Improvement in Soil Strength Using Stabilizers in Pavement

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***Abstract*— Rapid Industrialization resulting in high growth of transport vehicles with different laden weights of itin limited road space demands for improving the load carrying capacity of road from economy point of view by utilizing waste material in proper dosages. The preliminary investigation of black cotton soil is carried out to evaluate the physical & engineering properties as per IS. Stabilization of locally available materials was studied by using lime and fly ash as stabilizers in different proportions.Solidry is added to black cotton soil to improve the bearing capacity of soil. Systematic laboratory investigations were carried out on black cotton soilusing stabilizers physical properties of it, to determine optimum compaction value, CBR value too. As stabilizers shows improvement meeting the standard of quality needed to show enhanced performance of pavement. Stabilizers are less costly and can lead to cost effective economic construction and fulfilling the load sustaining quality, durability and riding quality performance of the road can be increased.**

I. INTRODUCTION

Due to rapid boom in industrialization coupled with increase in transport vehicles in conjunction with the rapid growth of population has created a need for better and economical vehicular operation which requires good highway having proper geometric design, pavement condition and maintenance from long run point of view. Hence, new innovative materials or industrial waste materials which are abundantly stacked sometimes pollute the atmosphere but also occupies precious land of developing country, which is one of the problem which needs to be tackled. There are two treatments available to improve the quality and strength of soil. These are soil modification & soil stabilization. The purpose of soil modification is to create the working platform for road construction.

Stabilization requires more thorough design methodology during construction than soil modification. The method of sub grade stabilization include physical processes such as soil densification, blends with granular materials and chemical processes with stabilizers (fly ash, lime and solidry). Today, stabilization of soil by incorporation of cement or lime is a technique widely used throughout the world, especially in road construction to improve base and sub grade. [8]

II. OBJECTIVE OF THE STUDY

Following are the objective of the study.

- To determine the engineering properties of the black cotton soil by conducting different strength tests.
- The intent of the study is to save the natural resources & saving naturally available material for the future generation.
- To arrive at optimum mix proportions using stabilizers for field applications to improve the Strength of road.

III. MATERIALS

The objective of this study is to identify factors that contribute to improving the behaviour of soils togain strength in black cotton soil and to choose optimum content of the stabilizers. Following are the materials which are to be used in this study.

I. Black Cotton Soil
II. Fly ash
III. Lime
IV. Solidry

A. Black cotton soil

The experimental work is to be conducted with black cotton soil procured from Surat (Latitude: 21.195° N & Longitude: 72.819° E) south Gujarat. The black cotton soil is a type of expansive soil with potential for shrinkage and swelling under moisture change. It has high plasticity and can retain moisture throughout the dry season. It exhibits low bearing capacity and high volume change hence are troublesome as pavement subgrades. [6]

B. Fly ash

Fly ash samples used in this study were extracted from ukai thermal power station. It is a by-product of the combustion of pulverized coal in electric power generating power plants. It is an effective agent to improve subgrade conditions, promotes cost savings through reduction in the required pavement thickness.

C. *Lime*

Lime sample used in this study was purchased from local market. CaO, CaO*MgO, Ca $(OH)_2$, $Ca(OH)_2$,*MgO, $Ca(OH)_2$,*$Mg(OH)_2$ are the basic constituents of the lime. It has got proper mineralogy to produce long term strength, reduction quality in shrinking, swelling and soil plasticity with adequate durability

D. *Solidry*

Solidry is a powder with organic chemical coated, which further increases the protection of the treated soil against the softening effect of water, preserves the treated soil, stops the swelling behaviour of thesoil and increases the soil specific bonding characteristics. Following are the physical data for the solidry. [9]

- Change in Physical State: <120°C
- Density: 2.8 – 3.2 Kg/cm^3
- P^H Value: 6.0 – 8.0
- Manufacturer: Consolid Construction Investment Consultancy Industry Overseas Trade Ltd. Co.

IV. TEST RESULTS

All the tests were performed according to Indian Standards and properties derived are as shown:

A. *Properties of Black Cotton Soil*

Following are the properties for the black cotton soil which were performed in the laboratory as per Indian Standards. IS: 1498 – 1970 describes the Indian Standard on Classification and Identification of soil for engineering purposes.

