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Risk Analysis of Road Structures in Sri Lanka due to the 2004 Giant Earthquake and Tsunami in the Indian Ocean

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Houses and infrastructures in Sri Lanka were extensively affected by the tsunami due to the 2004 Giant Earthquake and Tsunami in the Indian Ocean. More than 200, 000 totally and partially damaged houses caused more than 42, 000 fatalities and missings. The road structures along the east, south and west coast in Sri Lanka were affected and more than 9 bridges were severely damaged and collapsed. A clarification of the damage mechanism of affected houses and infrastructures are necessary to go on the reconstruction and rehabilitation of those structures in the country and propose the countermeasures against the tsunami wave loads. In this study, focusing on the damage of road structures, especially bridges, the tsunami wave loads were inversely identified based on the damage assessment of the damaged bridges in Sri Lanka. From the analysis the relation of the tsunami wave velocity with the tsunami wave heights was clarified. Added to the risk analysis of road structures due to the tsunami, the hydraulics model experiment was done for the models of the affected bridges to evaluate the dependence of the collapse of the bridges with the dominant physical parameters of tsunamis. From the field surveys for the affected areas in Sri Lanka, more than 60 data in terms of the damaged bridges could be collected. The bridges along the road in the northeast coast in Trincomalee, and along the A2 road in the west, southwest and south coast between Colombo and Hambantota were surveyed. The position and dimension of bridges, and distance from the coastal line to the target bridge were measured. The data of tsunami wave heights on the sites were collected based on the hearing from the habitants in the area, or the measurement of the inundation heights marked near the houses. The damage of the bridges was categorized to washed-out or movement of decks, severe damage of abutment, and damage of attachments upon decks such as rails and lumps. Firstly, based on the collected 60 data, the damage of bridges due to the tsunami was related with the tsunami wave heights that were from 1.22m to 12.37m, and the fragility of bridges against the assumed tsunami wave heights was clarified. The 9 data among the 60 data indicates that simple spanned bridges without the suitable shear keys between the deck and its supporting pier, or abutment are fragile against the tsunami wave. Secondly, by using the data related to washed-out or movement of decks, that were 9 data, assuming that the drag force of the deck to the tsunami wave becomes equivalent to the friction force between the deck and another structural component, the tsunami wave velocity on the site was inversely computed. Varying the dominant parameters in the computation such as the friction coefficient and the

coefficient of the drag force, the sensitivity of the inversed tsunami velocity on the tsunami wave heights was analyzed. In the case of the friction coefficient of 0.6 and the coefficient of the drag force of 2.0, the values of the tsunami wave velocity that are 4.1 m/s to 10.6 m/s, related to the tsunami wave heights become higher ones than the values evaluated by the previous studies. In the hydraulics model study, assuming the 3 types of model bridges, and 4 or 5 types of the deck configurations in each model bridge, totally 13 case studies were conducted by varying the tsunami wave heights and wave velocity. It was found that the boundary regions in terms of the safety and the damage of decks due to tsunamis were distinguished to propose the numerical equation in the relation between the tsunami wave heights and wave velocity. The dependence of the slenderness ratio and the mass of decks onto the tsunami wave velocity, in which the damage of decks due to tsunamis occurred, was clarified.