Features of static and dynamic field compaction of embankment slope

Suman Manandhar, Noriyuki Yasufuku, *Taizo Kobayashi, Kiyoshi Omine, Hemanta Hazarika, Satoshi Suenaga, and **Mitsuru Taniyama
Department of Civil and Structural Engineering, Kyushu University, Fukuoka, Japan
* Department of Civil and Architectural Engineering, Fukui University, Fukui, Japan
**Asakawagumi Construction Company, Wakayama, Japan

1 INTRODUCTION

The theme of research is the continuation of the first field investigation of medium-sized embankment slope of Wakayama Prefecture, Japan in which quality of the overall embankment slope was assessed and present in JSCE on 2011. In the first part of site investigation, slope of the embankment was modified into three different zones based on increasing relative compaction by tamping method using a bucket of the excavator. Usual, intermediate and high compaction energies were the relative terms given to the modified slopes and it was found that dry densities of slopes were increased. At the mean time, due to excessive water content of the embankment reduced the stiffness of the slope which received relatively highest tamping energy. Besides, there occurred scatterings of data measurements throughout the embankment (Manandhar et al. 2011). These limitations have alerted to improve in the methodology of embankment construction in the field. Therefore, it is necessary to build the embankment with low water content with compared to first field investigation. This paper will discuss the part of second site investigation of the new embankment in Wakayama Prefecture. The main objective is to improve the quality of the embankment through increasing relative degree of compaction by based on simple and improved compaction methodologies.

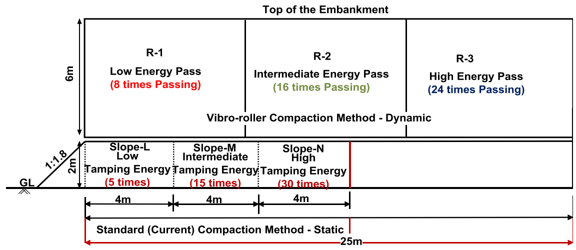

Fig. 1 Geometry of the construction of field embankment.

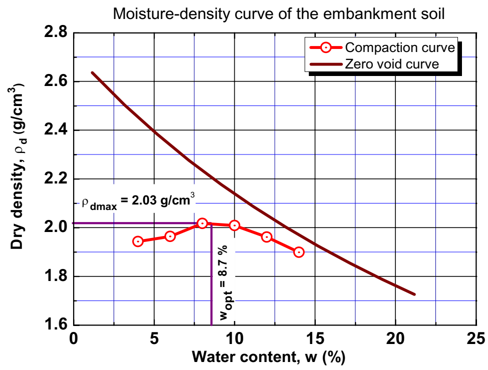

Fig. 2 Moisture density curve of the embankment soil.

2 FIELD AND LABORATORY CONSIDERATIONS

2.1 Embankment characteristics

The embankment slope has dimensions of 25 m in length with 1:1.8 and 1:1.5 slope gradients. The height of the slope from the ground level is 2 m. The slope gradient of 1:1.8 has been subjected for modification of slopes as shown by Fig. 1. Two types of compaction methodologies, static and dynamic compaction have been adopted to build the embankment. Bucket of excavator was used to provide static compaction by tamping the slope. Similarly, vibro-roller was used at the top of the embankment to provide dynamic compaction. The bucket of excavator had been used to create beautiful slopes. Hence in initially built embankment, simple static compaction methodology has been applied on the slope of the embankment. In this study, half part of the slope has been partitioned equally into three parts (Fig. 1) and at first about 30 cm thicknesses of soils was remolded again. During remolding, three different compaction energies have given to slopes. As the main theme is to improve the quality of the embankment slope, counting of number of blow has been considered to make easy to understand. Three different slopes (L, M and N) have been named based on increasing number of tamping blows by bucket of tamping. Slope-L has been subjected to 5 number of tamping blow for each compacted layer. Similarly Slope-M and Slope-N have been subjected to 15 and 30 tamping blows respectively. Proceeding, dynamic compaction by vibro-roller has been performed at the top of the embankment. The horizontal area has also divided into three equal dimensions and named as R-1, R-2, and R-3 respectively. R-1 is the portion which has been generally considered as the construction company as the standard/usual compaction and 8 numbers of passes have been used. Then, number of vibro-roller passes has been increased to 16 and 24 numbers of vibro-roller passing to recompact the horizontal area of R-2 and R-3. Afterwards, field measurements have been carried out to delineate the improvement of the quality and discuss the results obtained by the simplest compaction methodologies.

2.2 Field and laboratory measurements

The site investigation constitutes two parts. The field measurements were taken for initially built embankment and modified embankment to make comparisons between usually constructed embankment and modified ones. Three important parameters were traced in the field to check the features of embankment by compaction methodologies. Radio isotope (RI) nuclear density gauge was used to obtain the desire dry density of the embankment. If optimum water content and maximum dry density of the embankment soil are known through Proctor test in the laboratory and set up in the RI, it directly gives the wet and dry densities together with relative degree of compaction at measured section. Similarly, portable falling weight deflectometer (FWD) was used to know the stiffness of the entire embankment. It measures the force and acceleration

Key Words: embankment slope, static and dynamic field compaction, dry density, water content, stiffness

by load cells and accelerometer by free falling of a circular disc which is developed at the geotechnical laboratory, Kyushu University (Ninomiya et al. 2009). Finally, samplings from each section were collected to know the moisture content of the embankment.

Laboratory tests include particle size analysis, maximum and minimum densities, specific gravity, moisture content of the field and to determine moisture-density curve by standard Proctor test. Gravelly sand with few fines has initial moisture content of 13. 35 %. The maximum dry density and optimum water content of the field soil are 2.03 g/cm^3 and 8.7 % respectively (Fig. 2).

