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Stabilization by Modification of Lithomargic Clay(Shedi Soil) Using GGBS,Lime and Other Additives

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Abstract- *Shedi soil (lithomargic clay) is very sensitive to water and loses its strength when it is saturated. Generally this soil is classified as silty sand or sandy silt with higher percentage silt content. The lithomargic soilstratum exists at considerable depth below ground level and is formed from lateritic soil by some chemical action of ground water. It does not possess any desirable engineering property and its behaviour is unpredictable. This type of soil is abundantly available in the coast belt of south-western India, starting from Cochin to Goa. In thispaper an attempt is made to study the behaviour of the shedi soil before and after stabilization. The experimental work involves the study on engineering behaviour of lithomargic soil of western coast of India in Mudipu area with field and laboratory investigation to find classification of soil and to test the engineering property along withAtterberg limits which indicates the strength of soil to some extent. In this work the objective is also to improve the engineering property by stabilizing the soil by additives such as lime, GGBS and chemical admixtures such as NaCl, NaOH, Na_2SO_4. It is observed that the unconfined strength of the shedi soil can be improved with certain % of lime, GGBS and chemical admixtures, separately in combination with soil and the results obtained are promising so as to practice in ground improvement for foundation and pavement formation. It has been observed that 5% lime and 30% GGBS by weight separately added to shedi soil is found to be optimum dosage for obtaining maximum UCS values after 0,7 and 30 days of curing. Combination of mixtures such asshedi soil+ GGBS, shedi soil+ GGBS and lime, shedi soil+ GGBS and 1% of NaCl, NaOH, Na_2SO_4 are also tried to obtain maximum strength of stabilized shedi soil.*

Keywords-*Shedi soil, lithomargic clay, stabilization, GGBS, additives*

I INTRODUCTION

1.1General

Lithomargic clay (shedi soil) is an expansive soil and has great affinity towards water. When it comes in contact with water it expands and it behaves as a liquid by losing its strength (especially in rainy season). When it loses water from it (especially in summer), it shrinks. This property of expansion and shrinkage cause serious problems like formation of potholes, dilation problems etc in the pavement constructed over this soil. Shedi soil is highly porous but hard and strong. They have negligible cohesion (bonding between particles) and high permeability. This makes it unsuitable for construction of any civil structures. A Lithomargic soil stratum is very common throughout west coast of India from Malabar (Kerala) to Ratnagiri in Maharashtra – wherever laterite soils are found.

1.2Lithomargic soilsand its modification

Lithomargic soils are considered to be "treacherous soil" by geotechnical engineers due to its low strength and unpredictable behaviour. There is not much study on this type of soil and this has added to the difficulty in designing structures in lithomargic soil stratum. Lithomargic soil is considered to be a weaker soil. It does not possess any desirable engineering property and its behaviour is unpredictable, especially when the soil is fully saturated. Therefore construction on this type of soil requires special design and precautions, which leads to extra cost of construction. [2].Soil stabilization by modification usually results in something less than a thoroughly cemented or semi hardened material. This type of stabilization may be accomplished by compacting, mechanical blending, addition of cementing materials in small amounts, or addition of chemical modifiers. Cement and lime modifiers (cement-modified soil and lime-modified soil) are used in extremely small amounts and do not provide high-strength cementing action, but instead reduce the plasticity of clay soils. Calcium chloride or sodium chloride is added to the soil to retain moisture, control dust, hold fine material for better compaction, and to reduce frost heave by lowering the freezing point of water in the soil.

1.3Objectives

1) To Study the index properties of soil, compaction characteristics and strength parameters
2) To Study the mineral characteristics of the soil and its classification.
3) To improve the properties of shedi soil by stabilizing the soil with different additives
4) To stabilize the soil using additives such as lime, GGBS, NaCl, NaOH, Na_2SO_4.

