Utilization of Cement content for Stabilization of Jamshoro Soil

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***Abstract*: Soil in the region of Jamshoro is expansive (expands when gets moist and contracts when becomes dry). Due to this unique behavior, the soil of Jamshoro cannot be used directly for foundations of major constructions (i.e. roads and buildings) because it will cause rutting and excessive deformation in motorway (M-9, Hyderabad to Karachi, Pakistan) and will affect other road networks running in the vicinity of Jamshoro. It will also cause differential settlements in the foundations of the buildings constructed in the Jamshoro region. Because of that it is obvious that Jamshoro soil cannot be used directly for subgrade material for roads and foundations of buildings. This type of soil can be stabilized by using chemical additives and geo reinforcements. Therefore it is necessary to stabilize this kind of soil. In this research Jamshoro soil were brought into consideration to observe its basic geotechnical properties. Then various proportions of cement content that was 0%, 1%, 2%, 4%, 6%, 8%, 10% and 12% were added and mixed by dry weight of soil to examine the effect of cement content on California Bearing Ratio and Swelling potential. It was observed that cement content can be utilized to improve California Bearing Ratio and Swelling potential for this type of soil.**

***Keywords*: California Bearing Ratio, Swelling Potential, Jamshoro soil.**

I. INTRODUCTION

Three major universities lie in this region therefore Jamshoro city is known as Educational hub. Superhighway is a main highway which connects Karachi with north of Pakistan. This highway is busy highway in Pakistan. Superhighway has been turned into Motorway (M-9), having length of about 136 km with 6 lanes. Soil in the surrounding of Jamshoro comprises of large deposits of expansive soil known as shale. This type of soil is more problematic soil, therefore it is causing serious problems of rutting and excessive deformation in road network running in vicinity of Jamshoro. Direct construction of multistory buildings in Jamshoro are not possible due to expansive behavior of soil. Soil can be improved by replacing soil or stabilization of soil. Soil stabilization by using certain chemicals is more economical than replacement of soil. To improve the geotechnical properties of soil, soil stabilization techniques are being applied to alter the geotechnical properties of expansive soils. [15, 21]

Various researchers used different materials at different proportions to enhance the desired properties of weak soils. The effect of cement content on unconfined compressive strength were described by using various proportions of cement content to check the effect of cement content on unconfined compressive strength. Proportions of cement content used were 0%, 5%, 10%, 15% and 20% by dry weight of soil. Results showed that with the increasing of cement content unconfined compressive strength was increasing but ideal cement content were observed at 15%. [Hindu, A.K and Khaskheli, G.B]. The effect of cement on geotechnical properties and swelling potential of expansive soil were determined. Thoroughly mixing of soil samples were adopted to get proper homogeneity, it was very much difficult to get homogeneity in terms of soil but it was tried to get homogeneous mixture for every soil samples prepared by mixing with soil and cement by adopting standards. Different proportions of cement used was from 5%-20 % with the interval of 5% cement by weight of dry soil. Samples were made on optimum moisture contents of soil. For dry density relationship the procedure adopted was of modified proctor test. Direct shear test was adopted after being cured for 1, 7, 14 and 28 days. By keeping in view the experimental results, it was decided that there was a considerable increase of the expansive soil was found with the curing period. The researchers concluded that with the mixing cement content to expansive soil there was progress found in swelling and direct shear stress. It was also observed that with the increase of cement content and curing period shear strength increased. Finally it was concluded that geotechnical properties of Jamshoro soil (shale) can be improved by the utilization of cement content by keeping in view past research and standards of laboratory tests. [21].Commonly adopted technique nowadays to enhance properties for this type of expansive soil across the world is Soil stabilization. Laboratory tests were performed in sequence according to the requirement of researchers to know the effect of bagasse fibers and hydrated lime on the shrink-swell behavior and engineering properties of expansive soils. Bagasse fiber used in this study for the purpose of reinforcement for expansive soil stabilization. Various proportions of bagasse fibers were used with hydrated lime. Finally it was found that bagasse fibers reinforcement blended with hydrated lime cause an increase in compressive strength of expansive soil with increase in curing time and additives contents. Conclusion made on the basis of results was that with the combined usage of bagasse fibers and hydrated lime expansive soils can be stabilized. [17].

Many chemicals like fly ash, cement, lime etc. were used by different researchers to enhance the geotechnical properties of expansive soils of their interest. In this research basic geotechnical properties of Jamshoro soil were observed. This research meant to determine the effect of cement content on California bearing ratio and swelling potential, various proportions of cement content that was 0%, 1%, 2%, 4%, 6%, 8%, 10% and 12% were added and mixed by dry weight of soil. Stabilizer cement was selected on the basis percentage passing the No.200 sieve and plasticity index of soil determined in laboratory. [15]. Basic geotechnical properties of untreated soil were examined in laboratory and then the effect of cement content on California bearing ratio and swelling potential were investigated by mixing above mentioned proportions.

