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The Experimental Study on Soil Improvement with Additive Materials on Highways

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Abstract: ***Soil stabilization methods are important in dealing with for geotechnical engineering and transportation engineering departments. The bearing capacity of the soils may not sufficient at some planned road routes. In this case, these soils must be completely removed and it must be applied the new soils which are sufficient bearing capacity or one of several ground stabilization methods are applied. There are a lot of stabilization methods. One of the most important soil stabilization methods is the stabilization of the soils with materials such as lime, fly ash, glass fiber and rubber particles. In this study, exhaustive tests have been conducted in the laboratory to investigate the availability of soils with lime, glass fiber and rubber particles for increasing the bearing capacity. Soil samples have been prepared at optimum water content and unconfined pressure tests have been carried out. Soil samples have been prepared at 5% content lime, glass fiber and rubber particles and have been determined effect of choicing of different materials for stabilization. It has seen that the choice of different materials was important for soil stabilizations.***

Keywords: soil stabilization, unconfined pressure test, lime, rubber particles, glass fiber

1. Introduction

As many of construction is concentrated in populated urban areas, there is increasing need to construct on soft subsoils, which were considered unsuitable for construction just a couple of decades ago. Soft soils have been made in recent years in advanced constitutive modeling of such materials. For high subgrade constructions, selection of appropriate materials for embankment construction is a the more important issue not only in terms of cost but also expected engineering performance. Loadings, excavations and transportation of these materials are the most important component of the total cost during embankment building process. At conventional approach, the soft soils at geotechnical engineering are removed and replaced by gravel or squashed rock layer. The embankment, subbase and base materials are provided that receive sites resulting in important cost increases. Using onsite soils is the most economical touch particularly in comparison to bringing choose borrow materials from faraway locations. It is reasonable that stabilization of borderline on-site soils and improvement of their engineering properties can be an well-balanced alternative to take on loan plant. Stabilization of the soils with limes, rubber particles and glass fibers became a very good choice for design engineers. Stabilization with additive materials can be used as an alternative method to conventional materials in the construction of geotechnical and geoenvironmental substructure.

2. Previous Studies

There is a lot of studies about soil stabilization with addictive materials but there is a limited study to compare the addictive materials in the literature. These studies are presented below. Ajayi-Majebi et al. [1] noticed the development effect of an epoxy gum and a polyamide stiffener on clay-silt soils. In the research, 3 day cured balanced soil pattern with 4% additives showed major increase in CBR. Bhattacharja and Bhatty [4] compared the performance of lime and cement on three different types of soils in Texas with PI of 25%, 37% and 42%, and found that for all soils, better performance was observed from cement stabilizer. However, there was great decrease in the strength (by more than 50%) of the cement treated soils with delay compaction of 24 hour. Tingle and Santori [5] declared successful implementation of synthetic polymers and lignosulfonate for developing unconfined compression strength of both weak and oil clay soils. There are several challenges associated with finding new construction sites so that they can be constructed on poor soil. So that, more advances and improvements in technology are being implemented in most parts of the world. Removal of top soil and replacement with good soil is the most commonly adopted modern strategy in conventinal application. In order to remove of top soil, the new techniques – particularly chemical soil stabilisation by lime - are utilised to improve the soils engineering properties [7]. Mirzababaei et al. [9] have explored the effect of two polymers including 3 to 10% methyl methacrylate and 1 to 3% vinyl acetate, separately on the free surge potential of 3 several fat clay soils. They noticed important decrease in free surge potential and creation of aggregated clay-granular pattern with the supplement of polymers. The chemical soil stabilisation process with lime and/or fly ash is presented as a approved and tried technique for resistance development of the soil by [15]. This is clear sufficient when investigate several tests and comment studies certificated by diverse different writers ([2], [3], [6], [8], [10], [11], [12], [13], [15], [16]). All report that lime has been soundly and successfully operated with the major practical of growing the bearing capacity of the soils [14].

In this study, exhaustive tests have been conducted in the laboratory to investigate the availability of soils with lime, glass fiber and rubber particles for increasing the bearing capacity. Soil samples have been prepared at optimum water content and unconfined pressure tests have been carried out. Soil samples have been prepared at 5% content lime, glass fiber and rubber particles and have been determined effect of choicing of different materials for stabilization.