Table 1. Properties of BC Soil

Soil	Grain Size (%)		Atterberg's Limit (%)			FSI (%)
	Sand	Silt/clay	LL	PL	PI	
BC Soil	12	88	59	24	35	60

The analysis indicated that the black cotton soil is of the classification of CH category.

- Compaction Result for Black Cotton Soil

As per IS: 2720 (Part VII – 1978) Compaction test was carried out for black cotton soil. From this test Moisture Dry Density and Optimum Moisture Content are found out as shown in Fig 1.

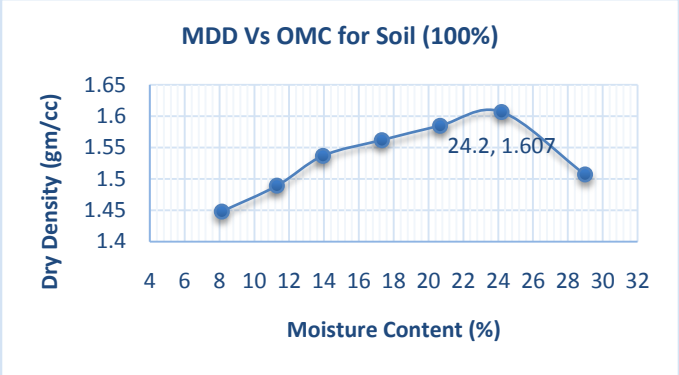

Fig 1. Moisture Content Vs Dry Density Graph for BC Soil

- CBR Result for Black Cotton Soil

As per IS: 2720 (Part 16 – 1987) CBR test was performed for 100 % black cotton soil, remoulded at OMC & ODD later 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.

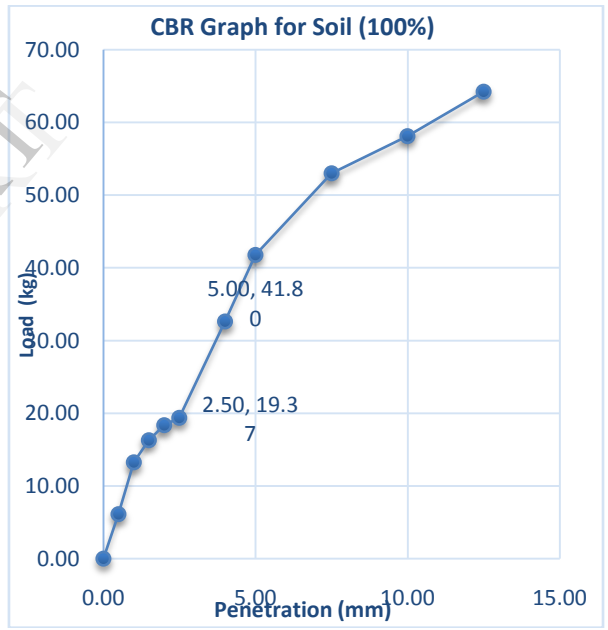

Fig 2. Load Penetration Curve for BC Soil

Now, CBR at 2.5 mm

$$\text{CBR} = \frac{\text{Corrected test load from graph}}{\text{Std. load for same penetration}} \times 100$$

$$\text{CBR} = \frac{19.37}{1370} \times 100 = 1.4\%$$

CBR at 2.5 mm = 1.4%

$$\text{CBR at 5 mm} = \frac{41.80}{2055} \times 100 = 2.0\%$$

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. [10]

B. Compaction Test for Stabilizers (Lime & Fly ash)

Following are the different proportions of lime and fly ash, which can be effectively utilized to alter the properties in CH category of black cotton soil. Result of compaction test are shown in table 2

Table 2. Different Proportions for Lime & FA

Sr. No.	Proportions	MDD (gm/cc)	OMC (%)
1.	Soil (98%) + Lime (2%)	1.748	19.62
2.	Soil (97%) + Lime (3%)	1.780	16.50
3.	Soil (90%) + Fly ash (10%)	1.593	19.00
4.	Soil (88%) + Fly ash (12%)	1.789	16.84
5.	Soil (85%) + Fly ash (15%)	1.564	15.82
6.	Soil (88%) + Fly ash (10%) + Lime (2%)	1.630	16.61
7.	Soil (83%) + Fly ash (15%) + Lime (2%)	1.610	14.51
8.	Soil (85%) + Fly ash (12%) + Lime (3%)	1.788	16.21