II. MATERIALS & METHODS

A. Soil to be studied

Expansive soil was the main concern in this research. This type of soil has problems of rutting and excessive deformation in roads and differential settlements buildings constructed in Jamshoro region. Soil used in this research was taken 55 feet away from CED, MUET, Jamshoro, Sindh, Pakistan. The collected soil was taken by excavating a 3 feet deep pit. Index properties of soil were calculated by performing standards. Index properties of Jamshoro soil are given in Table.1 [13].

B. Cement

Hyderabad city being local source was brought into consideration for the purchase of cement. Lucky cement factory is situated beside Motorway M-9 (Hyderabad to Karachi, Pakistan). Lucky brand cement was used in this study. Various proportions of cement content used in this research are shown in Table.2

C. Water

Keeping in view literature, every type of impurities like organic materials, salts, alkalis, oils and acids etc. were avoided in water for water to be used in this work.

Table 1: Index properties of Jamshoro soil

Parameter	Value	Parameter	Value
Natural moisture content	8%	Group	A-7-6
Liquid limit	70%	Free swell in water	35.49%
Plastic limit	39	Free swell in kerosene	10%
Plasticity index	31	Fine grained (-#200)	61.12%

Table 2: Various proportions of cement content used in research

Mix No.	Cement content (%) by dry weight of soil
1	0
2	1
3	2
4	4
5	6
6	8
7	10
8	12

D. Methodology

Soil collected from pit was sieved from #4 sieve. To get the homogeneous mixture for further testing soil was properly mixed. Thermostatically controlled oven was used to dry soil samples. Soil was then mixed with Ordinary Portland cement with cement proportions of 0%, 1%, 2%, 4%, 6%, 8%, 10% and 12% by dry weight of soil. Codes and standards were adopted for the preparation and testing of specimens. All the sample preparations and testing of specimens were conducted at Civil engineering department in geotechnical engineering laboratory of Mehran University of Engineering and Technology, Jamshoro, Sindh, Pakistan. For each soil-cement mix optimum moisture content was obtained by performing modified proctor test. Soaked and un-soaked CBR tests were performed to know the impact of cement on California bearing ratio and swelling potential. CBR tests were performed by maintaining optimum moisture content and applying modified compaction efforts. [15].

E. Index properties of untreated soil

By following the standard method given in ASTM D 4318-00, liquid limit, plastic limit and plasticity index were obtained. Natural moisture content were obtained by adopting ASTM D2216. ASTM D421, 422, 2217 method was followed for the classification of soil. [1].

F. Compaction tests

For the determination of compaction tests for each soil cement mix, ASTM D1557-91 standard was followed to acquire optimum moisture content and maximum dry density. Proportions of cement content used were 0%, 1%, 2%, 4%, 6%, 8%, 10%, and 12%.

G. California Bearing Ratio and CBR Swelling tests

To compute the strength of soil CBR test is very much important. By applying the optimum moisture content obtained from modified proctor test for each untreated and soil cement mix CBR tests were performed according to the ASTM D1883. CBR test were conducted in both conditions. Soon after compaction un-soaked CBR was performed. For the determination of soaked CBR samples were being soaked in water for 96 hours and then were tested. Soaked CBR were performed by keeping in view the behavior of subgrade in extreme condition means under heavy rainfall or flooded situations. CBR swelling were also determined because it also relates the expansive (swelling) behavior of soil under every type of structures. [15].

III. RESULTS

A. Effect of cement content on California Bearing Ratio and CBR Swelling tests

The effect of cement content on un-soaked CBR is given in Fig.1. By the replacement with cement content, the un-soaked CBR in start increases, and then fluctuates. Un-soaked CBR obtained was 42.86 %, 48.57%, 68.57%, 74.29%, 51.43%, 59.05%, 60.95%, and 51.43% by replacing with cement content of proportions of 0%, 1%, 2%, 4%, 6%, 8%, 10%, and 12% respectively. Maximum un-soaked CBR was found at cement content of 4%= 74.29%.