II LITERATURE REVIEW

Shedi soil is the name given to the locally available whitish, pinkish or yellowish silty sand. In their study an attempt was made to study the behaviour of the shedi soil before and after quarry dust stabilization[3].Lime slurry and lime pile technique are viable choices for in-situ stabilization of expansive soil deposits. The results indicated that slurry application to soil deposits with shrinkage is effectiveand that it may therefore be preferred to chemically stabilize soil deposits during the dry season [10].The suitability of existing soil as sub-base or sub-grade course depends on soil characteristics and strength. The blended samples were allowed for seven days curing and properties like California Bearing Ratio (CBR), tensile strength, Unconfined Compressive Strength (UCS), permeability and Atterberg's limits were studied[9].Stabilization with lime+GGBS effectively combats the expansion associated with presence of sulfate in soil and equally combats expansion associated sulfides such as pyrites. Where GGBS is being used for enhanced resistance to sulphate expansion, theproportion of GGBS should at least equal that of the quicklime and typically for highresistance to sulphate expansion, a GGBS: quicklime ratio of 3**:**1, or even higher, may beappropriate [8].The ICL addition of lime provides an indication of the amount of lime required to satisfy ion exchange. For clay with high cation exchange capacity, considerable benefits can be gained by lime addition below the ICL value. In general, the stabilized soil exhibits enhanced mechanical properties such as strength, modulus of elasticity and California bearing ratio as well as durability in terms of water resistance, water absorbedness and shrinkage [3].

III MATERIALS AND METHODOLOGY

3.1 Physical and Index Properties

Lithomargic clay which is present in the coastal region is a problematic soil; it has to be stabilized to improve its characteristics. The initial investigations are done in order to know characteristics of soil. The soil sample was taken from a place called Mudipu which is about 7 kilometers inwards from the sea coast to the south of Mangalore, Karnataka. The laboratory investigations were carried out for various characteristics and with these results, classification of soil is also done. The soil studied in this investigation has been sampled at depth ranging between 1.0 and 3.0m below ground level The shedi soil sample prepared has been tested in the laboratory to determine the engineering properties as per the relevant Indian standard code procedure.The particle size distribution of shedi soil is presented in Table-3.1**.**Specific gravity test was conducted on the pure shedi soil sample as per IS-2720(Part 3)-1987. Properties of shedi soil were determined for the soil fraction passing through 425micron sieve. The liquid limit of the shedi soil has been determined by using Casagrande apparatus. Representative soil sample (shedi soil) passing through 4.75mm sieve has been used to obtain the dry density moisture content relationship by the standard Proctor Compaction Test as per IS-2720 (Part 7)-1980. The proctor maximum dry density and moisture content are given in the Table-3.2 for the shedi soil.

Table 3.1: Particle size distributionTable3.2: Classification of soil

Sl. No	Sieve Size	Wt. retained	%Wt	Cummulative % retained	Cumulative % Finer
1	4.75mm	12	2.4	2	98.0
2	2.36mm	22	4.4	2.3	97.7
3	1.18mm	187	37.4	16.3	83.70
4	0.6mm	123	24.6	61.7	38.50
5	0.425mm	138	27.6	86.5	13.50
6	0.30mm	18	23.4	94.8	5.20
7	0.150mm	16	12.5	100	0
8	Pan	0	3.6	100	0

Table 3.3: Characteristics of Lithomargic soil

	Gravel	Sand (medium)	Sand (fine)	Silt	Clay
Percentage	2%	13%	21%	48%	16%

Characteristics	Symbol	Values
Density	P	1500-1750kg/m^3
Natural water content	W_n	20-30%
Atterberg limits	Liquid limit(W_L) Plastic limit(W_P) Plasticity index(I_P) Shrinkage limit (W_s)	36-41 30-38 2-6 33-35
Specific gravity	G	2.6-2.75
Proctor Density		1550-1620kg/m^3
O.M.C	W	18-21%
UCS @ MDD	$Ø_u$ Q_u	25-15 degrees 108.00 KN/m^2
C.B.R(soaked)	-	1.2-4.0
Indian Standard classification	(USC)	MI-OI, SM-SC
Textural classification	(USA)	Sandy Loam

3.2Additives for Stabilization

The following are the different types of ingredients used for the stabilization of lithomargic soil.

