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Research Article

Improvement the Strength of Inorganic Clayey Soil using Cement Additive

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Abstract

Roads are regarded as arteries and veins of a country which are essential for sustainable economic growth. Rapid population growth and industrialization generated the use of transportation facility to carry commercial vehicle loads and repetitive applications of it thereby producing heavier stresses especially on road running in clayey soil areas are known for bed condition and unpredictable behaviour for which the nature of the soil contribute to some extent The failures of pavement in from of heave depression cracking and unevenness are caused by the seasonal moisture variation in subgrade soil. The correct stabilization of foundation soils constitutes an increasingly important issue in the present civil engineering world to alter the properties of soil to meet the desired engineering properties for improving strength and durability. Initially the investigation of soil is carried out to evaluate the physical and engineering properties as per Indian Standard classified as CL (Clay soil having low plasticity) as per Indian Standard (1498 – 1970) by conducting laboratory tests and to evaluate the improvement in properties by the addition of 2 % PPC as stabilizers to be used in pavement design for economy.

Keywords: *Cement, Soil Stabilization, strength, Stabilization*

1. Introduction

India is faced with the tremendous challenge of preserving and enhancing the transportation system to meet the ever increasing stresses due to heavier loads coming through layers to the underlying soil. The quality of subgrade will greatly influence the pavement design and service life of the pavement. The key success in soil stabilization is soil testing.

Traditional stabilizers generally rely on pozzolanic reactions and caution exchange to modify and/or stabilize. Portland pozzolana cement is comprised of calcium-silicates and calcium-aluminates that hydrate to form cementations products and has been successfully used for binding soil particles together, thereby forming a hard stable mass.

2. Objectives

To study the transformation of soil index properties of untreated local soil and also study the impact of addition of 2 % PPC to untreated soil by dry weight of the soil to be stabilized for subgrade for road construction plus the benefit of economy to pavement designers and contactors.

3. Literature Review

Study on the Geotechnical Properties of Cement based Composite Fine-grained Soil states that the effect of cement on the performance of soil, collected from Khanjahan Ali Hall at Khulna University of Engineering & Technology (KUET) in Khulna, Bangladesh. The addition of cement was found to improve the engineering properties of available soil in stabilized forms specifically strength, workability, and compaction and compressibility characteristics. Therefore, laboratory tests such as compaction, Atterberg limits, unconfined compressive strength, direct shear and consolidation tests for different percentages of cement content and original soil samples were performed. These test results show that the soil can be made lighter which leads to decrease in dry density and increase in moisture content and reduced compressibility due to the addition of cement with the soil. Besides that the unconfined compressive strength and shear strength of soil can be optimized with the addition of 7.5% of cement content. (Grytan sarkar, md. rafiqul Islam, Muhammed alamgir, md. Rokonuzzaman (2012)).

An experimental study for identification and comparison of plastic index and shrinkage properties of clay soils with the addition of cement that there has been an increasing application of various clay minerals with high plasticity in environmental and geotechnical projects. One of the weaknesses of clay minerals is their shrinkage potential while desiccating. It is imperative to modify the properties of these minerals by combining them with other materials. The present article tries to examine the effect of adding cement to clay on its shrinkage properties and to compare it with normal clay. A considerable number of expansion experiments were carried out on mixed samples with different weight percentages. The results suggested

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the significant effect of modification of clay soils in Golestan Province by adding cement on their shrinkage properties, such that increased percentage of additives increases the shrinkage limit of clay-additive mixture and the cracks caused by shrinkage decrease in terms of length and width. Finally, the clay additive mixture pattern can be obtained that provides the basic, necessary properties which correspond to the aims of the project. In the present article, cement is used as a chemical for improving the shrinkage properties of expansive and problematic soils in Golestan Province. During the course of experiments, four samples of different soils are used with plasticity indices of 20, 30, 35, and 40. Here, the plasticity properties (including liquid limit, plastic limit, shrinkage limit, and plastic index) of clay soils in the region will be examined and compared before and after adding different percentages of cement. (Mehdi gharib, Hamidreza Saba, Arash barazesh (2012)).

