Stabilization of Subgrade Soil with Geogrid and Waste Material

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Abstract: Black Cotton soil due to its expansive nature possess a serious problem during and after construction of pavement Generally Black cotton soil is removed or replaced with other stronger material when encountered During Construction. Soil stabilization is generally adopted for a given project site, if the existing subgrade is not sufficient to provide the required strength. Also, during contact of Water (Ground water, Rain water) due to swell-shrinkage behavior of expansive soil it causes various problem. On the other hand, due to rapid industrialization throughout the world, large amount of waste material is generated. Out of which Mining waste account a significant portion The Present study was undertaken with the objective of utilizing Mining waste material to poor subgrade and provide a feasible solution which can reduce the environmental impact as well as improve subgrade characteristic. In the experimental study, Black cotton soil was obtained and mixes were prepared with mining waste, lime and coir fiber. Further for attaining better strength Geogrid was inserted at one third height from the top of the CBR mould. The un-soaked and soaked CBR showed a slight improvement in strength. But there was a significant reduction in swell pressure when compared to parent soil.

***Keyboard* – Subgrade Layer, Expansive Soil Stabilization, Mining Waste, Geogrid Mesh**

I. INTRODUCTION

Well Built and Maintained Road plays a major role in the development of nation. Subgrade soil is the integral part of the pavement as its provides the support to the pavement beneath. Subgrade Soil is essential component of pavement structures and inadequate subgrade performance is the cause of many premature pavement failures.

Subgrade Should give adequate strength to the pavement under adverse climatic and loading condition. It has been observed that Subgrade when constructed on black cotton soil show several types of damages to the pavement structures.

On investigation it has been found that when black cotton soil is being encountered during the construction of Highways it is essentially been replaced or removed instead of Stabilizing it. Stabilizing the soil has also considerable impact on the strength and swell-shrink behavior of the soil. Soil with significant plasticity may also shrink and swell substantially with change in moisture condition and may cause a reduction in the density and strength of the subgrade, accelerating pavement deterioration.

II. BACKGROUND AND OBJECTIVE

Past Researcher have attempted using waste material, such as industrial waste, fly-ash (Bhuvaneshwari, Robinson et al. 2005, Brooks 2009), waste plastic(Choudhary, Jha et al. 2010), copper slag(Gupta, Thomas et al. 2012) in the subgrade.(Prasad, Raju et al. 2009) .

It has been found that lower thickness is being achieved by using those waste materials by improving the strength of the subgrade. Geogrid, one kind of geosynthetics is mainly used for separation of the layers and increases modulus and stiffness of soil in the pavement construction. Many published papers demonstrate that the function of any geogrid reinforcement provided in the pavement is very complex generally, geogrid is inserted in the granular base layer of the surfaced pavement.

Lime Has been used for soil stabilization as it reduces the swell-shrinkage behavior. Optimum Percentage of Lime is generally found out between 3% to 8% for Expansive soil.(Basma and Tuncer 1991). Coir fiber is also used for soil stabilization(Sivakumar Babu, Vasudevan et al. 2008)

For developing countries like India Urbanization and Industrialization is a must and this activity extremely demands to uplift nation's economy. Mining is a major industrial activity and today mining industry occupies a unique position in the world and contributors roughly 6% of the world production with value of US$30 trillion.

Mining waste can be defined as a part of the material that results from the exploration, mining and processing of ore. It may consist of ordinary mining waste, unusable mineralized material or of natural materials, processed to varying degrees during the ore processing and enrichment phases, and possibly containing chemical, inorganic and organic additives. Overburden and the top soil are also classified as waste if found unusable. In most of the mines in India, the waste is deposited on the lands within the mining lease area. It has no technical and economic requirement. Therefore, it is necessary to plan out the disposal of waste in a systematic and scientific manner with due emphasis on environmental protection. Generally Mining waste is disposed of by terrestrial impoundment, underground backfilling, deep water disposal and recycling.(Jain and Das 2017).

Till Now Mining Waste have not been used in the Pavement Construction. Also, geogrid is not placed in the soil waste material mixture.