C. California Bearing Ratio Test for Stabilizers (Lime & Fly ash)

The California Bearing Ratio test is penetration test meant for the evaluation of subgrade strengths of roads and pavement. The CBR value of the specimen reflects on the strength of the specimen in soaked condition as tested in the laboratory. The soak CBR test is carried out after the submergence of sample in water for 4 days in accordance to IS: 2720 (part 16).

Theresults indicate that CBR at 5.00 mm is 2.0% while by the addition of Fly ash and lime in dosages shows a remarkable rise in CBR value. This indicates that the load carrying capacity increases due to the reaction which are taking place changing the bonding property of black cotton soil by stabilizers. Following are the test results for lime and fly ash.

- Comparison of CBR Values

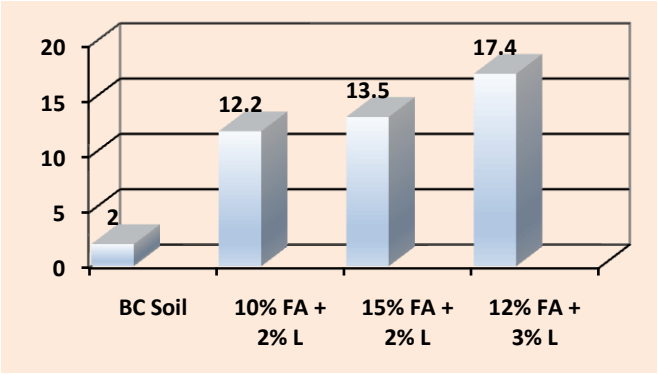

Fig 3. Comparison for CBR Values

Theresults indicate that CBR at 5 mm is 2.0%. By the addition of Fly ash and lime in dosages to BC soil shows a remarkable rise in CBR value. This indicates that the load carrying capacity increases due to the reaction which is taking place changing the bonding property of black cotton soil by stabilizers, also the thickness of layers can be reduced.

D. Solidry (Stabilizer)

Solidry is available as a powder form. It achieves the more effect when added in the amount 1% - 2% by weight of the soil. Solidry as an additive in the consolid system is used mainly for wet soil. Following are the advantages of solidry. [7]

- → Decrease permeability and capillary rise
- → Increase CBR
- → Increase water resistance
- → Decreases softening of soil by water

- Compaction Test for Solidry

As suggest in manufacturer guidelines, it is applied at a rate of 20 to 40 kg/m^3 of soil or 1% to 2% by weight of soil. Table 5 shows the different proportions for solidry and their compaction values.

Table 3. Compaction Result for Solidry

Sr. No.	Proportions	MDD (gm/cc)	OMC (%)
1.	Soil (99%) + Solidry (1%)	1.74	20.60
2.	Soil (98.7%) + Solidry (1.3%)	1.781	13.10
3.	Soil (98.3%) + Solidry (1.7%)	1.83	15.50
4.	Soil (98%) + Solidry (2%)	1.84	13.50

E. Comparison of CBR Valueswith dosage of Solidry

After compaction test CBR test were performed on different proportions of solidry. The soak CBR test is carried out after the submergence of sample in water for 96 hours in accordance to IS: 2720 (part 16). Following are the test results for solidry as shown in fig4.

