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An assessment of building vulnerability to a tsunami in the Galle coastal area, Sri Lanka

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ABSTRACT

Tsunami vulnerability assessment is the initial step for effective planning and implementation of tsunami risk reduction. Whilst the high tsunami risk of the Galle coastal area is well known, the structural vulnerability to tsunami hazards has never been assessed. This paper presents tsunami vulnerability for structures, relative vulnerability indexes, and vulnerable areas in Galle city, Sri Lanka. To develop the relative vulnerability index map, data on 705 buildings in terms of attributes of the building, protection of the building, and depth of the water flow at the building location were obtained from field surveys. The results of the structural vulnerability assessment show that if the 2004 Indian Ocean tsunami were to occur today, 35% of the buildings would be affected in the Galle coastal area and when we consider the 100 m buffer zone, this value increases to 56%. Buildings with minor vulnerability constituted around only 3% inside the 100 m buffer zone.

1. Introduction

Cities located in coastal areas are vulnerable to tsunami disasters because of the concentration of people, buildings, infrastructure, and socioeconomic activities in the area. Once the tsunami strikes, there will be tremendous losses and damage in the city [1]. A total of 350 thousand people died in the Sumatra–Andaman earthquake on December 26, 2004 in one of the 10 worst earthquakes and the Indian Ocean tsunami is the worst natural disaster of that kind [2]. Sri Lanka was the most affected country by the 2004 Indian Ocean Tsunami after Indonesia.

Before 2004, only two historical tsunamis were known in Sri Lanka [3]; the December 31, 1881 tsunami after an earthquake in the western central part of the Bay of Bengal and the August 28, 1883 tsunami after the earthquake in South Sumatra. But compared with the 2004 Indian Ocean tsunami, these two tsunamis are very modest. During the 2004 tsunami disaster, between 31,000 and 37,000 people were killed by drowning or debris impact and nearly 100,000 houses were destroyed in Sri Lanka. Fig. 1 shows the run-up height, horizontal inundation distance, total number of dead and missing people, total number of affected people, and the total number of damaged housing units on a district basis all around the island due to the tsunami attack in December 2004 [4]. Hettiarachchi [5] recommended that attention must be focused on early warning and evacuation relating to the rapid onset of extreme events which can impact coastal communities within a very short time and still remains a major challenge. Satyanarayana et al. [6] provided an indication of vulnerable and less vulnerable areas along the Sri Lankan coast in the face of ocean impacts. They identify that, among the coastal sites, Trincomalee, Yala, and Puttalam are "less vulnerable" areas whereas the Kaluvanchikudy-Komari area and Jaffna are "vulnerable" areas. In addition, they mention that for the less vulnerable areas, multispecies mangrove and dense vegetation coastal features such as sand dunes, and Casuarina and coconut plantations are suggested to help reducing vulnerability. Samarasekara et al. [7] reported that not only natural barriers but also physical infrastructure which is not designed to defend against tsunamis can nevertheless provide some protection to buildings located behind them. For the future planning and development of the coastal area, identification of which parts of the coastline are more vulnerable to a tsunami event is essential. The use of various satellite data sets and remote sensing methods for tsunami damage detection was and is still a topic of several studies [8–11]. The post-tsunami field surveys allowed researchers to understand the damage along the coasts of Sri Lanka [12,13]. Most of the field surveys were focused on the coast of eastern and southern Sri Lanka, where major effects were expected.

Mehdiyev et al. [14] studied the tsunami disaster damage detection and assessment in the Galle coastal area using high-resolution satellite data, GIS, and GPS. By a combination of high-resolution satellite imagery, visual interpretation, and ground truth GIS data, a tsunami damage map of Galle city was generated in this study. It also shows that visual observation with the support of standard GIS and image processing can enable damage identification and mapping to be done very

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