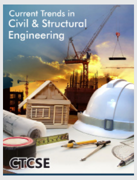

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Research Article

Vesicular Material for Reducing Expansion of Soils

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Abstract

Soils with expansion problems have volumetric deformations due to changes in its humidity. There are several soil improvement techniques that consist of materials that react chemically with clay soil or materials that encapsulate the clays to isolate them from water. This work presents a physical alternative based on the use of natural vesicular materials to reduce the change in soil volume. It is concluded that the decrease in expansion of soils using natural void structures like scoria depend on its amount of void volume. This study showed that the volume corresponding to the decrease in expansion required in a soil is equivalent to approximately half of its hollow volume within the soil.

Keywords: Vesicular material; Vesicular rock; Expansive soil; Expansion; Volcanic material; Absorption; Soils; Soil improvement

Introduction

Many countries in the world have to deal with the problem of expansive clays. These soils have volumetric instability due to humidity variations. There are alternative solutions such as the removal of problematic soil to place inert material, chemical treatment of soils and construction of reinforced foundation structures [1]. Inverted ribbed slabs (with void volume between the slab and the ground) are a type of foundation that has been proposed to minimize the problem of expanding soils [2]. The spacing between the raised slab and supports (girders placed on expansive soil) depends on the expansive potential of the soil and the applied load [3]. Porous solids include two types of porous bodies (i.e., natural, and artificial). Natural porous solids can be found universally, such as bones that support the bodies and limbs of animals and human beings, plant leaves, wood, sponge, coral, pumice, and lava. Artificial porous materials can be subclassified further into porous metals, porous ceramics, and polymer foams [4]. About earthy porous materials, scoria and pumice have several similarities. They are both volcanic rocks (often pyroclastic) and they contain vesicles. Vesicles in pumice are usually smaller and more irregularly shaped. Vesicles in Scoria can be much larger than vesicles in pumice are [5]. Pumice, scoria, tuff, and volcanic cinders used for concrete lightweight aggregate are naturally occurring porous or vesicular lava and ash [6]. Normally, the concrete aggregates are dry and absorb a significant amount of water from the matrix (up to 30% by weight for some types of aggregates) [7]. So, we can say that theoretically the expansive soil volume must be equal to the volume of the void structure placed within the soil. In this work a natural earthy void material was added into the soil with the aim of placing hollow spaces that can be filled when the expansion appears and therefore, decrease the vertical expansion [8].

Tests and Experimental Methods

Geotechnical characterization of the expansive soil and void structure used

Geotechnical characterization of the expansive soil was made such as gradation test (ASTM D422-63(2007) e2, 2007). Then, the liquid and plastic limits were determined (ASTM D4318-10, 2010), as well as the Shrinkage limit (ASTM D 2427-04, 2008). With this information, the soil was classified by the Unified Soil Classification System (USCS) (ASTM D 2487-93, 1993) [9-12]. Its specific weight and specific gravity were obtained (ASTM D 2854-10, 2010). Soil moisture was obtained (ASTM D2216-10, 2010). The void material used was natural volcanic material (scoria). The size of scoria between 0.074 (200 mesh) and 4.76 mm (4 mesh) was used in this work (ASTM D422-63(2007) e2, 2007). Dosages of scoria were 6, 10 and 15% on the dry weight of the soil. The absorption was tested (ASTM C127-12, 2010).

Experimental study

The expansion test of the natural soil and natural soil with scoria were tested (ASTM D4546-03, 2003). The soil was mixed with different dosages of void structures. Then the material was placed with the same specific weight and moisture of the natural soil within a consolidation ring (Figure 1).

Figure 1: Natural void structures (scoria), expansive soil and consolidation ring.

Then we proceeded to determine the approximate volume of voids of scoria (ASTM C29/C29M-09, 2009). First, we obtained the dry scoria after placing in the oven to 100 degrees Celsius. After a certain amount of dry volcanic rock (Ws) were placed into a graduated cylinder to a volume chosen. Then we introduce water into the cylinder in the volume occupied by the soil and determine the weight of the soil and water (Ws +Ww). The difference in the two weights is the weight of water that occupies the void volume (Wvs) of scoria and the weight of water of the void volume of cylinder (Wvc) [12-14]. After we tested the Absorption scoria to determine the amount of absorbed water (Wa) or percentage of voids of scoria. In this test the soil remained submerged 24 h, then scoria was drained, and its weight determined for the calculation of the amount of water that occupies the voids scoria (Wv).

Result

Geotechnical properties of expansive soil and soil decreased Expansion

By gradation analysis (ASTM D422-63(2007) e2, 2007), it was determined that the soil was a material with fines, since 98.55 % of its particles went through a sieve 200 (0.074 mm), and 1.45% of sands. The liquid limit was 72 % and the plastic limit of 30.6%, thus the plastic index was 41.4% (ASTM D4318-10, 2010). From these results, the soil can be classified as high compressibility clay (CH) according to the Unified Soil Classification System (USCS), (ASTM D 2487-93, 1993). The volumetric shrinkage limit was 9.8% (ASTM D 2427-04, 2008), specific weight of 14.68 kN/m3 and specific gravity of soil as 2.55 (ASTM D 2854-10, 2010) and natural moisture was 11.2% (ASTM D2216-10, 2010).