3. Material and Methodology

In this study, lime, glass fiber and rubber particles (Figure 1) stabilization have been used to increase the bearing capacity of road pavements will be built on the subgrades. For this purpose, test mixtures were prepared adding 5% with addictive materials for determining effect of strength at cohesive soil's (medium plasticity clay) road subgrade. Soil samples have been prepared at optimum water content and unconfined pressure tests have been carried out. In the examinations, clay samples which were taken Çukurova region and below the 0.074 mm screen area were used. Experiments were performed at soil mechanics laboratory of Çukurova University on clay samples. The liquid limit value of the cohesive material is approximately 42% and the plastic limit value is approximately 24%[18]. The grade of the ground was determined as a medium plastisite clay (CI) according to TS 1500 [17]. In the experiments, unconfined compressive test machine (Figure 2) has been used. The prime aim of this device machine is to define the unconfined compressive capacity, whichever is then used to calculate the unconsolidated undrained shear strength of the clay under unconfined conditions. In accordance with the ASTM standard [19], the unconfined compressive strength is described as the compressive stress at which an free cylindrical sample of soil will lose out in a basic compression test. Besides, in this test process, the unconfined compressed strength is engaged as the maximum load reached per unit area, or the load per unit area at 15% axial strain, whatever comprises first during the performance of a test. In order to soils, the undrained shear strength is necessary for the description of the bearing capacity of foundations. The undrained shear strength (qu) of clays is usually decided from an unconfined compression test. The undrained shear strength of a cohesive soil is equal to one-half the unconfined compressive strength when the soil is under the $\phi = 0$ condition (ϕ = the angle of internal friction). The most supreme condition for the soil generally occurs directly after structures, which offers undrained conditions, when the undrained shear strength is basically equal to the cohesion (cu). The tests were carried out with respect to the standards and taking into account the following rules. It has removed the soil sample from Shelby tube sampler. It has been cutten a soil specimen which is the ratio (L/d) is approximately between 2 and 2.5. Where L and d are the length and diameter of soil specimen, separately. It has been measured the full diameter of the top of the pattern at three locations 120° aside, and then provide the same measurements on the bottom of the sample. It has been weighed the sample and has been recorded the mass on the data sheet. It has been placed the sample in the compression device and center it on the bottom plate carefully.

It has been regulated the device so that the upper plate just makes contact with the specimen and set the load and deformation dials to zero. It has been applied load which device produces an axial strain at a rate of 0.5% to 2.0% per minute. It has been recorded the load and deformation dial readings on the data sheet at every 20 to 50 divisions on deformation the dial. The vertical load has been applyed until the loading decreases on the specimen significantly. When the vertical load have decreased, the strain deformation graph has been drawn by completing the experiment. The sample has been removed the compression device and has been taken a sample for determining water content.

Figure 1: Addictive materials

Figure 2: Unconfined compressive test machine

4. Results and Tables

With the purpose of studying the effects of mixing medium plasticity clay soil with glass fiber, lime and rubber particles mixed with 5% alternative material. Three different medium plasticity clay soil-mixtures prepared in the laboratory and each experiment's unconfined compressive strength calculated as Figure 2, Figure 3 and Figure 4. According tothis figures, nonlinear behaviour was observed in curves in all experiments.

Figure 2 shows the comparison of unconfined compressive strength at the medium plasticity clay soils and medium plasticity clay soils with the rubber particles mixture. Hence, it can be inferred that when 95% of medium plasticity clay soil and 5% of rubber particles fiber blended, the unconfined compressive strength of the mixture increases from 1.29 kPa up to 1.56 kPa.

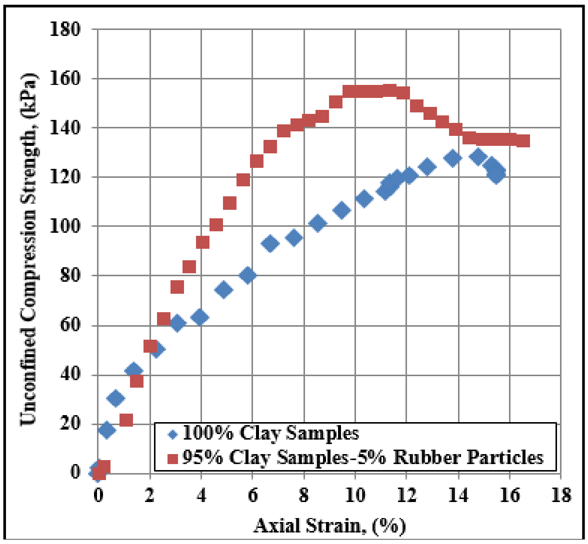


Figure 2: Unconfined compression strength for only clay sample and clay with rubber particles [20]

