Comparing the properties of EPS and glass foam mixed with cement and sand

Comparer les propriétés d'EPS et mousse de verre mélangé avec du ciment et du sable

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ABSTRACT: One of the formations in which the waste materials can be used as a component is controlled low strength material (CLSM). CLSM is a self-compacting cementious material that is generally used as back-fill as an alternative to compacted-fill. In this study, the availability of glass foam and Expanded polystyrene (EPS) geofoam as a component for CLSM production was investigated, some geotechnical properties including strength and unit weight characteristics of composite soils were explored using several laboratory tests. When the results are compared, EPS mixtures have lower unit weight and undrained shear strength values compared to glass foam mixtures. Therefore use of glass foam will have the advantage of higher strength compared to EPS mixtures and can be used as a subbase material. As a result, it was found that a mixture containing cement, polystyrene foam or glass foam and sand, can be successfully used in some applications such as improvement of slopes and reduction of embankment weight.

RÉSUMÉ : La formation dans laquelle les déchets peuvent être utilisés comme un composant est contrôlé par matériel de faible résistance (CMFR). CMFR est un matériau auto compactant ciment est généralement utilisé comme remblai comme alternative au remblai compacté. Dans cette étude, la disponibilité de verre de mousse et Expanded polystyrène (EPS) mousse géotechnique en tant que composant pour la production de CMFR a été étudiée. Certaines propriétés géotechniques, y compris la force et l'unité de poids caractéristiques des sols composites ont été explorées à l'aide de plusieurs tests de laboratoire. Lorsque les résultats sont comparés, mélanges de l'EPS ont poids unitaire inférieur et les valeurs de résistance au cisaillement non drainé par rapport aux mélanges de mousse de verre. Donc utilisation de mousse de verre auront l'avantage d'une résistance plus élevée par rapport à des mélanges d'EPS et peut être utilisée comme le matériau de remblai. En conséquence, il a été constaté qu'un mélange contenant du ciment, mousse de polystyrène ou mousse de verre et du sable, peut être utilisé avec succès dans certaines applications comme l'amélioration des pistes et réduction du poids de berge.

KEYWORDS: cement, EPS foam, glass foam, sand, soil improvement.

1 INTRODUCTION

With the rapid increase in the need for superstructure and the increase in demand for the multi-storey high-rise buildings, composite materials are used to improve weak soils. The use of environmental and industrial waste materials as raw material in composite soils helps protect environment with the recycling of these materials while providing more economic solutions. One of the formations in which the waste materials can be used as a component is controlled low strength material (CLSM). CLSM is a self-compacting cementious material that is generally used as back-fill as an alternative to compacted-fill. Use of the recyclable materials in civil engineering industry, especially in the geotechnical applications as raw materials, contributes to the economy and the environment.

In Turkey, a considerable sum of solid waste materials is made of glass (DPT, 2001). Glass foam is one of the waste glassware recycling products which are used in certain structural applications. With its porous structure and light weight, glass foam, generally used for thermal and acoustic isolation, is also a potential filling in geotechnical applications where lightweight is crucial. In Turkey, waste glass composes the significant part of solid wastes and one of the recycled glass product is glass foam. In this study, the availability of glass foam and expanded polystyrene (EPS) geofoam as a component for CLSM production was investigated, some geotechnical properties including strength and unit weight characteristics of composite soils were explored using several laboratory tests. A certain mixture design and some engineering properties of this lightweight composite fill were determined by unconfined compression and California Bearing Ratio (CBR) tests.

Lightweight fill materials can be used in geotechnical engineering for the consolidation and bearing capacity problems of very soft soils, for filling applications performed on potentially collapsible slopes generally. Expanded polystyrene (EPS) geofoam which is obtained from the oil is used in low strength and soft soil construction as a lightweight fill material in different places of the world today. Expanded polystyrene foam is supplied as raw materials in the form of small particles. EPS is widely used in various geotechnical applications such as embankments, retaining structures, slope stability, bridge piers and other applications (Aksoy 1998 and Aytekin 1997). EPS has advantages of low cost and durability properties for long years against other types of lightweight materials, as well. Due to these reasons, expanded polystyrene has been popular over time in civil engineering and widely used as light and compressible fill material in many geotechnical application areas.