3 RESULTS AND DISCUSSIONS

The simplest compaction methodology using bucket of excavator in the slope with increasing tamping blow differentiating into three zones showed that dry density was increased up to 88 % of relative degree of compaction with some scattering (Fig. 3). When vibro-roller was used at the top of the embankment, relative degree of compaction was increased nearly up to 95 % (Fig. 4). Similarly, soil stiffness of the slope was also increased with increasing tamping energy (Fig. 5). However, Fig. 6 shows decrease in stiffness in intermediate compaction energy by vibro-roller compactor at the top with some fluctuations on measuring data. But in case of the highest number of passing, the stiffness was also increased. Water contents were increased with increasing compaction energies in both horizontal and slope of the embankment. When water content was exceeded to optimum water content of laboratory result, stiffness was fluctuated. Near to optimum water content slightly increased the stiffness in the slope while higher water contents fluctuated the results of stiffness of the ground indicating the moisture content is the most sensitive parameter to control the stiffness of the ground.

4 CONCLUSION

The simplest bucket tamping on the embankment slope with increasing number of tamping increased the relative degree of compaction along with stiffness of soil. At the mean time vibro-roller also achieved more relative degree of compaction at the top of the embankment. However, there are some fluctuations in data in measuring stiffness. Therefore, it is necessary to conduct some elemental tests in the laboratory to find the target value of good soil stiffness which cope with moisture content and would help to generalize the field condition at that dry density.

5 ACKNOWLEDGEMENTS

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6 REFERENCES

Manadhar, S., Yasufuku, N., Omine, K., Kobayashi, T., Hazarika, H., and Taniyama, M. 2011. Quality of embankment slope based on compaction energy: A case study. 66th Annual Meeting of JSCE, Matsuyama, Shikoku, Japan, September 7-9, 2011:143-144.

Ninomiya, H., Yasufuku, N., Omine, K., & Kobayashi T. 2009. Characteristic and purpose of portably nondestructive evaluation device of slope soundness. 44th Annual meeting of JGS, August 18-21, Yokohama: 69-70.

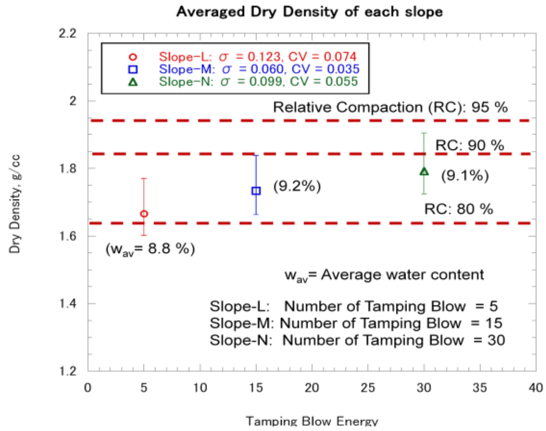

Fig. 3 Increase of dry density with increasing tamping compaction.

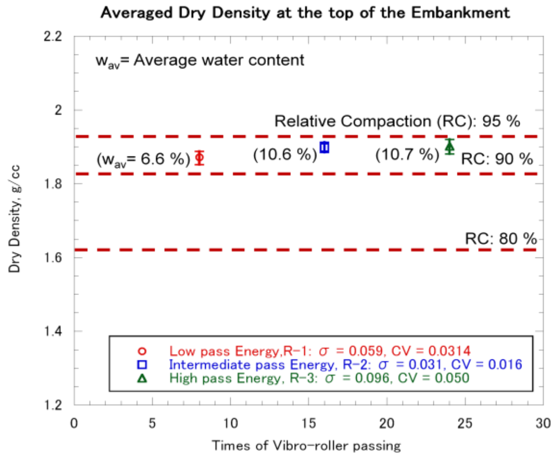

Fig. 4 Increase in dry density by vibro-roller compaction.

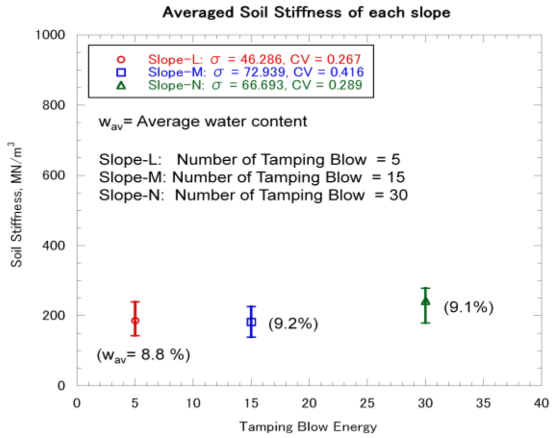

Fig. 5 Tamping compaction increases stiffness in slopes.

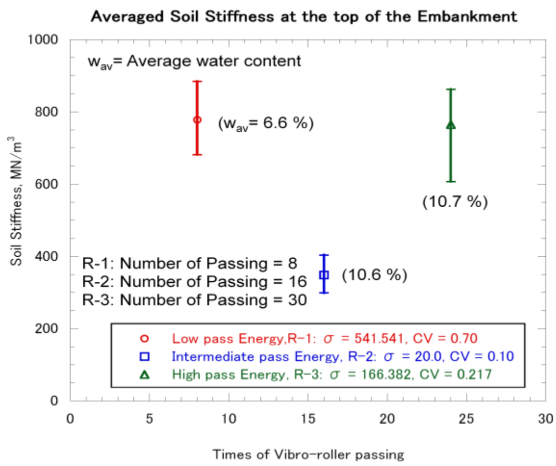

Fig. 6 Fluctions of stiffness by vibro-roller compaction.