Determination of the soil decreased expansion

The natural expansion was 16.4%. We observed that 6%, 10% and 15% of scoria decreased 1.75%, 2.8% and 3.45% respectively of natural expansion soil (16.4%). The average diameter and height of odometer used were 7.65cm and 2.0cm respectively (ASTM D4546-03, 2003), then the total volume of soil was 91.927cm3. The dry weight of soil was 142.67g [15].

Determination the void volume in the material

Table 1: Calculation of the percentage of voids of scoria.

Measured Parameter	Result
a) weight of cylinder	41.59g
b) weight of dry scoria	57.73g
c) weight of dry scoria + cylinder= a+b	99.32g
d) weight of water + dry scoria + cylinder	118.37g
e) volume occupied in the cylinder	47 ml
f) weight of scoria drained + cylinder	109.9g
g) weight of water that occupies the void volume of scoria (Wvs)=d-f	8.47g
h) weight of water that occupies the void volume of cylinder (Wvc)=f-c	10.58g
i) Percentage of voids (g/b)	14.67%

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Table 2: Void volume of scoria vs vertical expansion decrease.

Scoria Used Weight-Dosage	Volume Scoria	Void Volume Scoria (14.67%)	Expansion Decrease	Expansion Decrease Volume	Expanded Minus Occupied Volume
8.56g (6%)	6.96ml	1.02ml	1.75%	1.6ml	56.86%
14.26g (10%)	11.6ml	1.7ml	2.80%	2.57ml	51.17%
21.4g (15%)	17.42ml	2.55ml	3.45%	3.17ml	24.31%

Table 1 shows the measured parameter of scoria to obtain the void volume of scoria. From Table 1 the water volume of voids was 14.67% of the total volume of scoria. Table 2 shows the volume of the weights of the material used taking into account the total volume used in the test and the total dry weight of the material. The decrease in vertical expansion was calculated with the volume of soil used (91.927 cm3). The results showed that the void volume of scoria was lower than vertical volume decreased. The average of difference of expanded and occupied volume is 44.11%.4 [16] (Table 2).

Conclusion

It is concluded that the decrease in expansion of soils using natural void structures like scoria depend on its amount of void volume. Even when the elongated vesicles of scoria are small and irregular, the reduction in expansion was almost double what was expected from the hollow volume of the material. The above is probably due to the void structures placed within the soil likely led to a horizontal expansion due to expansion pressure and increase the density of soil. Therefore, according to the natural expansion of the soil we may include void structures with the amount of void volume required for such expansion. This study showed that the volume corresponding to the decrease in expansion required in a soil is equivalent to approximately half of its hollow volume within the soil. In this paper we demonstrate that the incorporation of void structures in soil can be a reliable and simple alternative for reducing expansion.

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None.

Conflict of Interest

No conflict of interest.

References

1. Chen FH (1988) Foundations on Expansive Soils, Ed. Elsevier Scientific Publishing Co, Amsterdam.
2. Kalantri B (2012) Foundations on expansive soils: A Review. Research Journal of Applied Sciences, Engineering and Technology 4(18): 3231-3237.
3. Patrone J, Prefumo JE (2005) The action of expansive soils on foundations. Prevention and control methods. Memory of Scientific and Technical Diffusion Work 4: 51-74.
4. Liu P, Chen GF (2014) Porous materials: processing and applications. Elsevier, USA.
5. Le Maitre RW (2005) Igneous Rocks: A Classification and Glossary of Terms: Recommendations of the International Union of Geological Sciences Subcommission on the Systematics of Igneous Rocks (2^{nd} Edn.), Cambridge University Press.
6. Lamond JF, Pielert JH (2006) Significance of Tests and Properties of Concrete and Concrete-Making Materials. ASTM International. Bridgeport, NJ.
7. Alexander MG, Arliguie G, Ballivy G, Bentur A, Marchand J (1999) Engineering and Transport Properties of the Interfacial Transition Zone in Cementitious Composites. RILEM Publications s.a.r.l. Cachan Cedex France.
8. ASTM D4546-03 (2003) Standard Test Methods for One-Dimensional Swell or Settlement Potential of Cohesive Soils. Annual Book of ASTM Standards. West Conshohocken, United States.
9. ASTM C127-12 (2010) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate. Annual Book of ASTM Standards. West Conshohocken, United States.
10. ASTM C29/C29M-09 (2009) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate. Annual Book of ASTM Standards. West Conshohocken, United States.
11. ASTM D2216-10 (2010) Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass. Annual Book of ASTM Standards. West Conshohocken, United States.
12. ASTM D 2427-04 (2008) Standard Test Method for Shrinkage Factors of Soils by the Mercury Method (Withdrawn 2008), Annual Book of ASTM Standards, West Conshohocken, United States.
13. ASTM D 2487-93 (1993) Standard Test Method for Classification of Soils for Engineering Purposes. Annual Book of ASTM Standards. West Conshohocken, United States.
14. ASTM D 2854-10 (2010) Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer, Annual Book of ASTM Standards. West Conshohocken, United States.
15. ASTM D422-63(2007) e2 (2007) Standard Test Method for Particle-Size Analysis of Soils, Annual Book of ASTM Standards, West Conshohocken, United States.
16. ASTM D4318-10 (2010) Standard Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of soils, Annual Book of ASTM Standards, West Conshohocken, United States.

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