A Study on Future Perspective of Disaster-Prevention Studies Obtained through the Inspection of 2004 Indian Ocean Tsunami-Devastated Sites in Thailand

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Tsunami, which was exemplified by 2004 Indian Ocean tsunami, notified the world of its threat, signifying quite a few unresolved issues on tsunami studies. In order to acquire on-site information and detect clues to the unresolved issues, Coastal Development Institute of Technology sent its own field survey teams to the tsunami-devastated sites of Thailand in March and April. This paper presented summaries of survey outcomes obtained in March field trip.

Key Words: tsunami, field survey, earthquake, disaster, Thailand

1. Introduction

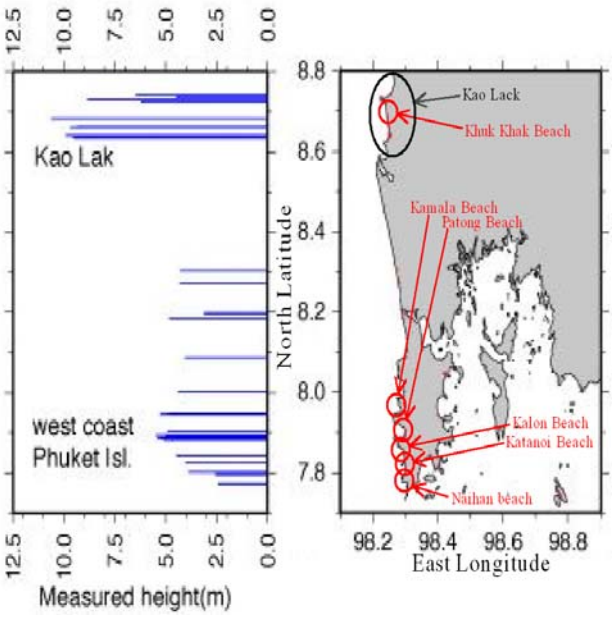
Coastal Development Institute of Technology (CDIT) has been making disaster-prevention studies in coastal areas among its main tasks. The importance of tsunami study is growing so as to reduce impacts owing to such earthquakes as Tokai, Tonankai-Nankai and Miyagi. Occurring on December 26, 2004, 2004 Indian Ocean tsunami with Sumatra-Andaman earthquake notified the world not only of the threat of tsunami but also the importance of countermeasure to it. In order to incorporate views concerning the tsunami into our research activities, while collecting data from several reports both by Japanese government and Japan Society of Civil Engineering, CDIT sent its own field survey squads to the tsunami-devastated sites in Thailand. This report summarized the first phase field survey in this March.

2. Outline of 2004 Indian Ocean tsunami

Sumatra-Andaman earthquake, magnitude of which is estimated at 9.0 with its focal region of 800km, originated in the Indian Ocean off the west coast of North Sumatra at 07:58:53 local time on December 26, triggering massive tsunamis that obliterated seaside communities in a dozen countries, especially inflicting catastrophic damages there. The first tsunami arrived in South Thailand and Sri Lanka two hours after the seismic strike. Even in the east coast of Africa 5000 kilometer off the seismic center, the tsunami was subsequently detected ten hours later. In more than 20 spots at Banda Aceh of North Sumatra, over 20-meter high tsunamis, the maximum height of which was 34.9 meters, were observed. In other areas, reported are such cases as over 10-meter high tsunamis in Kao LAK beach of South Thailand, those ranging from 5 to 6 meters in Phuket Island and so forth. Worldwide efforts were made for recovering devastated sites where approximately 300,000 people were killed, however there still remain yet-to-be-revived areas even two months after the catastrophe.

3. Purpose of Field Survey

CDIT's "First-Phase squad for 2004 Indian Ocean Tsunami survey", composed of the authors of this paper, visited the devastated sites in Phuket Island and Kao Lack beach of South Thailand on March 13th and 14th to make its field studies on aftermaths owing to the tsunami. Surveyed spots are depicted in Fig.1.



The above figure was excerpted from an internet website, http://www.drs.dpri.kyoto-u.ac.jp/sumatra/thailand/phuket_survey.html, of Disaster Prevention Research Institute, Kyoto University.

On 13th, the authors visited beaches of Patong, Kamala, Karon, Katanoi, Katayai and Naihan, all of which are located in east coast of Phuket Island, to investigate their afflictions and

rehabilitations. On 14th, we made a field survey on the planting density and damages in Khuk Khak beach of Kao Lack. These surveys were practiced with researchers both from Independent Administrative Institution, Port and Airport Research Institute and from Prince of Songkla University.

4. Aftermaths of Devastated Sites

Damages in Kamala beach and Khuk Khak beach of Kao Lack had remained unchanged for two months when we visited.

Kamala Beach in Phuket Island

Kamala beach, located in the center of Phuket Island, is 2000-meter long seashore, ranging in its width from 30 meters to 50 meters. Several Pine trees were found there. The vertical interval between its seashore and ground was approximately one meter and that between its sea and ground was approximately two meters. There were located hotels, roads, pathways, buildings and resort houses, mutual positions of which are depicted in Fig.2, behind surveyed spots.