Study of black cotton soil characteristics with cement waste dust and lime has stated that Stabilization of soils is an effective method for improvement of soil properties and the pavement system performance. Plasticity Index is one of the important properties of soil to determine the behavior of soil in presence of water. The poorest soil among all is Black Cotton Soil (BC Soil). In Rajkot area this BC Soil is spread over southern part of District. Rich proportion of montmorillonite is found in BC Soil from mineralogical analysis. High percentage of montomorillonite renders high degree of expansiveness. These property results cracks in soil without any warning. These cracks have sometimes extent severe limit like ½ to 12 deep. Use of this type of land may suffer severe damage to the construction with the change in atmospheric conditions. In this paper, BC Soil was tested using three different stabilizing agents - 1.Cement waste dust collected from the cement plant 2. Cement Dust + Lime Powder 3. Lime Powder. The cement waste dust was found best agent as a stabilizer to improve the Atterberg's Limit and hence Plasticity Index of BC Soil as well as the compressive strength of the same. Laboratory tests were performed with different percentages of three stages, each of them ranging from 1% to 9%. The behavior of BC Soil of Rajkot region was improved with stage no. 1, the percentage of Cement dust 7% of Cement dust in BC Soil is looking to be the appropriate mixing. Also in second stage, improvement is shown at 8% of combination of cement dust and Lime powder. Third stage was observed a best suited result at 9% of Lime powder in BC Soil. The results, thus obtained in laboratory under standard conditions provide satisfactory reason to use the Cement dust as a stabilizing agent for the purpose to improve Plasticity Index of BC Soil compare to other two combinations. After satisfying result of Plasticity Index, Cylindrical Samples of BC Soil with all three combinations were prepared to check the compressive strength of stabilized soil. Moisture content taken was the optimum percentage of plastic limit in each combination. The cylinders of size 50 mm in diameter and 60 mm height were tested after 3, 5, 7, 14, 21, 28 days. The relations for these periods were established among the use of all three different agents. Compressive strength of Cement dust stabilized BC Soil found more reliable. (J.B.Ozaa, Dr. P.J. Gundaliya (2012))

4. Materials

Following are the materials which are to be used in this study.

4.1 Soil

In this study, the soil under investigation is collected from Nadiad (Latitude 22.7000^0 N & Longitude 72.8700^0 E), Gujarat where the road is going to pass, Ahmedabad to Vadodara NH8. The visual examination indicated that soil under investigation is brown in color made of fine particles that cause it to stick together when wet, preventing normal drainage processes. Once it is wet it does not become dry soon. In like manner, when thoroughly dry, it is not soon wetted and shrinks causing cracks.

4.2 Cement

Cement is increasingly used as a stabilizing material for soils, particularly for the construction of highways. It can be used to stabilize sandy and clayey soils. The cement has an effect to decrease the liquid limit and to increase the plasticity index. The quantities of Portland Pozzolana cement is a multi-mineral compound made up of oxides of calcium, silica, alumina and iron. Portland Pozzolana cement is a multi-mineral compound made up of oxides of calcium, silica, alumina and iron. In presence of suitable amount of water, PCC hydrates help to stabilize flocculated clay particles through cementation. In these studies, 2 % of Portland pozzolana cement is used with the soil under investigation.

5. Test Results

Various tests were performing for identify the Engineering property of soil as per Indian Standard are as below:

5.1 Test Result of Untreated Soil

5.1.1 Atterberg Limits of Soil: As far as possible, they are an essential measure of the way of a fine grained soil. The behavior of the soil is related to the amount of water in the system and may show up in four states in particular Solid, Semi solid, Plastic, Liquid. In each, one express the consistency and conduct of a soil is distinctive and along these lines are its designing properties. Therefore, the limit between each one state can be characterized focused around a change in the Soil's conduct. The cutoff points were refined by Arther Casagrande.

