Protection of Sea Wall against Earthquake and Tsunami using Flexible Material.

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1. Introduction

Tsunami activated by earthquake is known to be one of the most powerful natural disaster which causes serious damage to many coastal protection structures. For example, tsunami generated by Tohoku earthquake of magnitude Mw-9.0 followed several compound disasters in coastal area of Japan in March 11, 2011. Many coastal protection structures such as seawalls and breakwaterswere found to be damaged seriously.But, surprisingly a waste tire retaining wallwhich was located just about 150 m away from a completely collapsed sea wall was found to be neither damaged nor scoured by tsunami. To know the reason behind that, many site investigations and laboratory tests were conducted by Hazarika et al (2013).This case study revealed that the flexible material like tire can resist the earthquake and tsunami forces due to advantageous physical and mechanical characteristics that such material possesses. According to destruction mechanismdue to earthquake and tsunami,the damage of the sea wall is mainly due to scouring at the back of the structures by drainage impact force and undertow (back wash) impact force of tsunami. Hence, to protect sea walls from earthquake and tsunami, construction of tire retaining wall behind sea wall as shown in Figure-1 is considered to be one of the effective measures.

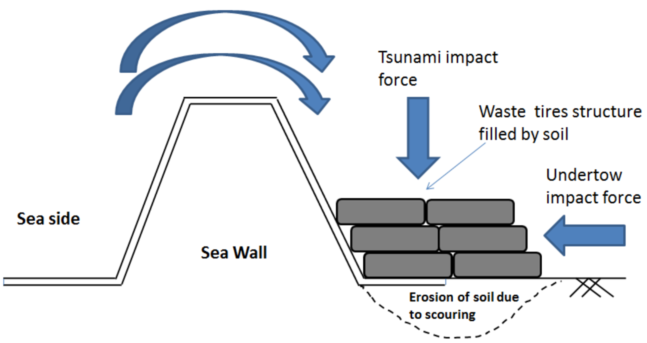

Figure 1 Protection of seawall by waste tire structure

Main purpose of this research is to demonstrate how effectively tire will function against the earthquake and tsunami to protect concrete sea wall. A new model for simulation of tsunami impact force (length 120 cm, height 100cm, width 30cm) has been developed in Geotechnical Engineering Laboratory of Kyushu University. The schematic diagram for the simulated condition used in the research is shown in Fig.2 and Fig.3. There is a hinged gate on the top of embankment model to reproduce the overflow phenomena by water reservoir. Water Falling Test (WFT) is conducted for the sea wall with tires behind it.

At the same time, in order to preserve the environment, field experiments were also performed in which various types of plants were cultivated inside the soil-filled tires to see how the greening effect could be maintained to preserve the environment as shown in fig. 4 and 5.

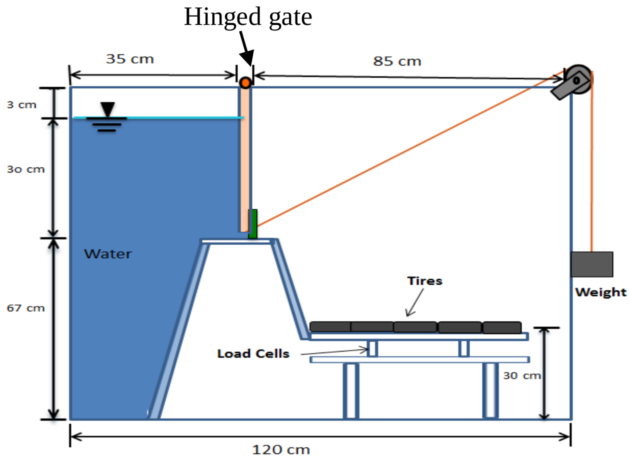

Figure 2 Cross Section view of Water Falling Test apparatus (Model for simulation of tsunami impact force)

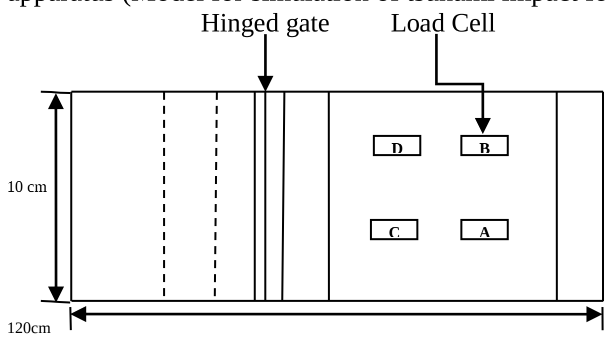

Figure 3 Top view of Water Falling Test apparatus

Figure 4 Real tire

Figure 5 Cultivation of Plants inside of real tire

2 Water Falling Test (W.F.T.)

Model tires (85mm outer diameter and 21 mm thickness) filled with Masado soil compacting to dry density of 1.43gm/cm^3 as shown in figure 4 & 5 are used and the tire samples are subjected by water impact force. Performance of the tire retaining wall under the impact force of water was observed. Then reduction of water impact force is calculated by connecting with data loader.