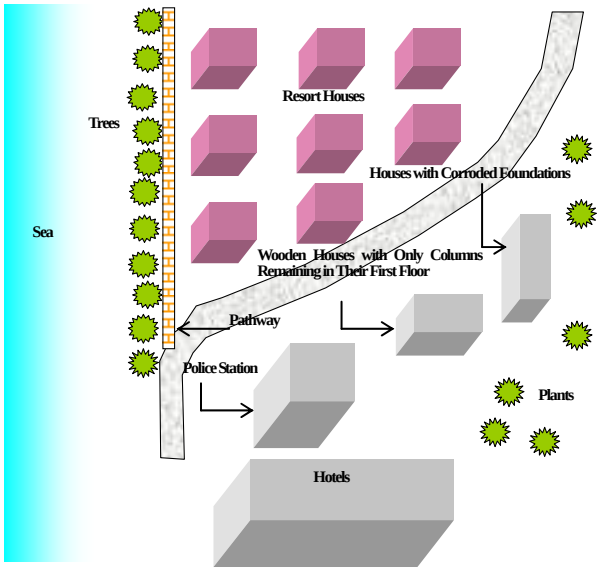


Fig.2 Air View of Surveyed Spots in Kamala Beach
Note: Precise distances among facilities are not shown up above.

A resort house owner who experienced the tsunami said that he could escape from the first wave, because its height was below his body. The second wave 15 minutes later, however, was high enough to be over the roof of his house. While finding works for rehabilitation and rubble removal of some damaged facilities, we could also find many damages in other facilities. Impacts on facilities due to the tsunami can be characterized by collapses of their seaside walls, depicted in Fig.3, excepting their columns and base structures. These impacts are reduced according to the distance from the coast. Dwellings in further inland areas, however, also suffered from noted damages, which were supposedly induced by the invasion of the tsunami into intervals between resort houses. Most of pathways were significantly inflicted; especially some of their surfaces were depressed by the outflow of their sand bases. Such damages, depicted in Fig.4, were notable in their seasides with no plants.

Fig.3　A Resort House Damaged in its Front

Fig.4 A Pathway Damaged by the Suction of its Base Sand

Hotels, fronts of which are open for the sea, also received severe damages, their recovery works going under way. It is considered that, judging from the discoloration of its nearby Palm trees' leaves, the police station, located near the coast road in the north of hotels, was struck by 4 to 5-meter high tsunami, remaining intact due to its firm structure depicted in Fig.5. In contrast, disastrous damages of wooden houses in further inland area, depicted in Fig.6, are characterized by missing walls in their first floors, and corrosions of their foundations. It is presumed that these damages were caused by the passage of highly energized tsunami.

Fig.5 Unaffected Building of Police Station

Fig.6 A Wooden House Sustaining Columns in its First Floor

Khuk Khak Beach in Khao Lak

We made surveys on damages around Theptharo Lagoon Beach Resort in Khuk Khak beach of Central Kao Lak. There were doted cottages, each of which are 10 meters wide, 15 meters deep and 4 meters high, along the coastline of lagoon shaped as sandpit. Since simple structures were installed in cottages, all of them suffered from such severe damages as disconnections between their superstructures and substructures, fractures of their members, inclinations or collapses, submersions under the lagoon and so on. We found disappearances of their front walls or collapses of their column in half of cottages. As for cottages near the sea, their damages, which are noted as complete collapses of their structures or those of their superstructures such as columns and walls, were more significant than cottages along the lagoon. Two cottages located farthest from the coast, however, remained comparatively intact, receiving small injuries only in their walls. Besides, traits of corrosion were also found in footings of many cottages. Most of pile foundations that were installed in the lagoon remained structurally sound. Many of newels on balconies, though they are set in forefronts of cottages, remained undamaged.

Attentions should be paid to Fig.8 showing a damaged house, around which its back and forth walls facing the sea were missed and rubbles of its 10-centimeter thick walls were scattered around. In addition, several bicycles also lay broken inland.

It is presumed that all aforementioned damages were also caused by same phenomenon as that in Kamala beach.

