakes. However, many of these poles were battered by debris and sheared off at the base. In addition, the older poles were very short allowing the up to 10-m surge submerge the electrical and

communications facilities. In the Phuket area, the electrical utility was in the process of replacing all of the short poles with taller ones. As a result, the new poles were onsite, and those that were damaged were being repaired quickly.

Most of the bridges in the region are reinforced concrete supported on piers, abutments, and deep foundations. Most of the damage was associated with abutment scouring and erosion and battering of concrete railings. Minor erosion was simply repaired using fill to restore the road surface. The railing damage had not been repaired, leaving an on-going safety concern. One bridge in Khao Lak was reported to have been swept away because of severe approach/pier erosion.

Khao Lak, a new upscale resort area north of Phuket, was completely devastated by waves that exceeded 10-m high in places. Resort infrastructure was almost total destroyed and all hotels are closed for extensive repair. Foundations were scoured, walls collapsed by wave pressure, and roof tiles removed by wave impact. Damage was severe to both first and second floor apartments. Nonetheless the beach, which was severely eroded by the tsunami, is recovering rapidly in this area. At least 100 ft. of beach has been accreted naturally since December 26. Many damaged hotels are now being demolished. Others stand like ghost towns.

A fishing port, Ban Nam Ken, north of Khao Lak, had extensive damage to concrete piers and nearly all the fishing fleet either destroyed in place or washed 1 km inland. It was also reported that a sewage treatment plant was inundated by the waves.

Lastly, one aspect of the restoration process found during this investigation, compared to many others around the world, was that repairs/restoration was moving very rapidly. Unfortunately for documentation of damages, much of the debris has been cleared on the hundreds of kilometers of inundation areas inspected. Sixty percent of the destroyed/damaged buildings had been demolished and removed. Fifty percent of the remaining buildings are under restoration with over 1 percent of them already open. This is a true honor to the people of Thailand.

In stark contrast to the mainland recovery efforts, Phi Phi Island, where approximately 3,000 people were killed, it was only now beginning to recover. This island is mostly privately owned and requires boat or helicopter access. As a result, recovery has been slow. Originally, the provincial government would not allow the disposal of collected debris. This decision was reversed around February 1, and now clearing and disposal by barge is progressing.

In addition, it was indicated that Phi Phi Island would begin a planning process to limit construction in the vulnerable areas to avoid future catastrophes. Much of the formerly developed area that was wiped out will apparently be converted to a memorial park.

Lessons Learned

Other than development of an early warning system, one of the greatest lessons learned from the event is that designers need to plan for tsunami inundation and the force of impact from the waves and associated debris. Structures can be designed with “flow-through” first stories with limited structural areas facing the tsunami. Another aspect is that drainage control for the ebbing tide is just as critical. Adequate drainage in facilities could be an effective means to prevent erosion and impact damage of critical infrastructure facilities.

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