The objective of the present Study is as follows:

- To Explore the possibility of using alternate waste material in soil which could improve geotechnical properties and can be used in Construction of Subgrade.
- To improve the strength and Swell behavior of subgrade soil mixes with the Mining waste and by introducing geogrid mesh at a certain height of the subgrade layer.
- To Explore the possibility of Using Expansive soil as Subgrade material.

III. Various Test used in this Investigation

Various test like Specific gravity test, Particle size distribution, Atterberg's limit test, Procter Density test, Swelling Pressure test and California bearing ratio (CBR) Have been conducted to observe the soil characterizes These tests have been carried on as per the guidelines if the IS codes.

IV. Material

3.1 Soil (S)

The Soil Was collected from Padra Village Near Vadodara, Gujarat. The Soil was Black Cotton Soil. The Geotechnical Properties of the soil obtained is as under:

Sr.No	**Test**	**IS Code**	**Test Value**
1	Specific Gravity	IS:2720(part 3/sec-1)-1980	2.09
2	Particle size distribution	Sieving test (IS: 460-1962)	Gravel Size (32%)
			Course Sand Size (14%)
			Medium Sand Size (2%)
			Fine Sand Size (20%)
		Hydrometer Test (IS: 2720) Part 4-1985	Silt Size (17%)
3	Atterberg's limit	IS:2720(part 5)-1985	Clay Size (15%)
	Liquid Limit (%)		29.28
	Plastic Limit (%)		16.5
	Shrinkage Limit (%)		5
	Plasticity Index		12.78

Table 1 Geotechnical Properties of Black cotton soil

3.2 Mine Waste (W)

The Mining Waste was collected from Shigao Mines, Salaulim, South Goa, Goa. The Waste Obtained Consisted of Iron ore and Lateritic waste which was black and Dark red in color respectively. It was in the form of Soft Rock which when Crushed become powdered material. The Important geotechnical properties as shown below:

Figure 1 Mining Waste Site

Table 2 Geotechnical Properties of Mine Waste

Sr.No	Test	IS Code	Test Value
1	Specific Gravity	IS:2720(part 3/sec-1)-1980	2.14
2	Particle size distribution	Sieving test (IS: 460-1962)	Sand (11.2%)

		Hydrometer Test (IS: 2720) Part 4-1985	Silt (13.66%)
			Clay (75.14%)
3	Atterberg's limit	IS:2720(part 5)-1985	
	Liquid Limit		58%
	Plastic Limit		29%
	Shrinkage Limit		7.00%
	Plasticity Index		29
4	Texture on Classification Based on Plasticity Chart		CH
5	Free Swell Index		70%

3.3 Lime

Hydrated Lime was used in this experiment. The Lime was in powdered form. Lime was added as an admixture at the rate of 5% to the soil.

3.4 Coir Fiber

Raw Coir Fiber was used for Investigation. The Fiber was obtained from Khanderoa market near Vadodara. Coir fiber obtained was first separated and dried under sunlight to remove all the moisture present and then used in the soil mixes. It was added at the rate of 1%. Length of the Coir fiber was kept constant at 50mm.

3.5 Geogrid

Geogrid are placed at a distance of one third (h/3) from top at full height of the CBR mould. The Schematic diagram of placing the geogrid sample is shown in figure 2. Geogrid is not damaged during Unsoaked and soaked condition in CBR test.Used Geogrid was Black in color with aperture size of 30 * 30 and tensile strength of 40kN/m.