1. GGBS
2. Lime

3. Sodium Salts (NaCl, Na_2SO_4, NaOH)

Safe bearing capacity of the soil is one of the main parameters which decide the type and size of the foundation to be adopted for a structure. To find the shear parameters of soil laboratory test like tri-axial test, direct shear test, UCC test and vane shear test can be adopted. For shedi soil unconsolidated un-drained test i.e. UCC test is more suitable to measure its strength where the lateral confining pressure is equal to zero. The study on the effect of a GGBS(chemical admixture),hydrated lime,Nacl,Na_2So_4,NaOH on the index and engineering properties(compaction and unconfined compression strength) of lithomargic soil (shedi soil) was carried out in the laboratory. The complete experimental program carried out in this project work is given below

Table 3.4 Experimental Programme

Mixture	Test Conducted	Curing (days)
Shedi soil (SS) alone	Atterberg limits, UCC test, Specific gravity, Fineness modulus.	0
GGBS alone	Atterberg limits, UCC test, Specific gravity, Fineness modulus.	0,7,30
SS+GGBS (0-60%)	Atterberg limits, UCC test.	0,7,30
SS+30% GGBS+LIME (1-6%)	Atterberg limits, UCC test.	0,7,30
SS+30% GGBS+1% NaCl	UCC test.	0,7,30
SS+30% GGBS+1% NaOH	UCC test, Atterberg limits.	0,7,30
SS+30% GGBS+1% Na_2SO_4	UCC test.	0,7,30

IV RESULTS AND DISCUSSION

The soil-additives mixtures were prepared by mixing known percentage of ingredients (by weight) with the lithomargic soil. All these mixtures were tested in laboratory for their index properties, compaction characteristics and unconfined compression strength.

4.1Stabilization of Shedi Soil by GGBS

Compaction test, test for Atterberg's limits and unconfined compressive strength test were carried out for various percentages of GGBS with shedi soil separately. The above tests were also carried out for varying percentage of Lime and salts with lithomargic soil treated with optimum percentage of GGBS. The compaction characteristics of Shedi soil with GGBS (10-60%) in Table 4.1 given below shows that the maximum dry density is maximum for 30% GGBS added with Shedi soil.

Table 4.1: Compaction characteristics of Shedi soil and GGBS mixture

Mixture	MDD (KN/m^3)	OMC (%)
Shedi soil (SS)	13.33	23
SS+10%GGBS	13.54	23
SS+15%GGBS	13.35	26
SS+20% GGBS	13.48	23
SS+25% GGBS	13.61	23
SS+30% GGBS	13.67	23
SS+35% GGBS	13.54	23
SS+40%GGBS	13.54	23
SS+45%GGBS	13.61	23
SS+50%GGBS	13.37	23
SS+55%GGBS	13.54	23
SS+60%GGBS	13.61	23

The addition of 10% GGBS, the liquid limit of shedi soil marginally increases with immediate testing. With further addition of GGBS, the liquid limit decreases marginally when curing with 10-60% GGBS for 7 and 30 days. However the liquid limits increase for higher percentage of GGBS addition. The variation of liquid limit of shedi soil treated with various percentage of GGBS with curing is as shown in figure 5.5a and 5.5b.with curing the liquid limit of shedi soil increases due to increasing flocculation and entrapped water in the large wide spaces of flocculated crevices, the effect of flocculation gradually decreases with increasing in % of GGBS because of increasing effect of dilution, hence liquid limit decreases marginal. Table 4.2 shows the Atterberg's limits for shedi soil withdifferent % of GGBS after different curing periods.

Table 4.2: Atterberg's Limits of Shedi Soil &GGBS

Curing period	0 days			7 days			30 days		
Attterberg's limits	LL	PL	SL	LL	PL	SL	LL	PL	SL
Shedi soil (SS) alone	39.80%	38.00%	35.20%	39.80%	38.00%	35.20%	39.80%	38.00%	35.20%
SS+10% GGBS	51.00%	31.67%	13.26%	48.00%	33.75%	20.06%	43.00%	33.92%	20.45%
SS+20% GGBS	47.1%	32.50%	15.41%	44.00%	35.41%	20.12%	42.10%	35.00%	21.32%
SS+30% GGBS	45.9%	32.50%	20.13%	43.90%	37.22%	22.98%	40.10%	37.87%	22.60%
SS+40% GGBS	45.00%	33.24%	32.17%	43.00%	37.85%	24.62%	38.80%	38.88%	25.70%
SS+50% GGBS	42.90%	33.33%	36.18%	42.00%	38.18%	26.00%	38.10%	39.20%	27.03%
SS+60% GGBS	42.00%	34.13%	40.24%	40.20%	40.38%	26.12%	40.10%	40.55%	27.89%