Geotechnical properties of EPS-cement-sand mixture were determined by unconfined compression tests and CBR tests. Ratio in terms of weight for cement to material of mixture was measured as 12/1. As a result, it was found that a mixture containing cement, polystyrene foam and sand, can be successfully used in some applications such as improvement of slopes and reducing the weight of embankments.

2 EXPERIMENTAL RESULTS

Figure 1 shows the grain size distribution curve for the sand used in the experiments. Sand used is classified as poorly graded sand (SP). The sand has a specific gravity of 2.64, maximum and minimum void ratio of 0.85 and 0.54 respectively. D_{60} of the sand used is 0.35mm and the internal friction angle was found 41. Considering the weight proportions of cement and glass foam, mixtures with different weight ratios of cement, which is used as the binding material, and glass foam, which is regarded as the main component having the largest volume ratio in the mixture, were prepared. Cement and water were mixed first, sand was added next if denoted in the design, and after these components make up a rather homogenous mixture, glass foam is added to the mixture and stirred till homogeneity again.

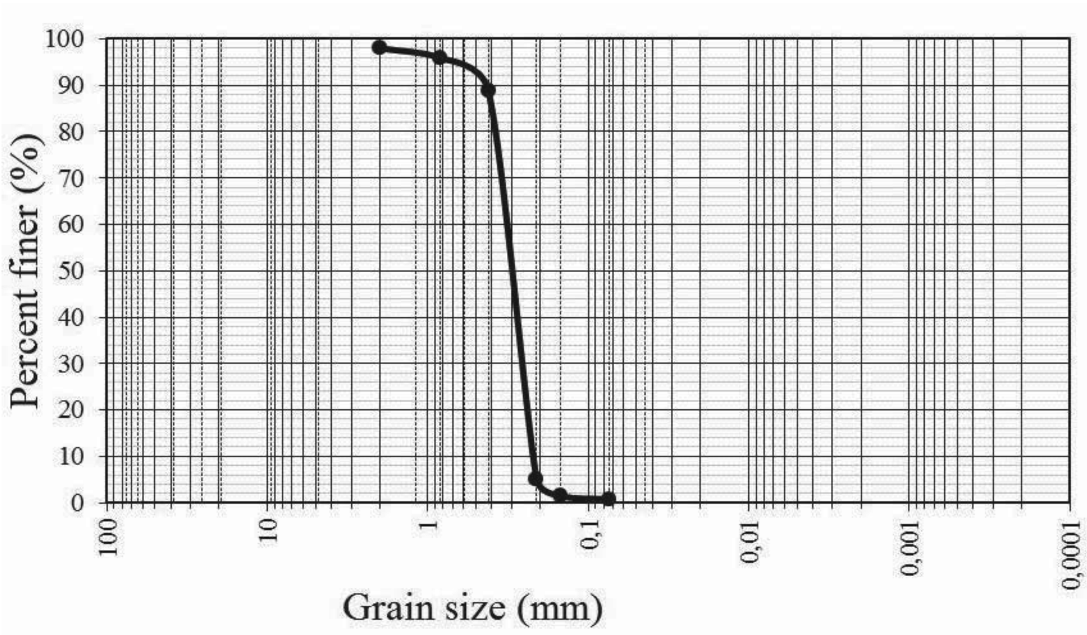

Figure 1. Grain size distribution curve for the sand used in the experiments.

When the 7-day experimental results of the mixtures that were produced using different sand ratios was examined, it has been observed that the optimum results were exhibited by the specimens which has equal sand and glass foam quantity and when cement over foamed sand mixture ratio is two. The water/cement ratio used is 0.45. Figure 2 shows the grain size distribution curve for the glass foam used in the experiments. The average value of the saturated unit weight of the glass foam mixture was found as 8.83 kN/m^3.