*5.1.2 Plasticity Index***:** It is the range of water content over which a soil behaves plastically. It is defined as the range of consistency with in which the soil exhibit plastic properties i.e. the numerical difference between the liquid limit and plastic limit.

5.1.3 Soil: Soil consistence provides a means of describing the degree and kind of cohesion and adhesion between the

Table 1 Soil Classification, FSI & Atterberg's Limit

Soil	Grain Size Distribution			Atterberg's Limit			FSI %
	Gravel (%)	Sand (%)	Silt/Clay (%)	L. L (%)	P. L. (%)	P. I. (%)	
Inorganic Clay Soil (CL)	3.56	37.64	58.80	30.40	19.43	10.97	17.50

soil particles as related to the resistance of the soil to deform or rupture.

5.1.4 Stabilizing Agent: A balancing out specialists is a mechanical, chemical or bituminous added substance used to keep up or build the properties of soil or other material utilized as a part of development.

The knowledge of the soil consistency is important in defining or classifying a soil type or predicting soil performance when used as a construction material. The soil consistency is a practical and an inexpensive way to distinguish between silts and clays. IS code 2720 (part V 1985) is followed for evaluating the Atterberg's limits in the laboratory for classification of soil. The test result for untreated soil is shown in table 1.

The soil is characterized as inorganic clay (CL) with low plasticity as per unified soil classification system (USCS) as fine grained soil passing 0.075 mm sieve is more than 50 percent and liquid limit falls in the range of 0 to 35.

5.1.5 Compaction result for Untreated Soil

Maximum density and optimum moisture are needed for field control during compaction so as to achieve satisfactory results. IS: 2720 (Part VII – 1978) is followed for compaction test was on inorganic clayey soil with low plasticity (CL). From this test Moisture Dry Density and Optimum Moisture Content are found out as shown in Fig 1.

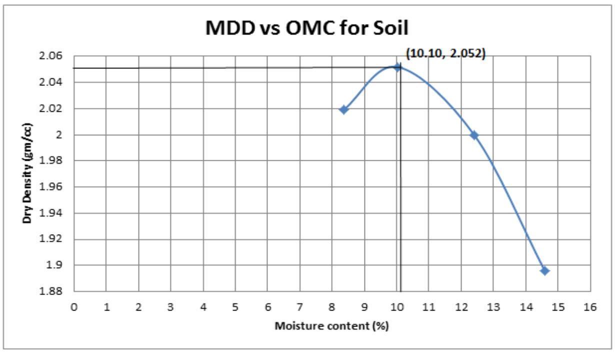

Fig.1 MDD Vs OMC Graph for soil

5.1.6 CBR Result of Untreated Soil

As per IS: 2720 (Part 16 – 1987) CBR test was performed for 100 % inorganic clayey soil with low plasticity (CL), remolded at OMC (10.10%) & MDD (2.052%). The surcharge weight of 5.0 kg is placed on the sample and was soaked for 96 hours. During testing, initial loading is applied on it so that the plunger is properly in contact with soil and penetration values are consistent with respect to the load applied.

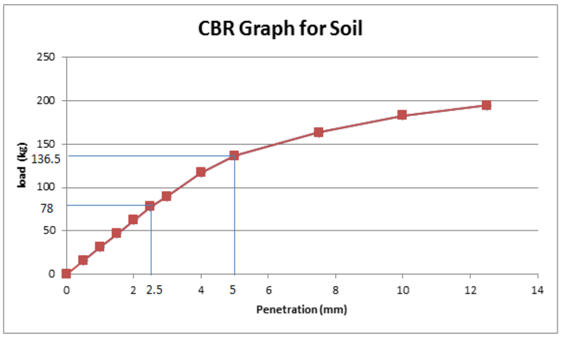

Fig.2 Load Penetration Curve for Untreated soil

CBR value from Graph,

Std. Penetration	Load*100/Std. load	CBR %
2.5 mm	(78*100)/1370	5.69
5 mm	(136.50*100)/2055	6.64

As the value of CBR at 5 mm is more, tests were repeated and values again obtained were more than CBR at 2.5 mm, hence CBR at 5 mm is considered.

