

Soil Stabilization using Geosynthetic Material (Steel Fibres)

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Abstract—Soil stabilization is the process which involves enhancing the physical properties of the soil in order to improve its strength, durability etc. by blending or mixing with additives. The different types of method used for soil stabilization are: Soil stabilization with cement, Soil stabilization with lime, Soil stabilization using bitumen, Chemical stabilization and a new emerging technology of stabilization by Geo textiles and Geo synthetic fibers. In this study, we are making use of Steel fibers as geo synthetic material for stabilization of soil. With the introduction of Steel fibers to the soil the CBR values will improve and thickness of pavement layer also gets reduced. It also reduces the intensity of stress on subgrade. Steel fibers is such a geosynthetic material which is effectively accessible, ecofriendly and furthermore savvy. With the use of soil adjustment strategy in development the general expense gets diminished when contrasted with the normal technique for development. The Highway Research Board (HRB) order of the dirt strata like dark cotton soil and sedu soil is finished utilizing appropriate examining system, for example, Core Cutter Method. To decide the attributes like Grading by Sieve Analysis, Atterbergs Limits i.e Liquid farthest point utilizing Cone Penetration Method and Casagrande Method, Plastic breaking point by rolling the example to 3mm breadth string, Shrinkage limit utilizing Shrinkage mechanical assembly, Optimum Moisture Content and Maximum Dry Density utilizing Standard Proctor Test and furthermore California Bearing Ratio by leading CBR test.

The pavement thickness was designed using pavement design catalogues published by IRC SP:20-2002. The estimation for the road is done by considering the item such as Jungle Cutting, Earthwork Excavation for Roadway and Drains, compacting and grading etc., as per SR 2016-17, PW, P and IWT circle Dharwad and suggestion of specification for the mixture of Steel fibers as Geo Synthetic material for stabilization using CBR value by CBR Test and Shear strength using Unconfined Compression Test.

The different tests were conducted in order to determine the different characteristics and properties of the black cotton soil and obtained with following results. The liquid limit of the soil with addition of Steel fibers was found to be decreasing when compared to liquid limit of soil alone.

The plastic furthest reaches of the dirt diminished with the expansion of filaments. The shrinkage furthest reaches of the dirt was expanded with increment in strands. The MDD of the dirt with expansion of Steel filaments by weight of soil is observed to increment upto 0.75% after that it diminishes and the comparing OMC is diminished with expansion of strands. The shear quality of soil diminished significantly with expansion of strands. The CBR estimation of the dirt expanded significantly. The distinctive tests were led so as to decide the diverse qualities and properties of the sedu soil and acquired with following outcomes. The fluid furthest reaches of the dirt alone was observed to be 36.5%. The MDD of the dirt with expansion of 0.25%, 0.5% Steel strands by

weight of soil is observed to be diminished by 0.83% and 0.75% , 1.0% Steel filaments by weight of soil is observed to be expanded by 0.11 % and 16.98% separately and the relating OMC is diminished by 15.62%, 21.87% and 33.75% individually. The shear quality of the dirt with the expansion of 0.25%, 0.5%, 0.75% and 1% of Steel strands is observed to be diminished by 38.57%, 38.57%, 35.25% and 5.85%.

The CBR estimation of the dirt with expansion of 0.25%, 0.5%, 0.75% and 1.0%, Steel filaments by weight of soil is observed to be expanded. From the restricted research center investigation directed we reasoned that the 0.75% of Steel fiber can generously improve the properties of Black cotton soil. Furthermore, in this way 0.75% of Steel fiber is the ideal fiber content for dark cotton soil.

The design thickness of flexible pavement before stabilization is obtained as 450mm and after stabilization is obtained as 250mm. The estimated cost for constructing flexible pavement before stabilization of soil is obtained as 4018050 Rs /Km and after stabilization of soil is obtained as 3721894Rs/Km. The estimated cost after stabilization is found to be decreased by 7.37%.

1. INTRODUCTION

Soil adjustment is the procedure which includes upgrading the physical properties of the dirt so as to improve its quality, strength and so on by mixing or blending it with added substances. The distinctive kinds of strategies utilized for soil adjustment are: Soil adjustment utilizing concrete, Soil adjustment utilizing lime, Soil adjustment utilizing bitumen, Chemical adjustment and another rising innovation of adjustment that is adjustment of soil by utilizing Geo materials and Geo engineered strands.

Geo synthetics are engineered items produced using different sorts of polymers which might be either Woven or Non-Woven. These are utilized to upgrade the attributes of soil and have given a functional method for developing structural building structures monetarily.