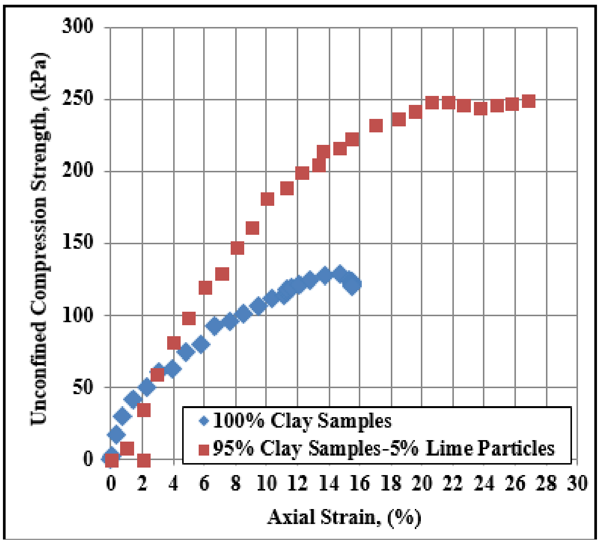


Figure 4: Unconfined compression strength for only clay sample and clay with lime particles

Figure 3 shows the comparison of unconfined compressive strength at the medium plasticity clay soils and medium plasticity clay soils with the glass fiber mixture. Hence, it can be inferred that when 95% of medium plasticity clay soil and 5% of glass fiber blended, the unconfined compressive strength of the mixture increases from 1.29 kPa up to 1.52 kPa.

Figure 5 shows the unconfined compressive strength the medium plasticity clay soil and medium plasticity clay soils formed by mixing different materials. It has been determined that there is a considerable increase in the unconfined compressive strength compared with medium plasticity clay soil in all three additive materials.

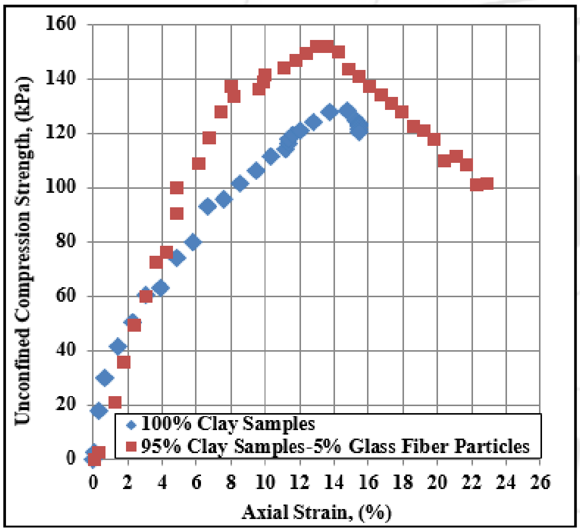


Figure 3: Unconfined compression strength for only clay sample and clay with glass fiber particles

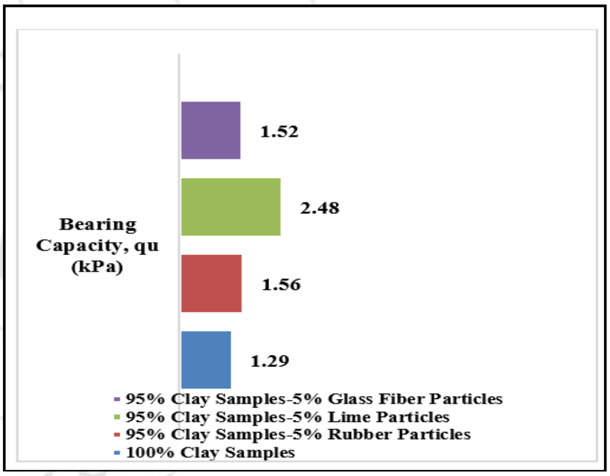
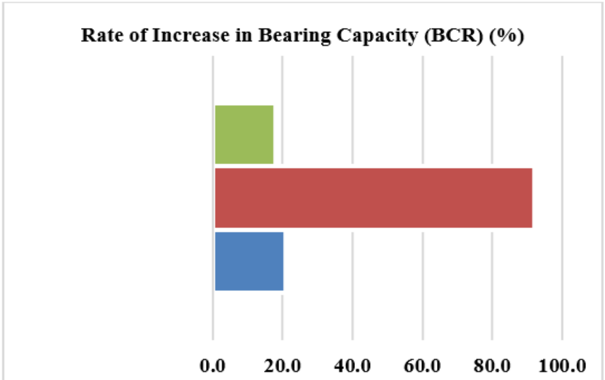


