

Effects of Sand Dune and Vegetation in the Coastal Area of Sri Lanka at the Indian Ocean Tsunami

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This study explored the effects of coastal vegetation and sand dune on tsunami protection based on field observations carried out after the Indian Ocean tsunami on 26 December 2004. Study locations covered about 250 km (19 locations) on the southern coast of Sri Lanka. The representative vegetation was classified into six types according to their habitat and the stand structures of the trees. The impact of vegetation structure on drag forces was analyzed using the observed characteristics of the tree species. The drag coefficient, including the vertical stand structures of trees, C_d -all, and the vegetation thickness in a unit area, dNu (d : reference diameter of trees, Nu : number of trees per unit area), varied greatly with the species classification. Based on the field survey and data analysis, *Rhizophora apiculata* and *Rhizophora mucronata* (hereafter *Rhizophora apiculata*-type), kinds of mangroves, and *Pandanus odoratissimus*, representative tree that grows in beach sand, were especially found to be effective in providing protection from tsunami damage due to its complex aerial root structure. Two layers of forest in the vertical direction with *P. odoratissimus* and *Casuarina equisetifolia* and a horizontal forest structure of small and large diameter trees were also important for increasing drag, trapping floating objects, broken branches, houses, and people. The vertical structure also provided an effective soft-landing for people washed up by the tsunami or for escaping when the tsunami waves hit, although its dNu is not large compared with *R. apiculata*-type and *P. odoratissimus*. The breaking moment of trees were investigated for the representative trees by pulling test. The threshold value for breaking was compared with the situation whether the trees were broken or not at the tsunami event. The breaking moment equation represents well the limitation of the representative species with the tsunami height. Sand dune and lagoon is a typical landscape in most part of the coastal zone of Sri Lanka. The combination of the sand dune followed by vegetation towards landside played an important role in Rekawa and Hambantota in Sri Lanka. On contrary, without vegetation at coast, the tsunami was accelerated when it overtopped the sand dune and large scale scouring was occurred and the houses and vegetation in the lagoon were destroyed. These information should be considered in future coastal landscape planning, rehabilitation, and tsunami hazard mapping.