In this investigation, we are making utilization of Steel filaments as geo engineered material for adjustment of soil. With the acquaintance of Steel filaments with the dirt the CBR esteems may improve and thickness of asphalt layer additionally may get decreased. It might likewise decrease the power of weight on subgrade. Steel filaments is such a geosynthetic material which is effectively accessible, eco-accommodating and furthermore financially savvy. With the utilization of soil adjustment procedure in development process the general expense may get diminished when contrasted with the common technique for development.

Objectives of the project work

To categorize the clayey soil namely black cotton soil and

Revised Manuscript Received on April 12, 2019.

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sedu soil as per Highway Research Board classification.

To analyze the characteristics of soil for different concentrations of Geo synthetic material (Steel fibers) mixed with it.

The design of flexible pavement without Geo synthetic material and with the optimum concentration of the geo synthetic material mixed with the above soil as per IRC SP:20-2002.

2. LITERATURE REVIEW

2.1 Stabilization of Black Cotton Soil using Lime and Geogrid^[2](2009)

Sujitkawade et al., studied the effect of Lime and geogrid on the properties of the soil. Their main objectives was to determine the properties of the soil before and after the addition of lime and geogrid to it. The different tests they conducted were natural moisture content determination, specific gravity, Atterbergs limits, Compaction test, Compressive Strength test. After studying and conducting the entire above test, the optimum lime content was found to be 15% and they concluded that there was a substantial increase in the compressive strength of the soil.

2.2 Geotextiles: An Overview^[3](2010)

AyushMithal and Dr. ShalinuShukla studied the effectiveness of use of geotextiles as reinforcement material for stabilization of soil for different engineering works. Their objectives were to study and introduce the properties of Geotextiles (such as Physical property, Mechanical property, Hydraulic property, Endurance property and Durability property), Fibers of Geotextiles, (they are natural and synthetic fibers), Types of Geotextiles, functions of Geotextiles, application of geotextiles and impact of geotextiles on environment. They have concluded that, due to the versatility of functions of geotextiles they can be used in many important civil engineering works. The use of geotextiles not only reduces construction cost but also reduce maintenance cost.

2.3 Improvement in CBR value of Black cotton soil by stabilizing it with vitrified polish waste^[4](2011)

Vegulla .Raghudeep et al . , studied the effect of vitrified polish waste on the properties of the soil. Their objective was to check the reduction in pavement thickness due to increase in CBR because of addition of polish waste. They conducted the tests like Grain size distribution, Atterbergs limits, Compaction tests and CBR tests on soil alone and with addition of vitrified polish waste. They conducted that 10% addition of vitrified polish waste resulted in substantial increase in CBR value and significant reduction in pavements thickness was reported.

3. ANALYSIS OF DATA

3.1 Wet Sieve Analysis

Wet sieve analysis of Black cotton soil collected from near was carried out in order to classify the soil. The following observations were made: Sample taken [passing 4.75mm sieve before washing] = 200 g

Sample retained on 0.075mm sieve after washing and drying = 115 g

Sample passed through 0.075mm sieve after washing = 85 g, 42.5%

Table 3.1: Sieve analysis of Black cotton soil

Sl.No.	IS sieve size	Particle size (D) Mm	Mass of soil retained (M _i)g	% Mass of retained (M _i /M)*100	Cumulative % retained, C	Cumulative % Fine N=100-C
1	2.000	2.000	0	0.00	0.00	100.00
2	1.000	1.000	06	05.22	5.22	94.78
3	0.600	0.600	37	32.17	37.39	62.61
4	0.425	0.425	09	07.83	45.22	54.78
5	0.300	0.300	15	13.04	58.26	41.74
6	0.212	0.212	17	14.78	73.04	26.96
7	0.150	0.150	00	0.00	73.04	26.96
8	0.075	0.075	29	25.22	98.26	01.74
9	Pan	0	0	0.00	98.26	01.74

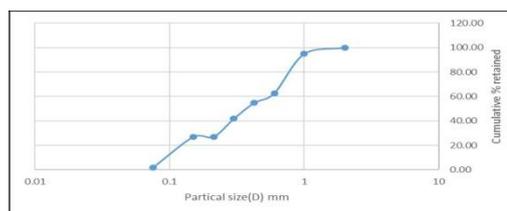


Figure 3.1: Particle size distribution curve of Black cotton soil

Liquid Limit Test

3.3.1 Cone Penetration Test

Sample Taken [passing through = 425µ]= 150 g

Table 3.2: Liquid limit test on Black cotton soil using cone penetration method

Trial No.	Water Content, %	Water Amount, ml	Penetration, mm
1	50	75	16
2	55	82.5	17
3	60	90	20
4	65	97.5	35
5	70	105	44