5.2 Test Result for Treated Soil with Cement

The collected soils and 2 % cement content was oven dried at 105 °C overnight to remove moisture and repress microbial activity. The oven dried samples were mixed thoroughly by hand in a large tray in a dry state. The index property of soil is obtained from Atterberg's test result.

Atterberg's Limit		
L. L. (%)	P. L. (%)	P. I. (%)
26	16.5	9.95

5.2.1 Compaction result for Treated Soil

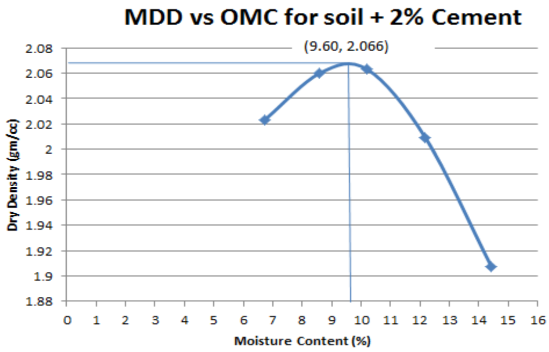

Fig. 3 MDD vs. OMC for soil+2% Cement

In field control, maximum dry density for specific input energy level is carried out on fine grained soil with 2 % cement as additive with suitable amount of water is added to lubricate the contact surfaces of soil particles and improve the compressibility of the soil matrix added prior to achieve compaction mechanically increasing the density of soil. The densification of soil is achieved by reducing air void space.

5.2.2 CBR Result of Treated Soil

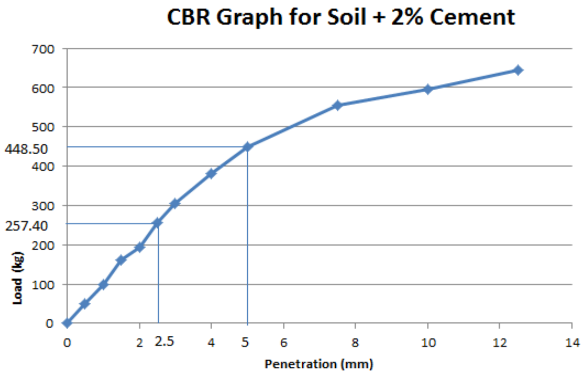

Fig. 4 CBR Graph for soil + 2% Cement

CBR value from Graph

Std. Penetration	Load*100/St. load	CBR %
2.5 mm	(257.40*100)/1370	18.79
5 mm	(448.50*100)/2055	21.82

There is a significant change in CBR value is noted for CL soil with 2% PCC content. The graph shows that the value of CBR at 5 mm is more compared to 2.5 mm penetration. Tests were repeated as per the codal practice and values again obtained for 5 mm penetration is more than CBR at 2.5 mm penetration, hence CBR at 5 mm is considered for carrying out study.

Conclusion

In the present research, experiments were conducted to stabilize the inorganic clay with low plasticity with fixed 2% PCC. The following conclusions are drawn.

There is a need for enhancing the engineering characteristics of CL soil for road construction by the addition of 2 % PCC so that the engineering property of clayey soil is improved. It has been noted that liquid limit decreases and plastic limit values are declining but the plasticity is decreasing compared with untreated soil. The increase in maximum dry density is a result of flocculation and agglomeration of inorganic clay with low plasticity soil particles with PCC which is due to the result of initial coating of soils by cement to form larger aggregate, which consequently occupy larger spaces.

Comparing CBR value of untreated CL soil and same treated with 2 % PCC indicates the good rise from 6.64 % to 21.82 %. This signifies that the strength of subgrade soil is improved thereby increasing the load carrying capacity of pavement. From economy point of view benefit associated with the utilization of 2 percent PCC is attractive and supports the sustainable development in road construction.

Recommendation for Further study

Trying out the usage of PCC in suitable proportion with nanotechnology chemical additive, to improve the engineering properties of local soil to be used in pavement design for economy.

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