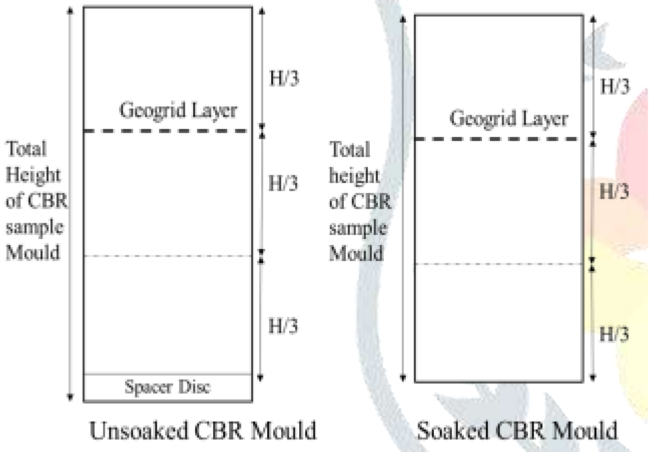

Figure 2 Placement of geogrid in CBR Mould

Figure 3 Biaxial Geogrid

V. PREPARATION OF MIXES

The parent soil was mixed with the Mine waste material. Lime and coir fibre was added as admixture. The description of mix composition ratio is given below in table:

Table 3 Description of mixes with identification marks

Sr no	Mix Composition	Nomenclature
1	Soil	S
2	Soil +Geogrid	S-G
3	Soil + Lime(5%)+Coir Fiber(1%)+Mining Waste(10%) +Geogrid	SLFM1-G
4	Soil+Lime(5%)+Coir Fiber(1%)+Mining Waste(20%) +Geogrid	SLFM2-G
5	Soil+Lime(5%)+Coir Fiber(1%)+Mining Waste(30%) +Geogrid	SLFM3-G

VI. TEST ON MIXES

6.1 Atterberg Limit

The Soil Was collected from Padra Village Near Vadodara, Gujarat. The Soil was Black Cotton Soil. The Geotechnical Properties of the soil obtained is as under:

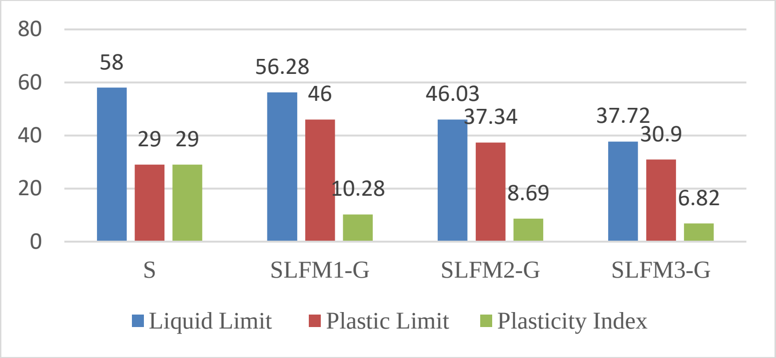

Figure 4 Atterberg Limit for soil with and without waste material

6.2 Optimum moisture content and maximum dry density

The light compaction test or Procter density test was conducted as per IS:2720(Part VIII). The Variation of optimum moisture content and maximum dry density of these mixes with the parent soil are shown in the figures

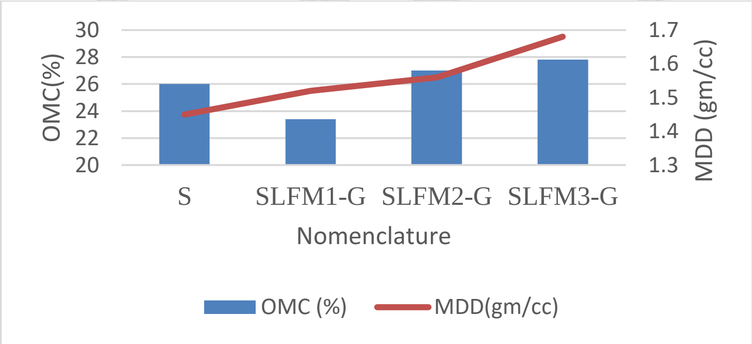

Figure 5 Variation of OMC and MDD for Various Mixes

6.3 California Bearing Ratio

California bearing ratio (CBR) was conducted as per IS:2720 (Part XVI)-1979.Unsoaked CBR and Soaked CBR for parent soil and parent Soil with geogrid was conducted. Then Un-soaked and soaked CBR was performed on the mixture proposed with variation in mine waste content from 10% ,20% and 30%. The geogrid was laid at a distance of H/3 from the top in CBR mould. The variation is presented in figures

