A numerical study on the effectiveness of tire chips reinforced quay wall subjected to static and dynamic load

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1 INTRODUCTION

Various mitigation techniques to protect waterfront retaining structures has been studied since the occurrence of the 1995 Hyogo-ken Nanbu earthquake which severely damage waterfront structures in Kobe Port as well as its facilities. Amongst the various existing techniques, the use of tire derived material has been getting attention. The used of such material not only provide an alternative in construction projects but also can reduce the stockpiled of the waste tires. Since tire derived material is the non-biodegradable materials, the long term stability of the material in the soil will not be an issue.

The main purpose of this study is to investigate the effectiveness of tire derived material in the form of chips as a reinforcement behind waterfront retaining structures from the numerical point of view. Laboratory experiments of this study has been conducted in Hazarika et al. (2006), Hazarika et al. (2008), Hazarika et al. (2010), Hazarika (2012) and Hazarika et al. (2012).

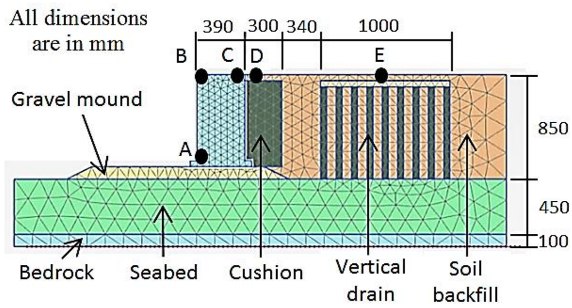

Fig. 1 Finite element mesh for the case of quay wall reinforced with cushion and vertical drains

2 METHODOLOGY

For this study, numerical models of a quay wall were constructed using PLAXIS 2D. Three study cases were considered which the first one consists of conventional quay wall without any additional element inside the soil backfill (Case 1). The remaining cases consist of the quay wall which reinforced with tire chips cushion (Case 2) and the combination of tire chips cushion and tire chips vertical drains (Case 3) respectively. The finite element mesh for the case of the quay wall reinforced with both cushion and vertical drains made of tire chips is shown in Figure 1. The numerical models were subjected to the seismic motions experienced in Port Island of Kobe during the 1995 Hyogo-ken Nanbu earthquake.

3 RESULTS AND DISCUSSION

Figure 2 shows the resultant displacement of the node element of all the cases at the end of static condition. As for the static condition in case 1, the displacement contour of the nodes extends from the backfill until the seabed layer. In comparison to that, the presence of the reinforcement inside the backfill reduce the amount of the node displacement especially under the quay wall.

Upon dynamic loading as shown in Figure 3, large displacement of nodes observed inside the seabed in front of the quay wall. The placement of cushion behind the quay wall helps to reduce the node displacement, while the combination of cushion and vertical drains improved the displacement not only in the seabed but also inside the backfill.

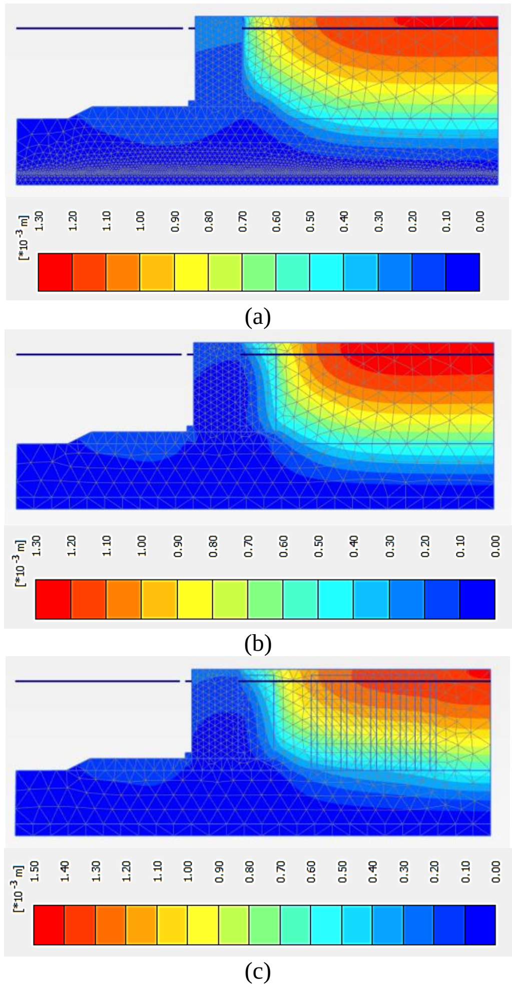

Fig. 2 Total displacement of nodes for static condition (a) case 1 (b) case 2 (c) case 3

Figure 4 shows the histories of the horizontal displacement at point B. The graph shows the comparison between the numerical study cases and the experimental results of the conventional quay wall case obtained by Hazarika et. al (2006). The horizontal displacement obtained numerically well match the results obtained experimentally except that the amount is slightly overestimated in the numerical analysis. The combination of cushion and vertical drains made of tire chips able to give sufficient reinforcement towards the quay wall in order to sustain the dynamic load.

