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Study of Soil Cement Stabilization for Pavement Base Course and Sub grade

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ABSTRACT:
Soil Stabilization is a process of treating a soil in such a manner as to maintain, alter or improve the performance of the soil as a construction material. The changes in the soil properties are brought about earlier by the incorporation of additives or by mechanical blending of different soil types. The aim of the study is to review on stabilization of soil using cement. In this report soil has been taken from Abu Pur Muradnagar U.P, and several laboratory test is done on that soil sample and soil mixed with cement.The experiments done on the treated and untreated soil are Atterberg's limit (liquid limit and plastic limit), Standard Proctor test, Water content, Direct Shear test and California bearing ratio (CBR) test by adding 2%, 4% and 6% of cement on the soil sample.

Key words: Cement, Direct Shear Test, California Bearing Ratio, and Atterberg's Limits.

1. INTRODUCTION

A proper understanding of the geotechnical properties of soils is a pre-requisite for its use in engineering construction works. Studies on the engineering properties of these materials have made geologists and engineers aware of a wide range of properties. However the relative abundance of soil notwithstanding, its suitability for various purposes can be enhanced through the modification of its properties by stabilization. Long term performance of pavement structures often depends on the stability of the underlying soils. Engineering design of these constructed facilities relies on the assumption that each layer in the pavement has the minimum specified structural quality to support and distribute the super imposed loads. These layers must resist excessive permanent deformation, resist shear and avoid excessive deflection that may result in fatigue cracking in overlying layers. Available earth materials do not always meet these requirements and may require improvements to their engineering properties in order to transform these inexpensive earth materials into effective construction materials. This is often accomplished by physical or chemical stabilization or modification of these problematic soils. Although the solution appears simple and straight forward, engineering properties of individual soils may vary widely due to heterogeneity in soil composition, difference in micro and macro structure among soils, variability and heterogeneity of geologic deposits and due to differences in physical and chemical interactions of air/water with soil particles. These differences necessitate the use of site-specific treatment options for stabilization.

1.1 PURPOSE

This manual establishes criteria for improving the engineering properties of soils used for pavement base courses, sub base courses, and sub grades by the use of additives which are mixed into the soil to effect the desired improvement. These criteria are also applicable to roads and airfields having a stabilized surface layer.

1.2 USE OF SOIL-CEMENT STABILIZATION

The use of soil-cement can be of great benefit to both owners and users of commercial facilities. Its cost compares favourably with that of granular-base pavement. When built for equal load carrying capacity, soil-cement is almost always less expensive than other low-cost site treatment or pavement methods. The use or reuse of in-place or nearby borrow materials eliminates the need for hauling of expensive, granular-base materials; thus both energy and materials are conserved.

1.3 MECHANISMS OF STABILIZATION

The stabilization mechanism may vary widely from the formation of new compounds binding the finer soil particles to coating particle surfaces by the additive to limit the moisture sensitivity. Therefore, a basic understanding of the stabilization mechanisms involved with each additive is required before selecting an effective stabilizer suited for a specific application. Chemical stabilization involves mixing or injecting the soil with chemically active compounds such as Portland cement, lime, fly ash, calcium or sodium chloride or with viscoelastic materials such as bitumen. Chemical stabilizers can be broadly divided in to three groups: Traditional stabilizers such as hydrated lime, Portland cement and Fly ash; Non-traditional stabilizers comprised of sulfonated oils, ammonium chloride, enzymes, polymers, and potassium compounds; and By-product stabilizers which include cement kiln dust, lime kiln dust etc. Among these, the most widely used chemical additives are lime, Portland cement and fly ash. Although stabilization with fly ash may be more economical when compared to the other two, the composition of fly ash can be highly variable

1.4 DIFFERENT TYPE OF STABILIZATION

i. Mechanical stabilization
ii. Geosynthetic stabilization
iii. Chemical stabilization

I. Mechanical stabilization –

This is the process of altering soil properties by changing the gradation through mixing with other soils, densifying the soils using compaction efforts, or undercutting the existing soils and replacing them with granular material. A common remedial procedure for wet and soft sub grade is to cover it with granular material or to partially remove and replace the wet sub grade with a granular material to a pre-determined depth below the grade lines. The compacted granular layer distributes the wheel loads over a wider area and serves as a working platform.

