Static examination of the interface behavior of the filter soil material-the asphaltic concrete core using direct shear apparatus- Case study: Mijran dam

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ABSTRACT

Recently, the advantages of using of asphalt concrete in the core compared to clayey core have increased the application of core asphalt concrete in embankment dams. Due to the importance of interfacial behavior the asphaltic core and soil filter in the stability of these dams and the need for a more detailed investigation of the complex behavior of materials in the core-filter interface, in present research, interfacial behavior of soil filter and asphalt core in the Mijran embankment dam (Mazandaran province) was investigated. For this purpose, a direct shear apparatus in the large scale is used. Soil materials, including clayey gravel (GC) and poorly graded gravel (GP), are according to the grain size distribution used in Mijran dam construction. In this research, the influence of factors such as compaction percentage of filter material and shear rate were investigated on shear strength and interlocking parameters (dilatancy angle and shear stiffness), as well as interaction ratio in the soil of filter and the core asphalt concrete interface. In this investigation, the ratio of the interfacial friction angle of soil material- asphalt concrete to the soil materials friction angle was defined as the interaction ratio. According to the findings, upon increasing the compaction level, the increase amount in the interaction ratio in the interface GP material was higher compared to the GC material in the interface. On the other hand, the influence of the shear rate on the interaction ratio was similar in both the GC and GP materials in the interface.

Keywords

Embankment dam, core asphalt concrete, large- scale direct shear apparatus, soil material-asphalt concrete interface, interaction ratio

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1. Introduction

The embankment dam is a structure or facility that is built on the river or canal by using materials without the mortar, in order to store and raise the water surface behind it [1]. The large eambankment dams in the world are built with different materials and there are three proposals for their construction: 1. Earth core; 2. Reinforced concrete or asphalt surface or geomembrane at upstream; and 3. Asphalt concrete core [2]. Compared to an earth core, the placement and compaction of asphalt concrete is less sensitive to adverse weather conditions. Asphalt concrete is practically impermeable, flexible, resistant to erosion and aging, efficient and compressible, and allows the construction of a jointless core [3]. The interaction of asphalt concrete and filter soil material in the dam with asphalt concrete core plays an important role in the performance of this type of dam [4]. In relation to the static and dynamic analysis of the dam with asphalt concrete core in laboratory, as well as the numerical modeling of this type of dam, there have been studies (Tajdini et al. [4-5]; Abdelaziz [6]; Cong et al. [7]; Zhang et al.[8]; Beren et al. [9]; Ghaffari & Binay [10]; Raj Bhat [11]).

By reviewing the relevant literature and previous studies, it can be said that there are few studies regarding the static investigation of the behavior of the interface between soil materials and asphalt concrete core in embankment and rockfill dams with asphalt concrete core. In the aforementioned studies, a direct shear device with a small box was used to investigate the interface behavior. Therefore, due to the limitations that exist in the results resulted from experiment with a small-scale shear box, the need to conduct research with a large-scale direct shear device is felt in order to investigate the behavior of the interface element. On the other hand, despite the influence of factors such as the relative density of soil materials and shear rate on the behavior of the interface, these factors have not been given much attention in the studies related to asphalt concrete core dams.

2. Methodology

In order to investigate the effect of variable parameters, i.e. the type of filter material, the relative density of the filter material and the shear rate, on the strength parameters of the filter soil material and the interface between core asphalt concrete and filter soil material (the interface materials), 2 sets of tests have been conducted in large-scale direct shear machine, using UU method, according to ASTM-D3080 [12] standard. The specifications of the samples made for large-scale direct shear test have been presented in Table 1. In this table, GC and GP, Dr, V and B, are referred to soil materials, relative density, shear rate and bitumen, respectively.

Table 1. Specifications of samples made for direct shear test

Variable parameter	Specimen name
Relative density	GC-Dr(50, 65, 80%)-Dry-V(1mm/min)
	Asphalt (B:4%)-GC(Dr:50, 65, 80%)-Dry -V(1mm/min)
	GP-Dr(50, 65, 80%)-Dry-V(1mm/min)
	Asphalt (B:4%)-GP(Dr:50, 65, 80%)-Dry -V(1mm/min)
Shear rate	GC(Dr:65%)-Dry-V(0.5, 1, 1.5, 3mm/min)
	Asphalt (B:4%)-GC(Dr:65%)-Dry-V(0.5, 1, 1.5, 3mm/min)
	GP(Dr:65%)-Dry-V(0.5, 1, 1.5, 3mm/min)
	Asphalt (B:4%)-GP(Dr:65%)-Dry-V(0.5, 1, 1.5, 3mm/min)

3. Discussion and results

3.1. Investigating the effect of relative density on shear strength parameters (cohesion and internal friction angle)

According to the changes in the shear strength parameters, it can be seen that in GC materials and GC interface materials, with the increase of relative density from 50% to 80%, cohesion and internal friction angle have an upward trend. On the other hand, in both categories of GP materials and GP interface materials, under dry conditions, with an increase in relative density from 50% to 80%, the amount of cohesion and internal friction angle, decreased and increased, respectively.

3.2. Investigating the effect of relative density on the interaction ratio

The ratio of the internal friction angle of the interface to the internal friction angle of sand materials (δ/ϕ) is called the interaction ratio. The changes of the interaction ratio against the relative density are shown in Figure 1.