In order to highlight the liquefied soil, the excess pore water pressure ratio at the end of the simulated time for all the cases are shown in Figure 5. The soil is considered to be fully liquefied when the pore water pressure ratio reached 1.0. Soil liquefaction observed behind the quay wall and inside the backfill in the conventional case (case 1). As in case 2, liquefied soil still presence inside the backfill which is far from the quay wall. However, for case 3, no sign of liquefied soil observed at the end of the simulated time.

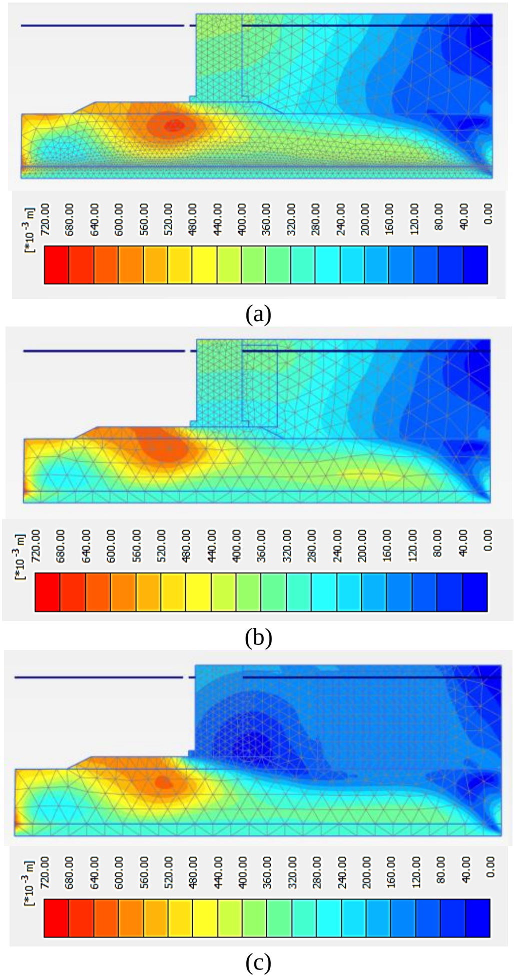

Fig. 3 Total displacement of nodes for dynamic condition (a) case 1 (b) case 2 (c) case 3

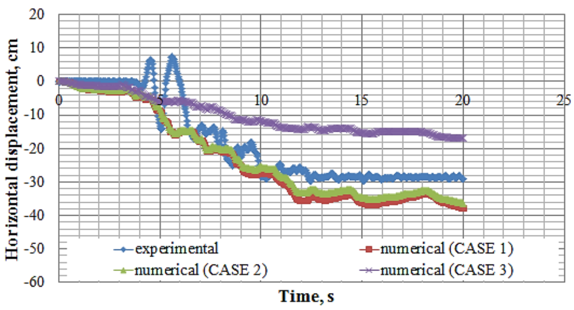

Fig. 4 Horizontal displacement at Point B

4 CONCLUSION

In this study, an earthquake resistant technique which involves the placement of cushion and vertical drain made of tire chips as part of the quay wall backfill was analyzed numerically using PLAXIS 2D software. The results were then compared with the conventional case with only sand as the backfill. In general, the reinforcement made of tire chips installed behind the quay wall and inside the backfill able to improve the performance of quay wall subjected to both static and dynamic loads.

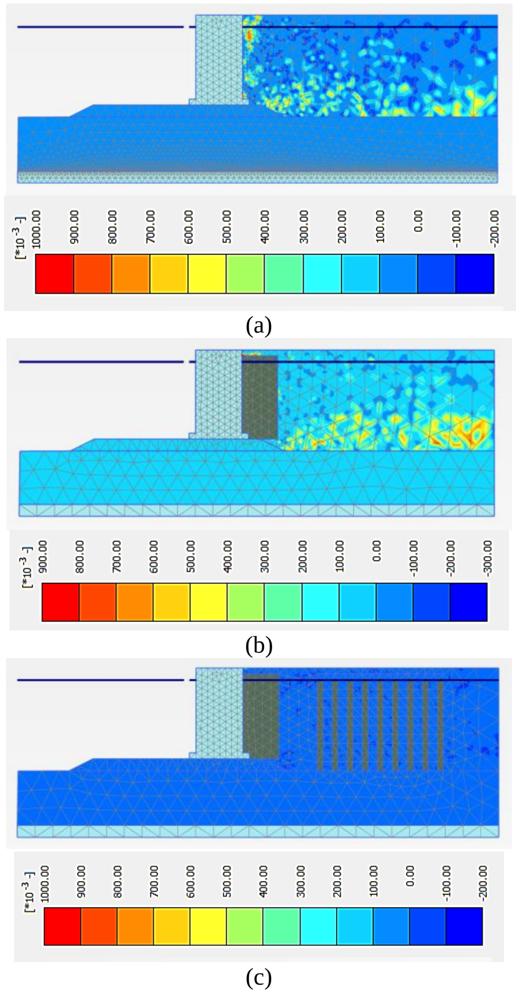

Fig. 5 Pore water pressure ratio at the end of the simulation time for (a) case 1 (b) case 2 (c) case 3

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