Liquid limit as obtained from graph = 60 % (Corresponding to 20mm penetration)

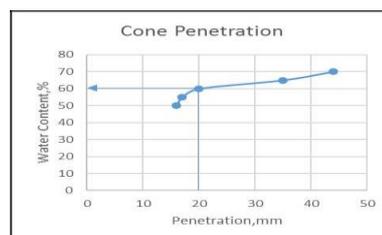


Figure 3.2: Liquid Limit curve (Cone Penetration)



3.2 Plastic Limit test:

Table 3.3: Plastic limit test on Black cotton soil

Trial Number	1
Container No.	GT-19
Mass of empty container, M ₁ g	32.15
Mass of container + wet soil, M ₂ g	47.15
Mass of container +dry soil, M ₃ g	44.50
Mass of water = M _w = M ₂ -M ₃	02.65
Mass of dry soil= M _d = M ₃ -M ₁ g	12.35
Plastic Limit,% W _p =(M _w /M _d)*100	21.46

3.3 Plasticity Index

Soil Sample - 1

$I_p = WL - WP = 60 - 21.46 = 38.36\%$

4. RESULT AND DISCUSSION

4.1. General

4.2. Atterbergs Limit

4.2.1. Liquid limit

1. The liquid limit of the soil alone was found to be 60%
2. The liquid limit of the soil with addition of 0.25%, 0.5%, 0.75% and 1.0%, by weight of soil is found to be 39.2%, 39.7%, 42.0% and 42.3% respectively.
3. The liquid limit of the soil with addition of 0.25%, 0.5%, 0.75% and 1.0%, Steel fibers is found to be decreased by 34.66%, 33.83%, 30.0% and 29.5% respectively, when compared to liquid limit of soil alone.

4.2.2. Plastic limit

1. The plastic limit of the soil alone was found to be 21.46%
2. The plastic limit of the soil with addition of 0.25%, 0.5%, 0.75% and 1.0%, Steel fibers by weight of soil is found to be 22.27%, 33.33%, 35.59% and 37.50% respectively.
3. The plastic limit of the soil with addition of 0.25%, 0.5%, 0.75% and 1.0%, Steel fibers is found to be decreased by 21.3%, 43.5%, 51.8% and 58.8% respectively, when compared to plastic limit of soil alone.

4.2.3. Plasticity Index

1. The plasticity index of the soil alone was found to be 38.54%.

2. The plasticity index of the soil with addition of 0.25%, 0.5%, 0.75% and 1.0%, Steel fibers by weight of soil is found to be 11.93%, 6.37%, 6.41% and 4.8% respectively.
3. The plasticity index of the soil with the addition of 0.25%, 0.5%, 0.75% and 1% of Steel fibers is found to be decreased by 69%, 84.47%, 83.36% and 87.54%.

4.2.4. Shrinkage limit

1. The shrinkage limit of the soil alone was found to be 23.309%
2. The shrinkage limit of the soil with addition of 0.25%, 0.5%, 0.75% and 1.0%, Steel fibers by weight of soil is found to be 16.471%, 15.876%, 8.043% and 5.826% respectively.
3. The shrinkage limit of the soil with the addition of 0.25%, 0.5%, 0.75% and 1% of Steel fibers is found to be decreased by 29.31%, 31.88%, 65.49% and 75%.

4.3 Standard Proctor Test

- The optimum moisture content (OMC) and maximum dry density (MDD) of soil alone was found to be 21.4% and 1.378 g/cc respectively.
- The MDD of the soil with addition of 0.25%, 0.5%, 0.75% and 1.0%, Steel fibers by weight of soil is found to be 1.401 g/cc, 1.425 g/cc, 1.565 g/cc and 1.378 g/cc respectively and the corresponding OMC is found to be 20.1%, 19%, 17% and 16% respectively.
- The MDD of the soil with addition of 0.25%, 0.5%, 0.75% and 1.0%, Steel fibers by weight of soil is found to be increased by 1.6%, 3.4%, 13.5% and 0% respectively and the corresponding OMC is decreased by 6%, 11.2%, 20.56% and 21.02% respectively.