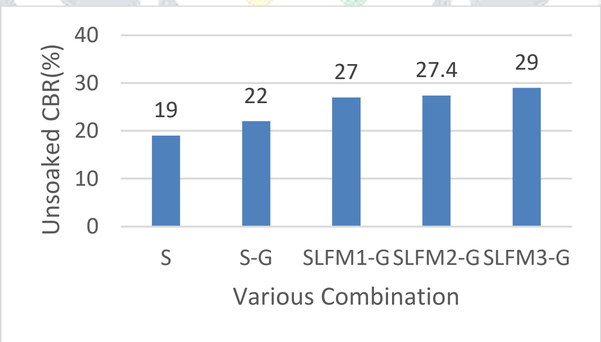

Figure 6 Un-soaked CBR Value without Geogrid and with Geogrid at H/3

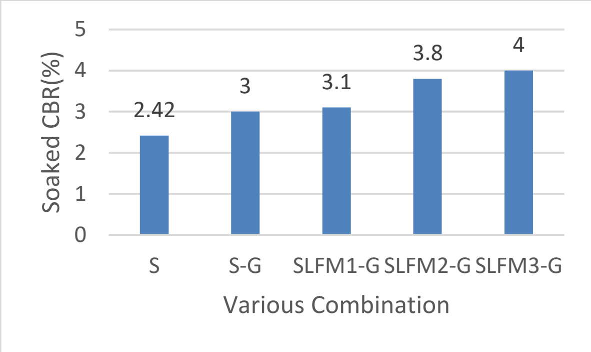

Figure 7 Soaked CBR Value without Geogrid and with Geogrid at H/3

6.4 Swell Pressure test

Raw Coir Fiber was used for Investigation. The Fiber was obtained from Khanderoa market near Vadodara. Coir fiber obtained was first separated and dried under sunlight to remove all the moisture present and then used in the soil mixes. It was added at the rate of 1%

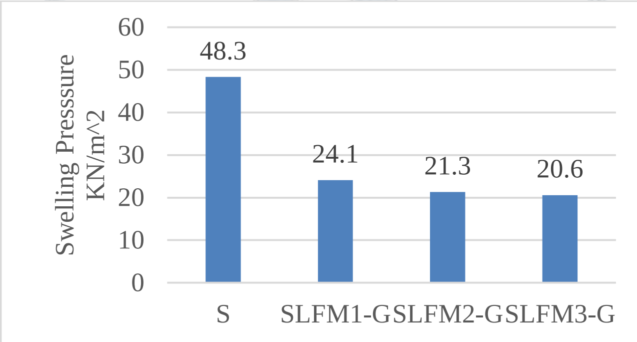

Figure 8 Variation of Swell pressure for Different mixes

VII. Results and Discussion

From the experiment and above figures the following results are obtained

Mining Waste Naturally Shows high CBR strength than Black Cotton soil. Mining waste act as filler material that improves the Strength when mixed with Black Cotton soil. Here Mining Waste Was added to the soil along with lime, coir fiber and geogrid

Following are the result obtained from the experiment and above figure

- Mining Waste when Mixed with Black cotton soil show that Plasticity Index reduces considerably as the percentage of waste content increases from 10% to 30%.for 10%,20% and 30% plasticity index was 10.28,8.69 and 6.82 respectively.
- Swelling of the Soil also reduces When Mining waste is added at 10%,20% and 30% the percentage reduction compared to virgin soil was observed by 50%,55% and 57% respectively. This shows that as we keep on increasing mining waste we could achieve reduced swelling.
- The CBR strength of the Soil also Improves with Increasing Percentage of Mining Waste. In Un-soaked Condition for 10%,20% and 30% the Strength Improves by 42%,44% and 52% respectively In Soaked Condition with Increasing Percentage by 10%,20% and 30% the Strength improves by 29%,57% and 65% respectively. It can be observed that mining imparts strength characteristics to the Black cotton soil.