Figure 5: Comparison of unconfined compression strength of samples

Figure 4 shows the comparison of unconfined compressive strength at the medium plasticity clay soils and medium plasticity clay soils with the lime mixture. Hence, it can be inferred that when 95% of medium plasticity clay soil and 5% of lime blended, the unconfined compressive strength of the mixture increases from 1.29 kPa up to 2.48 kPa.

Figure 6 shows the improvement ratio in point of unconfined compressive strength at medium plasticity clay soils formed by mixing different materials by only medium plasticity clay soils.

With respect to the data obtained from experiments, it is obvious that the maximum unconfined compressive strength of mixtures reached when mixed medium plasticity clay soil with 5% rubber particles, 5% glass fiber particles and 5% lime particles shows respectively 20.93%, 17.83% and 92.25% of increase compared to 100% medium plasticity clay soil. As a result, the improvement ratio in point of unconfined compressive strength with the glass fiber (17.83%) and waste rubber particles (20.93%) are also found to increase less than the lime particles (92.25%). It is considered that both mechanical improvement and chemical reaction in the lime mixture occurs when only a mechanical improvement is observed in the blend of glass fiber and rubber particles[21].



Glass Fiber Particles	17.82945736
Lime Particles	92.24806202
Rubber Particles	20.93023256

Figure 6: Rate of ıncrease in bearing capacity (%)

5. Conclusion

In this study, tests have been conducted in the laboratory to investigate the availability of soils with lime, glass fiber and rubber particles for increasing the bearing capacity. Soil samples have been prepared at optimum water content and unconfined pressure tests have been carried out. Soil samples have been prepared at 5% content lime, glass fiber and rubber particles and have been determined effect of choicing of different materials for stabilization. The experimental results are as follows:

It can be inferred that when 95% of high plasticity clay soil and 5% of rubber particles blended, the unconfined compressive strength of the mixture increases from 1.29 kPa up to 1.56 kPa, when 95% of high plasticity clay soil and 5% of glass fiber blended, the unconfined compressive strength of the mixture increases from 1.29 kPa up to 1.52 kPa, when 95% of high plasticity clay soil and 5% of lime blended, the unconfined compressive strength of the mixture increases from 1.29 kPa up to 2.48 kPa. The improvement ratio in point of unconfined compressive strength with the glass fiber (17.83%) and waste rubber particles (20.93%) are also found to increase less than the lime particles (92.25%). It is considered that both mechanical improvement and chemical reaction in the lime mixture occurs when only a mechanical improvement is observed in the blend of glass fiber and rubber particles. Using glass fiber particles and rubber particles in transportation and geotechnical engineering applications may be feasible to consume the waste of materials. Glass fiber particles and rubber particles can use for improvement of bearing capacity soil upto optimum content. They can effectively use as soil reinforcement beneath footing, roads embankment and retaining wall. However, it has been observed that these additives only provide mechanical improvement. The other addictive material is lime particles. This particle as being construction chemical can be feasible to soil stabilisation and dominant in soil stabilisation particularly for roads. It has been observed that this additive not only provide mechanical improvement but also chemical improvement. Therefore, it is thought that the improvement ratio is higher than other additive materials. Therefore, it is considered that in such soil improvement, the use of lime should be preferred in terms of the the improvement ratio compared to the other additive materials.

References

[1] A. Ajayi-Majebi, W.A. Grissom, L.S. Smith, and E.E. Jones, "Epoxy-Resin-Based Chemical Stabilization of a Fine, Poorly Graded Soil System," In Transportation Research Record 1295, TRB, National Research Council, Washington, D.C., 1991. (journal style)

[2] D. N. Little, "Handbook for stabilisation of pvement sugrades and base course with lime," United States of America Lime association of Texas, 1995. (book style)

[3] J. R. Prusinski and S. Bhattacharja, "Effectiveness of Portland cement and lime in stabilizing clay soils," Transportation Research Record. Issue-1652, pp 215-227, 1999. (journal style)

[4] S. Bhattacharja and J. I. Bhatty, "Comparative performance of the Portland cement and lime stabilization of moderate to high plasticity soils," Portland cement association, 2003. (journal style)