4.4 Unconfined Compression Test

- The shear strength of soil alone was found to be 1.27MPa.
- The shear strength of the soil with addition of 0.25%, 0.5%, 0.75% and 1.0%, Steel fibers by weight of soil is found to be 1.687, 1.838, 1.868 and 1.989% respectively.
- The shear strength of the soil with the addition of 0.25%, 0.5%, 0.75% and 1% of Steel fibers is found to be decreased by 32.83%, 44.72%, 47.08 and 56.61%.

4.5 California Bearing Ratio (CBR) Test

- The CBR value of soil alone was found to be 1.82%
- The CBR value of the soil with addition of 0.25%, 0.5%, 0.75% and 1.0%, Steel fibers by weight of soil is found to be 3.49%, 3.96%, 5.41% and 3.96% respectively.
- The CBR value of the soil with addition of 0.25%, 0.5%, 0.75% and 1.0%, Steel fibers by weight of soil is found to be increased by 91.75%, 117.5%, 197.25% and 117.5% respectively.

4.6 Atterbergs Limit (sedu soil)



4.6.1 Liquid limit

- The liquid limit of the soil alone was found to be 36.5%

4.7 Standard proctor test

- The optimum moisture content (OMC) and maximum dry density (MDD) of soil alone was found to be 16% and 1.802 g/cc respectively
- The MDD of the soil with addition of 0.25%, 0.5%, 0.75% and 1.0%, Steel fibers by weight of soil is found to be 1.788 g/cc, 1.788g/cc, 1.804 g/cc and 2.108 g/cc respectively and the corresponding OMC is found to be 13.5%, 13.5%, 12.5% and 10.6% respectively.
- The MDD of the soil with addition of 0.25%, 0.5% Steel fibers by weight of soil is found to be decreased by 0.83% and 0.75% , 1.0% steel fibers by weight of soil is found to be increased by 0.11 % and 16.98% respectively and the corresponding OMC is decreased by 15.62%, 21.87% and 33.75% respectively.

4.8 Unconfined Compression Test:

- The shear strength of soil alone was found to be 1.024 MPa.
- The shear strength of the soil with addition of 0.25%, 0.5%, 0.75% and 1.0%, Steel fibers by weight of soil is found to be 0.629, 0.629, 0.663 and 0.964% respectively.
- The shear strength of the soil with the addition of 0.25%, 0.5%, 0.75% and 1% of Steel fibers is found to be decreased by 38.57%, 38.57%, 35.25% and 5.85%.

4.9 California Bearing Ratio (CBR) Test

- The CBR value of soil alone was found to be 4.28%
- The CBR value of the soil with addition of 0.25%, 0.5%, 0.75% and 1.0%, Steel fibers by weight of soil is found to be 27.74%, 29.20%, 27.74% and 44.77% respectively.
- The CBR value of the soil with addition of 0.25%, 0.5%, 0.75% and 1.0%, Steel fibers by weight of soil is found to be increased. The design thickness of flexible pavement before stabilization is obtained as 450mm.
- The design thickness of flexible pavement after stabilization is obtained as 250mm. The estimated cost for constructing flexible pavement before stabilization of soil is obtained as 4018050 Rs /Km³
- The estimated cost for constructing flexible pavement after stabilization of soil is obtained as 3721894Rs/Km

CONCLUSIONS

On the basis of present experimental study, the following conclusions are drawn

- According to the Highway Research Board classification, the black cotton soil sample has been categorized as A-7-6 (4.549)
- There is substantial increase in MDD with increase in addition of fibers upto 0.75% by weight beyond which it decreased.
- There is substantial decrease in OMC with increase in addition of fibers.

- In unconfined compression test it was observed that the shear strength of the soil has increased with the increase in percentage of Steel fibers, when compared to that of shear strength of soil tested without fiber.
- The shear strength of the soil is maximum when 1% (by weight of soil) of Steel fibers is added to it. Hence in order to obtain higher shear resistance 1% of fibers (by weight of soil) can be considered as the optimum fiber content.
- The California bearing ratio (CBR) of the soil alone is obtained as 1.82% and it increased to 5.41% after stabilizing it with optimum percentage of Steel fibers.
- The percentage increase in CBR value after stabilizing it with optimum percentage of fibers is 197.25%.
- In the case of sedu soil there is substantial increase in MDD with increase in addition of fibers.
- In unconfined compression test it was observed that the shear strength of the soil has decreased with the increase in percentage of Steel fibers, when compared to that of shear strength of soil tested without fiber.
- The California bearing ratio (CBR) of the soil alone is obtained as 4.28% and there substantial increase in CBR value with addition of fibres.

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