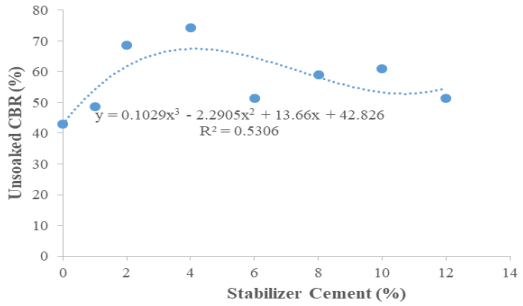

Fig 1: Effect of cement content on Unsoaked CBR of Jamshoro Soil

The effect of cement content on soaked CBR is shown in Fig.2. It was found that with the replacement of cement content, the soaked CBR improved up to 8% and then declines. Soaked CBR obtained was 1.43 %, 4.64%, 5.00%, 8.57%, 30.48%, 62.86%, 26.67%, and 14.29% by replacing with cement of 0%, 1%, 2%, 4%, 6%, 8%, 10%, and 12% respectively. Maximum soaked CBR was found at cement content of 8%= 62.86%.

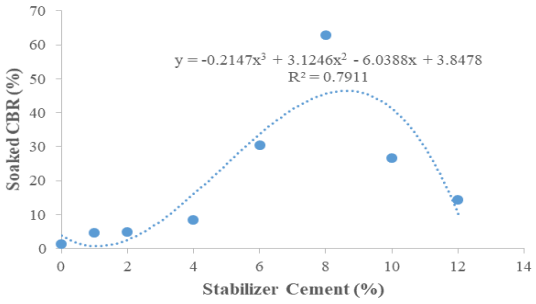

Fig 2: Effect of cement content on Soaked CBR of Jamshoro Soil

The impact of cement content on swelling characteristics are shown in Fig.3. It was observed that by replacing cement content, the swelling first increases and then decreases (10.9 for 0%CC and minimum was observed 5.88 for 8% CC). Swelling obtained was 10.90 %, 20.32%, 13.40%, 12.15%, 15.04%, 5.88%, 10.52%, and 11.30% by the replacing with cement content of 0%, 1%, 2%, 4%, 6%, 8%, 10%, and 12%, respectively.

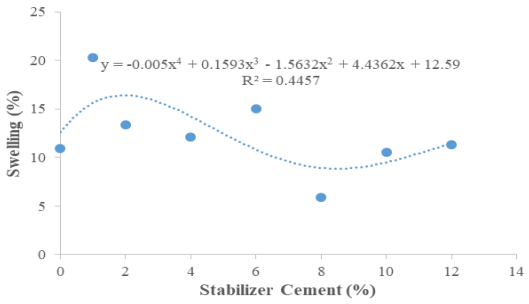

Fig 3: Effect of cement content on Swelling (%) of Jamshoro Soil

Load transfers to the subgrade from the series of layers, therefore subgrade is considered as vital part of pavement. Heavy loads transmitted from the pavement structure should be tolerated by the subgrade. There are two main characteristics for subgrade performance load bearing capacity which relates to CBR (≥10) and volume changes of the subgrade which relates to swelling potential. For supporting the heavy loads and repetitive loading without excessive deformation CBR in both conditions should be 10 or more and swelling potential should not be more than 10. [19]. In this research desired value of CBR in soaked and un-soaked conditions was achieved at 6% cement content. In same way to avoid the differential settlement in foundation of buildings there should be improved CBR and swelling potential. Observing above facts it was observed that 8% of cement content was found sufficient to stabilize this type of expansive soil.

IV. CONCLUSION

For investigating the impact of proportion of cement on swelling potential and California bearing ration of soil in the region of Jamshoro, experimental study was conducted. Following are the conclusion made from this study.

- During the experimental study it was found that by mixing cement content with soil, improvement were observed in both soaked and un-soaked CBR values. The extreme progress in un-soaked condition was acquired with 4% of cement content, which was 74.29% then alters. Maximum improvement was found at 8% of cement content in soaked condition, which was 62.86% then decreased. Un-soaked CBR remain higher than the soaked CBR for lower cement content in soil (0% - 6%). While soaked CBR became higher than un-soaked CBR at 8%CC, and then decreased.

- Mixing of cement to the soil affected the Swelling potential because it was found that by mixing cement with soil, increase in swelling potential was observed in start then started fluctuating. Swelling potential of 5.88% was found to be minimum which was at 8% of cement content.

Cement content of 8% was found optimum for improving this type of soil, however number of quarry sites should be increased to decide easily the optimum content of stabilizer for particular region.

RECOMMENDATIONS

- Other type of soil can also be brought into consideration to know the impact of cement content on it.
- This research shall also be extended to know the influence of cement content on other parameters of soil.