Figure 6 Tire model (Hollow)

Figure 7 Tire model (filled with soil)

Keywords: Tire retaining wall, Impact Force, Scouring,
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Several testing configurations have been conducted for different condition of tire placement so that the performance could be easily evaluated and the results were compared with the case of without using tire behind the sea wall.Following are the different cases tire specimen for the experiment.

Case 1: Without tire, Case2: 2 Layer of tires without soil Case 3: 3 Layer of tires without soil , Case 4: 2 Layer of tires with soil, Case 5: 3 Layer of tires with soil, Case 6: 3 Layer of stepped tires with soil.

Figure 8 Different condition of tire placement for WFT

3 Test Result

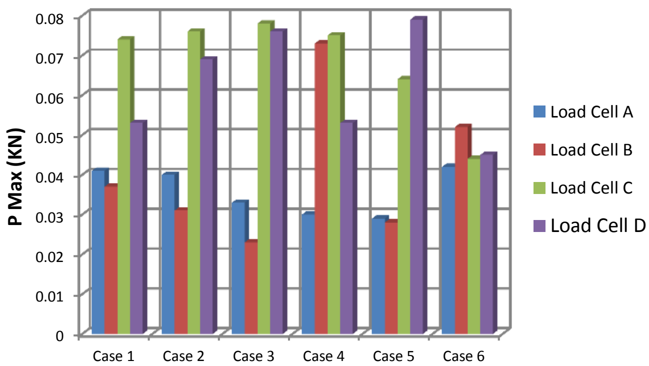

Figure 9 Maximum value of impact force each case.

Figure 9 shows water impact force recorded by each load cell A, B, C and D for each case. As seen from the figure impact force was reduced gradually in case 2 and 3 for load cell A and B in compare to case 1 when the layer is increased for hollow tire. Similarly impact force was reduced gradually in case 4 and 5 for load cell A and B when the layer is increased for tire filled with soil. Likewise, impact force was reduced significantly in case of 6 for Load cell C and D in compare to case 1.

4 Cultivation of plants in the tire structure

Kirinsou and Dichondra salt-tolerant plant has been used which is considered to be capable of withstanding the salinity condition. The plants were cultivated inside the tires filled with soil maintaining dry density of 1.43 gm/cm^{3}to see how effectively plants could maintain green and beautiful environment. Following cases of specimen has been carried out for the vegetation experiment and observed the possible growth.

Case ２：Tire two-stage, Case ３：Tire three-stage
Case ４：3 gear tire (stepped)

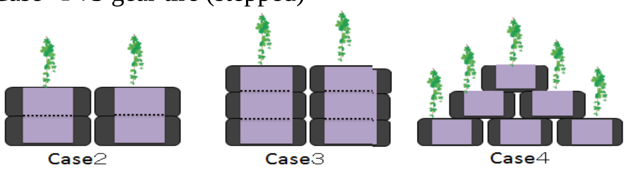

Figure 10 Different condition of tire placement for Cultivation

2 layer 3 layer 3 layer slope
Figure 11 Decondra in different cases at the end of July 2013

2 layer 3 layer 3 layer slope
Figure 12 Kirinsou in diff. cases at the end of July2013

2 layer 3 layer 3 layer slope
Figure 13 Decondra in diff. cases at the end of Setp.2013

2 layer 3 layer 3 layer slope
Figure 14 Kirinsou in diff. cases at the end of Sept.2013

Figure 11 and 12 are photos of Decondra and kirinsou plants for case 2, 3 and 4 taken at the end of July 2013 respectively. Similarly, figure 13 and 14 are photos for Decondra and kirinsou plants for case 2, 3 and 4 taken at the end of September 2013 respectively. As seen photos from figure 11 and 13, Decondra plant is growing satisfactorily from the month of July 2013 to September 2013. Similarly, as seen photos in figure 12 and 14, Kirinsou plant is also found to be growing satisfactorily from the month of July 2013 to September 2013.

5. Conclusion

Results from the tsunami impact force test showed a better performance. However accuracy should be improved by increasing the number of load cells. Also, field test shows that the greening effect could be maintained by planting trees inside the tires and could be one of the effective methods for recycling of waste tire.

REFERENCE

Hazarika, H.,Hara, T. Furuichi, H. 2013. Soil-Structure Interaction during Earthquake and Tsunami – Two Case Studies from the Latest Disaster in Japan, *Eighteenth International Conference on Soil Mechanics andGeotechnical Engineering, Paris, France, 131 – 142.*

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