II. Geosynthetic stabilization

Geogrid has been used to reinforce road sections. The inclusion of geogrid in sub grades changes the performance of the roadway in many ways. Tensile reinforcement, confinement, lateral spreading reduction, separation, construction uniformity and reduction in strain have been identified as primary reinforcement mechanisms. Empirical design and post-construction evaluation have lumped the above described benefits into better pavement performance during the design life.

III. Chemical stabilization –

The transformation of soil index properties by adding chemicals such as cement, fly ash, lime, or a combination of these, often alters the physical and chemical properties of the soil including the cementation of the soil particles.

2. LITERATURE REVIEW

Engineers are often faced with the problem of constructing roadbeds on or with soils, which do not possess sufficient strength to support wheel loads imposed upon them either in construction or during the service life of the pavement. It is, at times, necessary to treat these soils to provide a stable sub grade or a working platform for the construction of the pavement. These treatments result in less time and energy required for the production, handling, and placement of road and bridge fills and sub grades and therefore, less time to complete the construction process thus reducing the disruption and delays to traffic. These treatments are generally classified into two processes, soil modification or soil stabilization. The purpose of sub grade modification is to create a working platform for construction equipment.

Manikant Mandal and Dr, Mayajit Mazumdar (1995), a study was made on the effect of additives on lateritic soil stabilization with cement and lime. Particularly, the strength and fatigue behaviour, under repeated flexure, of stabilized latertic soil treated with additives, have not been studied in our country till now.
Arumugam and K. Muralidharan (1997), stabilizing the locally available soils and using them as subgrade materials generally reduce the cost of pavement construction. It was concluded that the mechanical stabilization saving in the construction cost of pavement upto 43% has been effected. Lime and cement stabilization saves the amount by 46.2% and 27.56% respectively. T.Lopez-Lara, J.A. Zepeda-Garrido and V.M. Castario (1999) this paper includes the evaluation of the main index properties of the soil, along with a characterization of the materials through X-ray diffraction.

Abu siddique and Bipradas rajbongshi (2002), A study of Mechanical properties of a cement stabilized coastal soil for use in road construction, this paper present the soil cement stabilization with 1%, 3%, and 5% cement fulfill the requirements of road sub-base and base subjected to light traffic. Analyses using CIRCLY computer program were conducted to estimate the thickness of soil-cement for paved and unpaved rural road maximum width 2.5 m and subjected to anticipated design traffic loading of light cross country vehicle (LCCV), i.e, jeep. Virender Kumar (2002).

Costas A.Anagno– stopoulos (2004), In this study, a laboratory test programme was carried out to find out the effect of inclusion of cement and acrylic resin on physical and engineering behaviour of a soft clay. A series of tests are conducted with the addition of 5% to 30% of cement contents and acrylic resin of 5% . It is concluded that the development of strength and stiffness for a short curing time (7 days) is delayed significantly because of A.R addition while for long curing time (28 days) the engineering parameters are increased considerably

3. METHODOLOGY

The use of stabilization to improve the properties of a material is becoming more widespread due to the increased strength and load spreading ability that these materials can offer. A collective experience has demonstrated that cement can be mixed to increase the strength of soil in different ways.However, the basics always remain the same: treated soil is the simple product of cementwith soil.There is no secret ingredient or proprietary formula that makes treated soil mixed with cement. Sstabilization is the process of mixing a stabiliser, for example cement, with a soil or imported aggregate to produce a material whose strength is greater than that of the original unbound material. In this report soil has been taken from ABU PUR Muradnagar U.P, and several laboratory test is done on that soil sample and soil mixed with cement.The experiments done on the treated and untreated soil are Atterberg's limit (liquid limit and plastic limit), Standard proctor test, Direct shear test and California bearing ratio (CBR) test by adding 2%, 4%, and 6% cement on the soil sample.

4. EXPERIMENTAL INVESTIGATION

This provides detail of materials used in the experimental work. A laboratory investigation program was carried out to evaluate the mechanical properties of the untreated soil and soil stabilized with waste tyre rubber. The soil was stabilized with cement contents by weight of soil. The test which carried out on the samples of untreated and stabilized soil are as follows:

1. Grain Size Analysis
2. Atterberg's Limits
3. Proctor Compaction Test
4. Direct Shear test
5. California Bearing Ratio Test

5. TEST RESULT

5.1Grain Size Analysis

Unified classification of Soil = SC/SM

The result obtained from the above test indicates that according to Unified Soil Classification System (USCS) the soil sample is SC (Silty Sands)/SM (Clayey Sands).