[5] J.S., Tingle and R.L., Santori, "Stablisation of clay soils with non traditional additives," National Research Council, Washington D.C., Transportation Research Record No. 1819, 72-84, 2003. (journal style)

[6] M. C. Geiman, G. M. Filz and T. L. Brandon, "Stabilization of Soft Clay Subgrades in Virginia," Phase I Laboratory Study Virginia Transportation Research Council, 2005. (book style)

[7] S. Vitton, "Introduction to soil stabilization," Michigan Technological University, 2006. (book style)

[8] C. Jung and A. Bobet, "Post-Construction Evaluation of Lime-Treated Soils," Indiana Department of Transportation State Office, 2008. (book style)

[9] M. Mirzababaei, S. Yasrobi and A. Al-Rawas, "Effect of polymers on swelling potential of expansive soils," Proceedings of the ICE Ground Improvement 162(3), 111-119, 2009. (conference style)

[10] M. D. Liu, S. Pemberton and B. Indraratna, "A study of the strength of lime treated soft clays," 2010. (journal style)

[11] R. Brooks, F. F. Udoeyo, V. K. Takkalapelli, "Geotechnical properites of problem soils stabilized with fly ash and lime stone dust in Philadelphia," American Society of Civil Engineers, Vol. 23, No. 5, pp. 711-716, 2011. (journal style)

[12] B. Celauro, A. Bevi;acqua, D. L. Bosco and C. Celauro, "Design procedures for soil-lime stabilization for road and railway embankments: Part 1, Review of design methods," Elsevier, 53: 755-764, 2012. (book style)

[13] S. A. A. Khattab and Y. A. Hussein, "The durability of fine grained soils stabilized with lime," Al-Rafidain Engineering 20 (1): 85-92, 2012. (journal style)

[14] A. S. Negi, M. Faizan, D. P. Siddharth and R. Singh, "Soil stabilization using lime," International Journal of

Innovative Research in Science, Engineering and Technology, 2 (3): 448-453, 2013. (journal style)

[15] A. Aldaood, M. Bouasker, and M. A. Mukhtar, "Free swell potential of lime-treated gypseous soil," Applied clay science, 102: 93-103, 2014a. (journal style)

[16] A. Aldaood, M. Bouasker, and M. A. Mukhtar, "Geotechnical properties of lime treated gypseous soils," Elsevier, 88-89: 39-48, 2014b. (journal style)

[17] TS 1500, İnşaat Mühendisliğinde Zeminlerin Sınıflandırılması. (book style)

[18] TS 1900-2, İnşaat Mühendisliğinde Zemin Laboratuvar Deneyleri - Bölüm 2: Mekanik Özelliklerin Tayini. (book style)

[19] ASTM D 2166 - Standard Test Method for Unconfined Compressive Strength of Cohesive Soil. (book style)

[20] B. Bagriacik, "Ulaşım Yapıları Temel Zeminlerinin Katkı Maddeleri ile Stabilizasyonu," 1st International Mediterranean Science and Engineering Congress (IMSEC 2016), 4581-4586, 2016. (conference style)

[21] B. Bagriacik, "Ulaşım Yapıları Temel Zemini İyileştirilmesinde Katkı Malzemesi Seçiminin Önemi," 2 International Congress On Engineering Architecture And Design, 825-826, 2017. (conference style)

Author Profile

Baki Bagriacik entered Cukurova University Faculty of Engineering and Architecture Department of Civil Engineering in 2004. In 2008, he graduated from the Faculty of Engineering and Architecture and the Department of Civil Engineering as the first. 30th anniversary of the establishment of the Faculty of Engineering and Architecture held at Cukurova University in celebration of the project and a final assignment in the competition won the first Civil Engineering and Engineering Faculty of Architecture eligible to receive awards as the latter. In addition, it is entitled to receive certificates and awards from different institutions and organizations. In 2010, he completed his master's degree in Civil Engineering Department of Cukurova University Institute of Science and was awarded the title of "High Engineer" and received scholarship support by TUBITAK during his master's degree. In 2015, he completed his Ph.D. in Civil Engineering Department of Cukurova University Institute of Science and was awarded the title of "Doctor" and received scholarship support by TUBITAK during his Ph.D. He is still working as a physician teaching staff at Cukurova University Faculty of Engineering and Architecture Department of Civil Engineering. There are many publications, notifications, awards and citations in his or her field of specialization in various national and international journals and symposia.