VIII. Implication for Pavement thickness design

An Improved subgrade will contribute to the overall strength of the pavement system. A Flexible Pavement was designed using IRC-37(2001). It was found there is great reduction in pavement as the subgrade CBR strength Improves. Also, as the layer thickness reduces of the upper layer such as sub-base and base course Due to which the overall cost of construction of the pavement also reduced. A flexible pavement has been designed for a cumulative traffic of 10 million standard axles (MSA) having an Un-stabilized expansive soil subgrade and Subgrade stabilized with optimum percentage Lime (5%), Coir fiber (1%) and Mine waste with Increasing percentage from 10%,20% and 30% Respectively. The Geogrid Have been Considered to be introduced into Subgrade layer at distance of 160mm (h/3) from the top surface of Subgrade. The Following Figure Depict the layer Pavement thickness design.

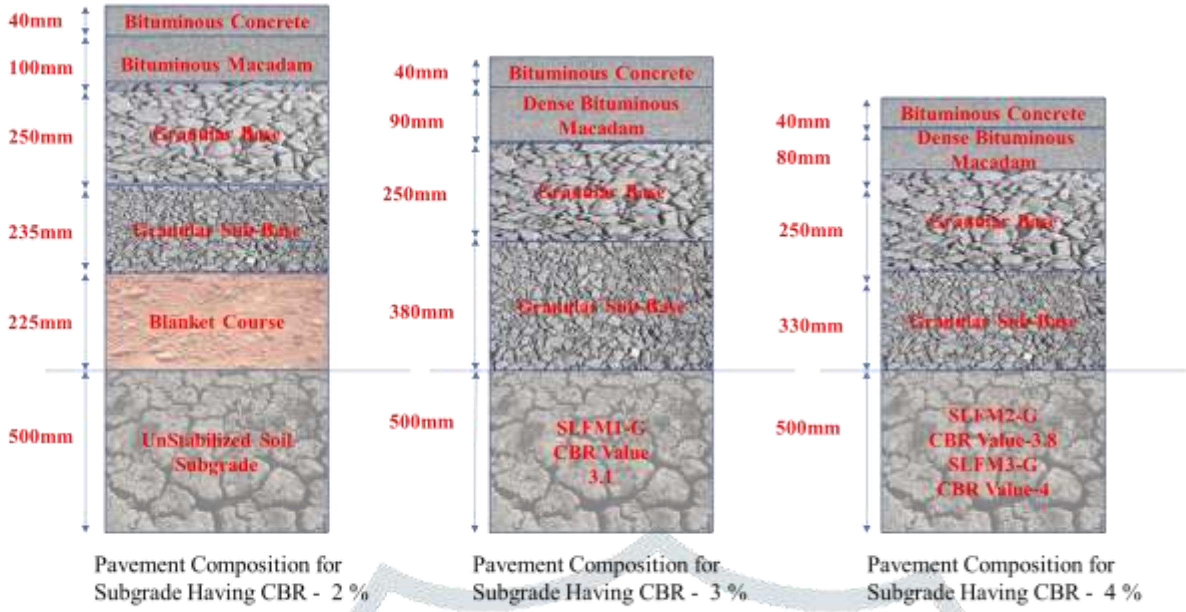

Figure 9 Pavement Layer Composition according to IRC-37-2001

An Economic analysis was done Considering the different CBR strength Value which reduces the Upper layer Pavement thickness. For 1km Length of road,10m Width of Road which consisted of one-way Single Carriage way road and Changing thickness of the pavement layer. The cost was reduced by 8% ,14% and 14% Compared to Un-stabilized Soil for SLFM-1, SLFM2 and SLFM3 Combination.

IX. Conclusion

Based on the results of the research described, the following conclusions were reached:

- Plasticity index Reduces Sufficiently which shows that onsite this composition could make subgrade soil easily workable
- Incorporation of Mining Waste along with Lime, coir fiber and Geogrid into subgrade soil significantly improves the CBR strength and stiffness of the pavement section very quickly. The benefit is particularly important because the heaviest load to be placed on the subgrade often occur during construction of the road and the development of associated properties.
- The Swelling Pressure is also considerably reduced with addition of these material which show that Black cotton soil could be stabilized and used as subgrade material which was previously not possible. But under very adverse condition these highly plastic clay may not be sufficient to improve soil properties to desired level

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