Measured by standard available means with reference to the Standard Liquid Limit Device. It is defined as the minimum water content at which a part of soil cut by a groove of standard dimensions will flow together for a distance of 12mm (1/2 inch) under an impact of 25 blows in the device.

5.2 Atterberg Limit

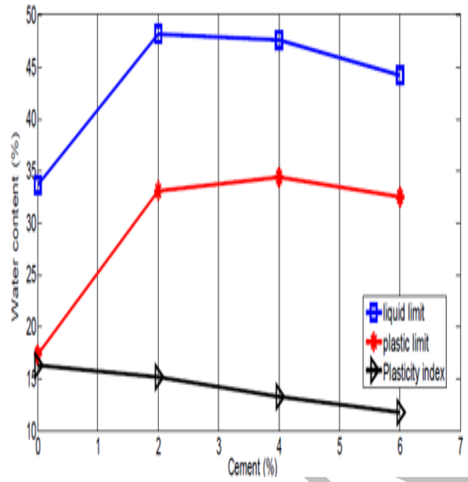
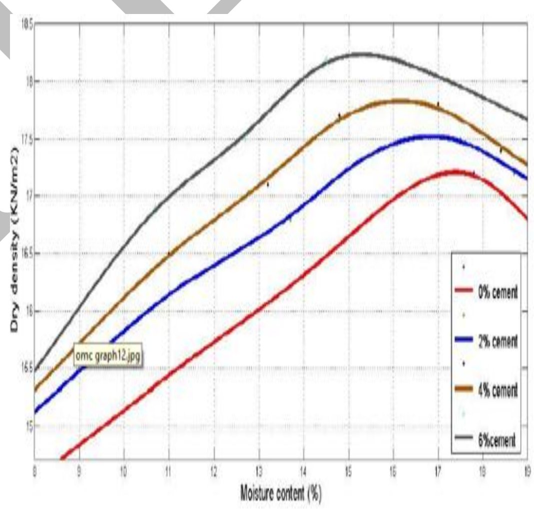


Fig.5.2 shows the effect of addition of cement on Atterberg's limits. It is observed that there is an increase in both liquid limit and plastic limit at 2 percent cement and thereafter both limits remain fairly constant. Plasticity index have very small change with increasing the percentage of cement. The initial increase in liquid limit indicates flocculation of soil particles due to addition of cement.

5.3 Moisture-density relation

The moisture-density relation of the samples are shown in fig 5.3 from the plots shown in fig. 5.3, the maximum dry density (γmax) increase while wopt decrease when 2%, 4%, and 6% cement added to soil sample as compared with the untreated sample, the value of γmax increase up to 1.06 while wopt reduced up to about 0.89 for the sample stabilized with 6% cement content,



5.4 Direct shear test

Test result of direct shear test indicates with increase in cement content the value of cohesion 'c' decreases and the value of angle of internal friction 'Φ' increases with every interval of increment of cement.

For Untreated Soil

From the curve c = 1.6

$\Phi = 38^0$

For 2% cement addition

From the curve c = 1.1

$\Phi = 40^0$

For 4% cement addition

From the curve c = 0.6

$\Phi = 41^0$

For 6% cement addition

From the curve c = 0.6

$\Phi = 40^0$

5.5 California Bearing Ratio

For untreated soil sample

Maximum value of CBR for sub grade = 5.07 %

For 2% cement added to soil sample

Maximum value of CBR for sub grade = 6.62 %

For 4% cement added to soil sample

Maximum value of CBR for sub grade = 8.23 %

For 6% cement added to soil sample

Maximum value of CBR for sub grade = 10.15 %

CONCLUSION

This study made a comprehensive examination of the effectiveness of cement treatment on geotechnical properties of soils taken from ABU PUR, Modinagar U.P.

1. Test result indicate that with the increase in cement content liquid limit, plastic limit and plasticity index decreases as compared to untreated sample.
2. Maximum dry density increases while optimum moisture content reduced with increasing 2%, 4%, and 6% cement with respect to untreated soil sample.
3. Test result of direct shear test indicates with increase in cement content the value of cohesion 'c' decreases and the value of angle of internal friction 'Φ' increases with every interval of increment of cement.
4. California bearing ratio (CBR) of stabilized samples increases sharply with increases cement content. CBR of sample stabilized with 6% cement and compacted of 5 layers with heavy energy of 55 blown in each layers fulfil the criteria proposed by AASHTO soil classification.

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