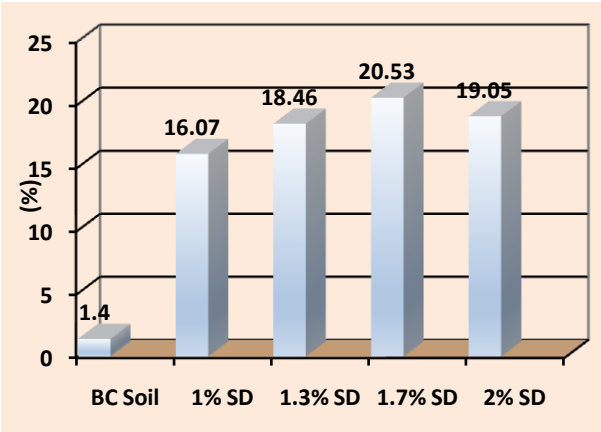

Fig 4. Comparison of CBR Value

The chart signifies that by increasing the solidry content in small percentages, the rise in trend of bearing capacity of soil is witnessed and growth is remarkable seen up to 1.7%. This indicates the load carrying capacity is enhanced by the addition of solidry. It is evident that as CBR of black cotton soil is very low, it would require more thicknesses which may result in huge amount of expenditure also the load carrying capacity is low. The sharp inclination in the growth of industry, transport, population demands the need of good quality of pavement by the addition of new innovative materials or solidry replacing it by changing the characteristics of the soil. Basic aim of soil modification is very foundation on which the road construction rely.

V. CONCLUSION

The scientific analysis carried out using laboratory investigations to determine different properties to meet the pavement needs are as shown.

Liquid limit and plastic limit identified for black cotton soil as CH category on which the compact test carried out shows that moisture content characteristics increases with the rise in dry density and moisture content but after 24.2% the sharp decline in dry density is noted with increasing moisture content. The CBR test conducted on this soil is low (2.0%)

Altering the characteristics of soil by the addition of stabilizers (lime & fly ash) in suitable dosages as per IS: 2720 (part 7) the MDD value can be increased slightly and OMC can be reduced. The load carrying capacity is increased almost 7 to 10 times that of black cotton soil (CH).

For the ideal CH category soil more than 98% proportion while the other use of solidry as a stabilizer in small dosages shows the high reduction in optimum moisture content, thereby showing significant rise in CBR value (20.53%) at 1.7% solidry by weight of soil.

It can be concluded that by altering the mix proportions to enhance the engineering properties of CH category of soil using stabilizers to arrive at the optimum dose to improve the strength of the road and the load carrying capacity is increased in less thickness compare to CH category of soil. These also signifies by using waste materials one is helping future generation from saving the natural resources and increases durability of the road thereby decreasing to a certain extent maintenance cost of the road too.

REFERENCES

[1] Bairwa Ramlakhan, Saxena Anil kumar, Arora T.R., "Effect of lime & fly ash on engineering properties of black cotton soil", IJETAE, Nov - 2013, pg. 535-541
[2] Bamnag Ismanto SISWOSEBROTHO, "Consolid system in Soil Stabilization", Proceeding of the Eastern Asia Society for Transportation Studies, Vol 3, No. 1, Oct – 2001, pg. 461-475
[3] Pankaj R. Modak, Prakash B. Nangare, Sanjay D. Nagrale, Ravindra D. Nalawade & Vivek S. Chauhan, "Stabilization of black cotton soil using admixtures", IJEIT, Vol.1, May-2013
[4] Praveen Kumar, Gaurav Pandey, "Use of Oils & Phosphates in Soil Stabilization", Indian Highways, May-2009, pg. 25-30
[5] R. K. Sharma, "Subgrade Characteristics of locally available soil mixed with fly ash & randomly distributed fibers", Indian Highways, Oct – 2012, pg. 25-30
[6] T. S. Ijimdiya, A. L. Ashimuyu, D. K. Abubakar, "Stabilization of Black Cotton Soil Using Groundnut Shell Ash", EJGE, Vol. 17, 2012, pg. 3645-3652
[7] Willbard N. Kassian, "Typical Field Application of Consolid in Tanzania", Director Tangerm Construction Company Limited.
[8] "Design Procedures for Soil Modification or Stabilization", Indianapolis, Jan-2008.
[9] "Solidry EU DIN Safety Data Sheet", Consolid Construction Investment Consultancy Industry Overseas Trade Limited Company.
[10] IS: 2720 (Part VIII) – 1997, "Determination of Water Content – Dry Density Relation Using Heavy Compaction"
[11] IS: 2720 (Part XVI) – 1987, "Determination of CBR
[12] IRC: 3812 – 1981, "Specification for Fly ash for Use as Pozzolona and Admixtures"