Form 2

Dissertation Abstract

Report no.	(Course-based) No.1229	Name	**Rahman Md Abedur**
Dissertation title	**Reduction of local scouring and tsunami energy by various types of landward vegetation behind a coastal embankment (堤防背後の様々なタイプの海岸林による津波エネルギーと局所洗掘の低減)**		

Abstract

※ The abstract should be in keeping with the structure of the dissertation (objective, statement of problem, investigation, conclusion) and should convey the substance of the dissertation.

Due to the excessive local scouring near the toe, many protective structures were severely destroyed at the Great East Japan Tsunami (GEJT) in 2011. For the mitigation of tsunami energy, the coastal forest is being considered as an effective natural protection and/or mitigation measure with respect to both environmental and economic aspects. After the disastrous event in GEJT, the mitigation strategy against tsunami inundation is drifting from only sea embankment to hybrid system arrangement of seaward levee and coastal vegetation. Thus, this study focused on reducing the local scouring and tsunami energy reduction by employing different types of coastal vegetation in landwards behind a coastal embankment, in five different phases, as a countermeasure against local scouring and tsunami energy reduction.

In the first phase, a series of laboratory experiments using a compound mitigation system in which a seaward embankment (E) followed by landward coastal vegetation (V) over a mound (M) (EM_V) was investigated in supercritical flow conditions, as a countermeasure against tsunami inundation. The changes of flow around the mitigation system and energy reduction were clarified under varying conditions of mound height and vegetation density. Cases of an embankment followed by only a mound (EM_{NV}) were also considered for comparison. Experimental results showed that three basic types of flow structures were observed within the mitigation system in EM_V cases. A water cushion was created within the mitigation system mainly due to the combined effects of the mound and vegetation. It significantly reduced the maximum total energy in EM_V cases by approximately 41%–66%, whereas in EM_{NV} cases the maximum energy reduction was found to be 23%–65%. Increments in both mound height and vegetation density can increase the intensity of the water cushion within the mitigation system by offering more drag and reflecting the flow, and hence can significantly reduce the energy of the flow.

In the second phase, to countermeasure the scouring and reduce tsunami energy, a series of laboratory experiments were conducted with the case where vertically double layered vegetation (VDLV) was introduced behind the seaward embankment on a gravel bed. The experimental results demonstrated that the overtopping flow from the embankment experienced a submerged hydraulic jump over the embankment, against all the considered cases. The dense VDLV i.e., dense (G/d=0.041, where G is the clear gap between the cylinders in the cross-stream direction, and d is the cylinder diameter) short submerged vegetation (L_1) incorporated within a sparse (G/d=2.125) tall emergent vegetation (L_2)

influenced the scour phenomena. It reduced the relative scoured depth by approximately 29−41% at the embankment toe, the maximum scoured depth by approximately 29−37%, and the scoured length by approximately 28−34%, as compared to that of single embankment system. Furthermore, dense VDLV provided the maximum i.e., 49−53%, loss to the total flow energy. The increase in the density of L_1 in VDLV offers a larger drag to the flow by shifting the position of the submerged hydraulic jump more towards the embankment top; hence, consequently results in significant reduction of scoured depth, scoured length and energy of the tsunami flow.

In the third phase experiment, a horizontally double layered vegetation is introduced as a countermeasure against local scouring and tsunami inundation. In can be seen that, due to the direct hitting of the overflow to the ground a large scour hole was generated in Case 1 (i.e., OE case), however, the magnitude of the scour hole is greatly reduced after the installation of HDLV of different configurations. The maximum reduction in scoured depth at the toe of the EM, the maximum scoured depth, and the scoured length, were found to be approximately 13%-31%, 11%-27%, and 12%-28%, respectively for HDLV cases, compared to the percentage difference with OE case. Due to the generation of scour hole and resistance offered by the HDLV, a submerged hydraulic jump was formed on the downward slope of EM and its position is shifted toward the EM top by varying different configurations of HDLV. This phenomenon caused an increased water cushion within the defense system, therefore a maximum of 52% of total relative energy reduction is observed in HDLV cases. Compared to that single-layered vegetation case, HDLV cases can reduce scouring within the defense system significantly due to the dense and intermediate configuration of the short layer.

In the fourth phase, as a countermeasure against local scouring, this study performed a series of flume experiments with landward forests models (the combination of a short frontal forest (SF) and a second tall forest (TF)) behind a coastal embankment model (EM) on a gravel bed). The effect of damming by tsunami-borne driftwood on scouring was also investigated. The maximum reduction of the scour depth at the EM toe, maximum scour depth, and scour length were found to be approximately 44.1–65.2%, 30.2–58.6%, and 21.9–41.9% compared with the single embankment system when the SF was placed between the EM and TF (i.e., Case 3). Moreover, damming (i.e., Case 5) was also found to be effective in reducing local scouring around the EM toe. However, at the highest overflow depth, significant scouring was observed beneath the formed driftwood dam, which implies the washout of SF. Both Case 3 and the damming case increased the energy reduction due to the increased water cushion effects within the defense system. However, considering the vulnerability of TF, Case 3 is recommended to mitigate a large tsunami.

The final phase experiment mainly focused on the utilization of damming. A series of model scale experiments were conducted to clarify the effect of debris dam on local scouring and energy reduction behind a coastal embankment (EM) on a gravel bed, where the tsunami induced debris (TBD) were modelled as an original tree. Moreover, to elucidate the influence the realistic modelling, the debris were also modelled as a circular cylinder for the comparison purpose. Experimental results show that, the Case 5 (i.e., 8 rows of TBD were placed starting from EM toe) resulted a maximum reduction of the scoured depth at the EM toe about 40.8−65.2%, maximum scoured depth about 36.3−56.5%, and scoured length about 34.1−41.9%. The trapping capability of the forest is decreased greatly when the TBDs are modelled as circular cylinders compared to the original tree debris. With the increase of rows of TBDs, the damming effect was increased which consequently resulted a greater shifting of position of the submerged hydraulic jump toward the EM top, hence reduced a noteworthy reduction in local scouring near the EM toe by reducing the intensity of the overflow depth to the ground. Therefore, due to this phenomena a maximum 43.6 % to 48.8% of total relative energy reduction of the tsunami flow is found in Case 5 i.e., when 8 rows of TBDs were placed starting from the EM toe.

In this study, various types of vegetations were introduced as countermeasure against local scouring and tsunami inundation, thus based on the land availability, proper management of vegetations, locations etc., the suitable vegetation configurations can be selected from the introduced systems in different objectives of this dissertation. The findings of this dissertation are important for the ideal design procedures of the defense structures in the coastal regions However, to make the findings of these study more fruitful, further experimental investigation by changing the gap condition and increasing the width of the vegetation models, clarifying the loads acting on the trees under damming conditions is necessary is required.