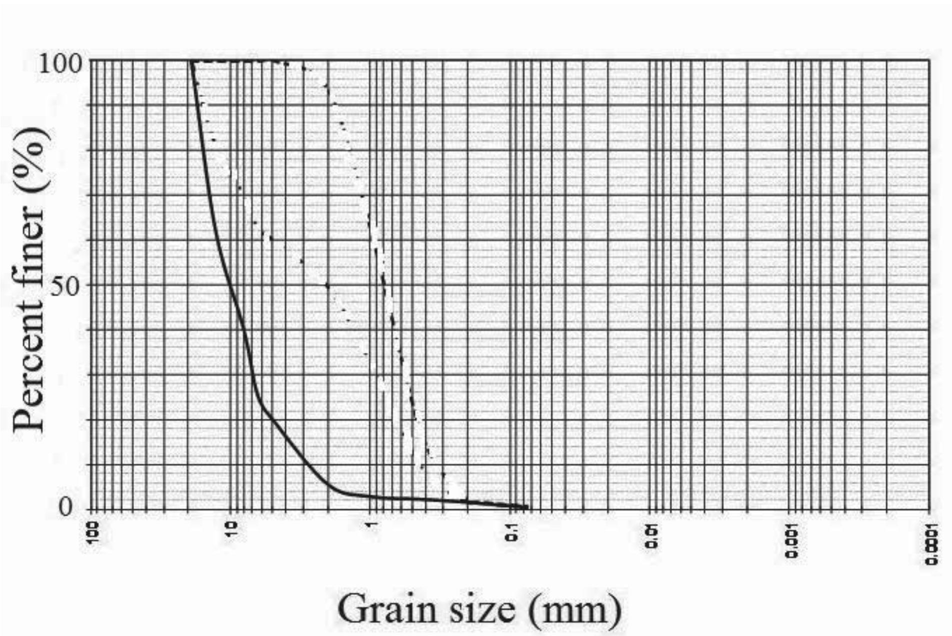

Figure 2. Grain size distribution curve for the glass foam used in the experiments.

Figure 3 shows the cement, sand and glass foam mixture sample used in the unconfined compression test. The average value of the typical 7-day unconfined compression strength of the mixture was determined as 0.75 MPa while the average of the 28-day unconfined compressive strength was 0.91 MPa. Figure 4 shows the results of these tests, as can be seen from the figure with time the strength of the sample increases. The CBR value of the 7-day mixtures was observed as 38.4 while this value was 78.9 for 28-day mixtures.

Figure 3. Cement, sand and glass foam mixture sample for the unconfined compression test (Tuncel, 2012).

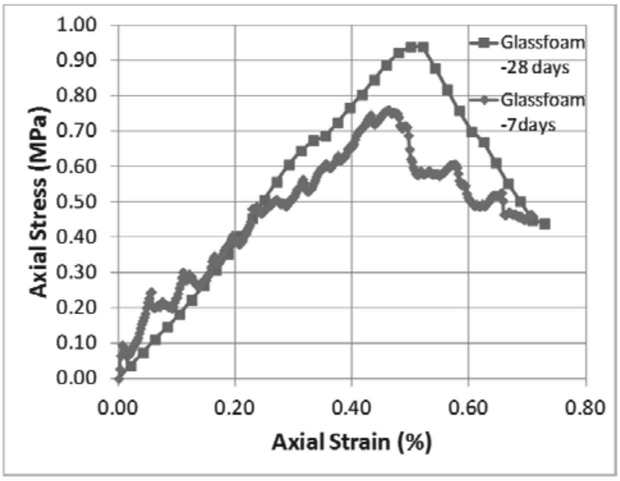

Figure 4. 7 and 28 days unconfined compression test results for the samples with glass foam.