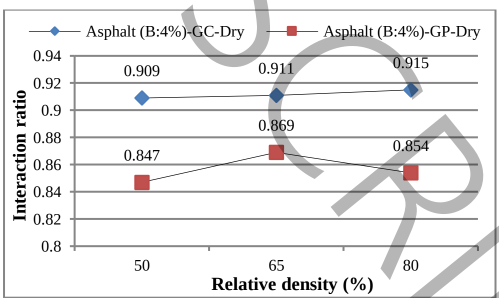

Figure 1. Changes of the interaction ratio in terms of relative density, under dry conditions and normal stress of 300 kPa

Figure 1 indicates an increase in the interaction ratio with an increase in relative density, in both categories of GC and GP interface materials.

3.3. Investigating the effect of shear rate on shear strength parameters (cohesion and internal friction angle)

By examining the cohesion changes of the samples, for different shear rates, it can be seen that in both categories soil materials (GC and GP) and GC and GP interface materials, with increasing shear rate, the amount of cohesion has increased. Regarding the changes in the internal friction angle, it can be said that in GC and GP soil materials, increasing the shear rate did not affect the value of the internal friction angle and its value remained constant. In the GC and GP interface materials, the internal friction angle has slightly increased with the increase of the shear rate from 0.5 to 3 mm/min.

3.4. Investigating the effect of shear rate on the interaction ratio

The changes of interaction ratio against different shear rates are shown in Figure 2.

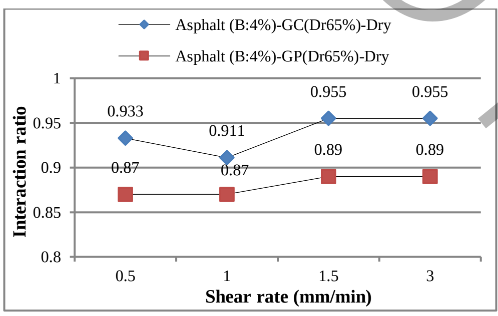

Figure 2. Changes of the interaction ratio in terms of shear rate, under dry conditions and normal stress of 300 kPa

Examining figure 2 shows that with the increase of the shear rate from 0.5 mm/min to 1 mm/min, the interaction ratio decreased and with the increase of the shear rate to 3 mm/min, the interaction ratio increased and reached a constant value. Also, by comparing the interaction ratio values of GP materials under different shear rates, it can be seen that with the increase of shear rate from 0.5 mm/min to 1 mm/min, the interaction ratio remained constant at 0.87. By increasing the shear rate from 1 mm/min to 3 mm/min, the interaction ratio increased by 2.3% and was fixed at 0.89.

4. Conclusions

According to the results of this study, the interaction ratio, for different values of relative density in dry conditions, for GC and GP materials, in the ranges of 0.909-0.915 and 0.847-0.869, respectively, and for different values of shear rates in dry conditions for GC and GP materials was obtained in the ranges of 0.911 -0.955 and 0.870-0.890, respectively.

5. References

[1] M. Fatahian, M. Yousofzadeh, Y. Koohzadian, Analysis Of Foundation And Fuselage Of Dams In Static And Quasi-Static By Using Numerical Models, Journal of Engineering & Construction Management, 1(2) (2016) 11-15.

[2] H. Shafiei, M.S. Eskandari, A review of the embankment dam with asphalt concrete core, International Journal of Science and Engineering Investigations, 5(8) (2016) 111-114.

[3] K. Höeg, Asphaltic concrete cores for embankment dams, Norwegian Geotechnical Institute Publicatie1993.

[4] M. Tajdini, R. Mahinroosta, H. Taherkhani, An investigation on the mechanical properties of granular materials in interface with asphaltic concrete, Construction and Building Materials, 62 (2014) 85-95.

[5] M. Tajdini, A. Rostami, M.M. Karimi, H. Taherkhani, Evaluation of the geo-mechanical parameters of the interface between asphalt concrete and sand with applying direct shear test and numerical modeling, Advanced Materials Research, 587 (2012) 116-121.

[6] A. Abdelaziz, C.-H. Ho, J. Shan, A. Almonnieay, Effect of freeze-thaw cycles on fatigue cracking and rutting of asphalt pavements, in: Pavement and Asset Management, CRC Press, 2019, pp. 199-205.

[7] L. Cong, M. Ren, J. Shi, F. Yang, G. Guo, Experimental investigation on performance deterioration of asphalt mixture under freeze–thaw cycles, International Journal of Transportation Science and Technology, 9(3) (2020) 218-228.

[8] M. Zhang, S. Sang, Y. Wang, X. Bai, Factors influencing the mechanical characteristics of a pile–soil interface in clay soil, Frontiers in Earth Science, 7 (2020) 364.

[9] M. Beren, I. Cobanoglu, S.B. Celik, O. Undul, Shear rate effect on strength characteristics of sandy soils, Soil Mechanics and Foundation Engineering, 57(4) (2020) 281-287.

[10] J. Ghaffari, R. Binay, Investigation of loading rate effect on the shear strength of clay-sand mixture in triaxial test, Amirkabir Journal of Civil Engineering, 53(4) (2021) 21-21.

[11] D. Raj Bhat, Shear rate effect on residual strength of typical clay soils, Innovative Infrastructure Solutions, 7(1) (2022) 1-16.

[12] ASTM-D3080, Standard Test Method for Direct Shear Test of Soils under Consolidated Drained Conditions, in West Conshohocken, PA: ASTM International.