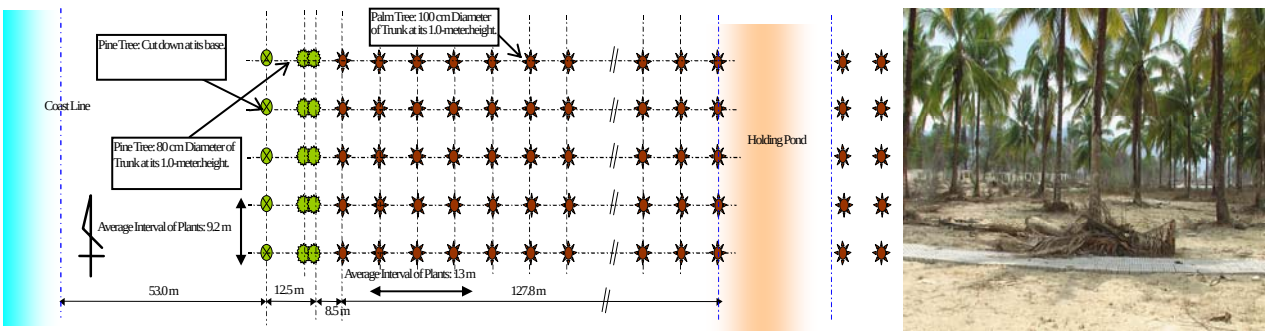
Fig.8 A House Damaged in its Seaside Wall

Survey on Planting Density

Planting density around Kao Lak Orchid Hotel was also investigated. Fig.9 depicts a survey outcome obtained in the south of the hotel. A part of pine trees that were planted before the development of surveyed spot remained in the coast, and the forestations of palm trees were gridironed at 10-meter intervals in approximately 100-meter wide inland zone. Trunk diameters of Palm trees were about one meter, and heights of them ranged from 10 to 30 meters. In 10-meter upper part of most trees, which were positioned in the third to the forth line of the planting strip, their barks were peeled. Levels of their peelings tended to be lower in accordance with the distance from the coast.

It indicates that planting strip with its observed degree of planting density did not perform enough to weaken the strength of the tsunami. Furthermore phenomena that roots of the trees prevented the outflow of beach sand and the collapse of ground were found not only in some spots but also in other beaches

Fig.7 Damaged Cottages



a) 200-meter South of Orchid Beach Resort

b) Conditions of Palm Trees

Fig.9 Survey Result of Planting Density

Fig.10 Corrosions at Bases of Trees

Other Beaches

Patong beach, the tsunami into which was reported worldwide by the media, is one of typical beaches in west coast of Phuket Island. We found some damages such as breaches of pavements in parking lots, corrosions of basements of trees and structures, collapses of coastal facilities due to outflows of foundation grounds and so on. But these damages did not affect civic life there any more. The beach was crowded with many visitors. Shops in the streets were also run as usual.

In Kalon beach, formed was the sandbank that is 4 to 5-meter high and approximately 10-meter wide. No particular damages were seen behind its back. In Katayai beach, rehabilitation works for damaged walls of hotels went under way. Some depressions due to outflows of sand basements were found there. In Katanoi beach, seen were such trails as the collapse of its riverbank, accumulated dusts in the coast and so on. In Naihan beach with large level gaps between its sea and ground, few tsunami trails were seen. There were many tourists, which are depicted in Fig.11.

Fig.11 Kata Yai Beach Crowded with Visitors

5. Conclusions

It is one of the most basic strategies against tsunami to predict their impacts. Based on this field survey, our summaries concerning on-site statuses during the tsunami strike are as follows:

(1) Hydraulic Traits of the Tsunami

The tsunami characterized by its significant fluid force made impulsive strikes on damaged structures, passing through intervals of structures, plants and so on with its strong impetus. Phenomena of such strikes and run-ups depended on geographical and sites conditions.

(2) Collapses of Structures and Plants

Buildings closest to coasts suffered from severe damages. While damages of bearing-wall structures were notable in their seaside walls, those of wave-pervious structures such as column structures were comparatively small. Furthermore rigid structures lied durable. As for trees, although their barks facing the sea were peeled, they remained intact.

(3) Characteristics of Ground Collapses

While surroundings of foundation structures were deeply corroded by the tsunami, roots of trees were presumed to be effective in preventing both outflows of sand basements and collapses of grounds.

It is generally known that hazard map can be an efficient tool to predict impacts due to tsunami. As this field survey clarified that impact due to tsunami could depend on geographical and land use conditions, it indicated the importance of hazard map that can present reliable information to reduce the impact due to tsunami. It is considered that issues to be resolved in further studies should be as follows: clarifications of fluid and impulsive forces of tsunami, the mechanism of tsunami passage between structures; the evaluation of structural performance against the strike of tsunami; the improvement of structural durability of coastal facilities. In addition, even though enough data on the correlation between planting density and tsunami could not be obtained, further research between them will continue to be one of the most important themes on tsunami studies.

6. Acknowledgments

Sumatra-Andaman earthquake and 2004 Indian Ocean tsunami killed quite a few people. Through this field survey, we firmly recognized the emergency to prevent such tragedies forever. It is hoped that this paper can be helpful in presenting one of the useful references not only for CDIT but also those whom it may concern. In conducting this field survey, we would like to express our sincere appreciations to Dr. Tetsuya Hiraishi, Head of Wave Laboratory at Independent Administrative Institute of Port and Airport Research Institute for his kind leads and advices. We strongly recommend that all readers shall refer to “First-Phase Report on Field Survey of 2004 Indian Ocean Tsunami” published by CDIT on May 2005, for more information.