REFERENCES

[1]. American Society for Testing and Materials (ASTM) (2000). Standard Test Methods for Liquid Limit, Plastic limits and Plasticity Index of Soils, ASTM D 4318-00, Philadelphia
[2]. American Society for Testing and Materials (ASTM) (2007). Standard Test Method for CBR (California Bearing Ratio) of Laboratory-Compacted Soils, ASTM D 1883-07, Philadelphia.
[3]. American Society for Testing and Materials (ASTM) (2012).Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort, ASTM D1557-12
[4]. American Society for Testing and Materials (ASTM).Standard Test Method for Materials Finer than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing, ASTM C117-17.
[5]. Aref al-Swaidani,, Ibrahim Hammoud and Ayman Meziab,. ,"Effect of adding natural pozzolana on geotechnical properties of lime-stabilized clay soil'', Journal of Rock Mechanics and Geotechnical Engineering, April 2016 pp.714-725.
[6]. Arora, K, R .Soil Mechanics and Foundation Engineering, Standard Publishers India 2009.
[7]. Azhani Zukri, "Pekan Soft Clay Treated With Hydrated Lime As A Method Of Soil Stabilizer'' in proc. Malaysian Technical Universities Conference on Engineering & Technology 2012, MUCET 2012 Part 3 - Civil and Chemical Engineering, Procedia Engineering 53,2 01 3, pp.37 – 41.
[8]. Bell, F. G. (1996). Lime stabilization of clay minerals and soils. Engineering Geology, vol. 42, no. 4, pp. 223-37.
[9]. Dang,L.C.; Fatahi,B,; and Khabbaz, H. (2016), "Behaviour of Expansive Soils Stabilized with Hydrated Lime and Bagasse Fibres'', Proceedings of the Third International Conference on Transportation Geotechnics, , V.143, 2016, Australia, pp. 658–665.
[10]. Dr.P.C Pumnia, Ashok Kumar Jain and Arun Kumar Jain, Soil Mechanics and Foundations, 16th ed. Laxmi Publications 2005, pp. 849-855.
[11]. Hasan, U.; Chegenizadeh, A.; Budihardjo, M.A.; and, Nikraz, H. "A Review of the Stabilisation Techniques on Expansive Soils," Australian Journal of Basic and Applied Sciences, V.9, No.7, May 2015, pp. 541-548.

[12]. Ji-ru, Z. and Xing, C."Stabilization of expansive soil by lime and fly ash", Journal of Wuhan University of Technology–Materials Science, Vol. 17, 2002, pp. 73–77.
[13]. Kumar, Ashok.; Kumar Aneel.; and Khaskheli, G.B, "Stabilization of Jamshoro soil with Lime," 1st International conference on Sustainable Development in Civil Engineering, MUET, Pakistan, Volume 1,2017, pp. 17-22.
[14]. Kumar, A. and Khaskehli, G.B., "Effect of Cement Content on Unconfined Compressive Strength of Jamshoro Soil". Proceeding of the International Symposium on Sustainable Geosynthetics and Green Technology for Climate Change (SGCC), Bangkok, Thailand, June 20-21, 2012.
[15]. Kumar, A., Khaskheli, G.B., and Korejo, R., "Improving CBR Value and Swelling Potential of Jamshoro Soil by Cement", Proceedings of 7th Regional Symposium on Infrastructure Development, pp. 1-5, Thailand, November 5-7, 2015.
[16]. Kumar, A., Khaskheli, G.B., and Phul, A.M., "Effect of Marble Powder on Various Geotechnical Properties of Jamshoro Soil" ,Proceedings of 3rd International Conference on Construction in Developing Countries, pp. 695-700, Thailand, July 4-6, 2012.
[17]. Liet Chi Dang, Behzad Fatahi and Hadi Khabbaz, "Behaviour of Expansive Soils Stabilized with Hydrated Lime and Bagasse Fibres," in Proc. 3rd International conference on Transportation Geotechnics ICTG ,2016, Volume 143,2016, pp. 658-665.
[18]. MUET, Report on Sub Soil Investigation of New Academic Zone, Mehran University of Engineering and Technology Jamshoro, Pakistan, 2006.
[19]. SUDAS, Design Guide for Improved Quality of Roadway Subgrades and Sub bases. Iowa Highway Research Board, 2008.
[20]. T.William Lambe and Robert V. Whitman, Soil Mechanics, John Wiley and sons ,New York, 1969, pp. 514-524.
[21]. Zaman, G.; Almani, Z.; and Hindu, A.K. "The Geotechnical Properties of Jamshoro Soil (Shale) With Cement", International Journal of Modern Research in Engineering & Management (IJMREM), Vol. 1, Issue 10, 2018, pp. 08–13.