The aim of the laboratory study of lightweight fill that consist of EPS-cement-sand mixture is investigation for its usability in geotechnical applications successfully. So for the solution of weak soils with low durability that have slope stability problems, it is tried to create more durable and compressible ligthweight soil than normal soils. The unit weight of the EPS mixture was 3.80 kN/m^3. Figure 5 shows the unconfined compression test sample of EPS, sand and cement mixture. Weight content of materials in mixture was selected, so different proportions such as 100%, 75%, 50% and 25% of EPS content of mixtures were prepared. To determine the ratio of EPS in the cementious material mixture, where sufficient shear strength is needed, unconfined compression tests were done. Prepared mixture samples were tested, then relevant percentage of expanded polystyrene content of material and cement/material ratio of mixture was determined. The relevant content of EPS in material is determined as 50% and ratio in terms of weight for cement/material of mixture was measured as 12/1. Unconfined compression value of 7 day sample is 0.22 MPa and of 28 day EPS mixed samples is 0.42MPa. According to the results, the mixture is defined as a low permeable lightweight fill and it also has CBR value that can be classified as medium. Figure 6 shows the results of these tests, as can be seen from the figure with time the strength of the sample increases.

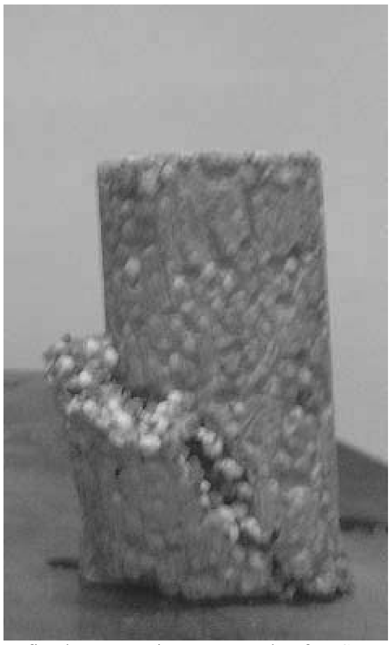

Figure 5. Unconfined compression test sample of EPS, sand and cement mixture (Ahmedov, 2012).

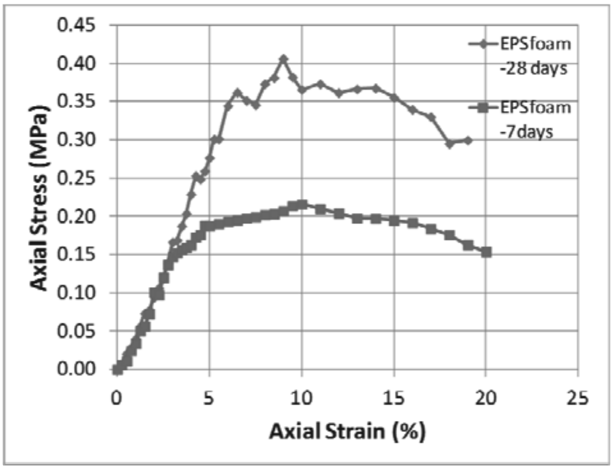

Figure 6. 7 and 28 days unconfined compression test results for the samples with EPS foam.

CBR tests showed that the glass foam-sand-cement mixtures have enough bearing capacity to be used as a subbase material. CBR values for 28 days old EPS mixture is 7 making it weak to be used as a subbase material. As a result, by producing lightweight fills with CLSM mixture produced using glass foam-sand-cement can be a solution for consolidation and bearing capacity problems of very soft soils which continually consolidate, constitution of geotechnical fills on potentially sliding slopes and reducing the stress distribution on retaining structures.

3 CONCLUSIONS

When the test results of the glass foam-sand-cement mixture compared with the other lightweight fill materials it was seen that glass foam-sand-cement mixture has a higher unconfined compressive strength and CBR value. The CLSM mixture produced using glass foam-sand-cement can be used as lightweight fills on very soft and continually consolidating soils for solving the consolidation and bearing capacity problems. It can be convenient to use this mixture as fill for potentially sliding slopes and for reducing the lateral stresses that received by soil retaining structures.

When the results are compared, EPS mixtures have lower unit weight and undrained shear strength values compared to glass foam mixtures. Therefore use of glass foam will have the advantage of higher strength compared to EPS mixtures and can be used as a subbase material.

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