#LL-Liquid limit, PL- plastic limit, SL-Shrinkage limit

Shedi soil is mixed with various percentages of GGBS and their strength properties have been studied.It was found that with the addition of 10% GGBS to shedi soil, the strength decreases and with further addition of GGBS the strength goes on increases up to 30% of GGBS addition to shedi soil. After 30% addition of GGBS, the strength starts decreasing both with immediate mixing and with curing periods, and hence 30% of GGBS is considered as the optimum for the next mixture. The results of unconfined compressive strength of shedi soil with various % of GGBS for various curing periods are shown in table 4.3

Table 4.3: Compressive strength (UCC) of soil and GGBS mixture for different days

Percentage of GGBS	0 Days(kN/m^2)	7 Days (kN/m^2)	30 Days (kN/m^2)
SS(alone)	108	108	108
10	89.12	122.44	132.34
15	90.67	123.06	136.65
20	109.16	125.60	142.44
25	113.48	133.32	145.89
30	115.73	142.57	151.67
35	108.54	125.68	148.23
40	106.94	124.80	146.88
45	95.63	123.06	136.56
50	80.92	121.28	132.33
55	78.31	116.49	131.33
60	77.46	102.41	122.04
GGBS alone	53.65	506.71	540.60

From the experimental work on the stabilization of shedi soil by lime and GGBS, it can be inferred that 6% of lime is maximum percentage to be added to obtain maximum unconfined compressive strength after 7 and 30 days of curing. The Atterberg's limits are found using a mixture of Shedi soil, optimum GGBS (30%) and various percent of lime (1-6%). It was found that the liquid limit starts increasing from 1% of lime and then marginally decreases till 6% and the plastic limit while increasing from 1% goes on increasing till the end i.e., till 6%. The Atterberg's limits for Shedi soil, GGBS & Lime are shown in table 4.4.

Table4.4: Atterberg's Limits of Shedi Soil, GGBS & Lime

Curing period	0 days			7 days			30 days		
Attterberg's limits	LL	PL	SL	LL	PL	SL	LL	PL	SL
SS+30% GGBS+1% LIME	52.80%	30.95%	20.21%	49.20%	31.25%	20.83%	47.50%	32.22%	21.32%
SS+30% GGBS+2% LIME	49.90%	32.46%	22.31%	47.50%	33.33%	23.81%	47.10%	34.28%	24.15%
SS+30% GGBS+3% LIME	48.90%	33.03%	24.16%	45.20%	33.92%	24.56%	45.50%	35.41%	24.78%
SS+30% GGBS+4% LIME	45.80%	35.64%	26.99%	44.40%	35.71%	27.14%	44.10%	36.11%	27.30%
SS+30% GGBS+5% LIME	43.50%	38.04%	28.11%	42.50%	35.71%	28.57%	42.00%	37.50%	28.77%
SS+30% GGBS+6% LIME	42.00%	40.00%	29.33%	40.40%	37.87%	30.00%	40.50%	38.80%	29.46%

#LL-Liquid limit, PL- plastic limit, SL-Shrinkage limit

Shedi soil is mixed with the optimum percent of GGBS with various percent of Lime and the compressive strength is found out using UCCS for different days of curing. The variation in compressive strength of Shedi soil, Optimum GGBS and lime (1-6%) is shown in the Table 4.5 which is given below.

Table 4.5: Compressive strength (UCCS) of shedi soil + OPT. GGBS and lime (1-6%) for different days

% of lime added	0 Days (kN/m^2)	7 Days (kN/m^2)	30 Days (kN/m^2)
SS+0% LIME	184.81	332.74	394.37
SS+1% LIME	113.55	626.72	678.69
SS+2% LIME	122.69	1047.53	936.71
SS+3% LIME	145.34	1149.03	1553.21
SS+4% LIME	157.66	1123.76	1541.51
SS+5% LIME	172.01	1723.83	2085.04
SS+6% LIME	149.58	1500.96	1979.21

In this study after finding optimum % of GGBS for stabilizing shedi soil (i.e. 30%) we have conducted the strength test on shedi soil mix with optimum % of GGBS (30%) and with varying lime content from 1% to 6% and it was found that the unconfined compressive strength is max for 5% lime along with optimum 30% of GGBS in shedi soil both at immediate testing as well as after 7 days and 30 days curing period.Compaction characteristics of shedi soil using opt. GGBS and Sodium salts were found by keeping the moulds for curing i.e., immediate testing, 7 and 30 days. It is found from the table that NaCl and Na_2SO_4 give very less strength when compared to the strength of NaOH, hence we consider NaOH as the best sodium salt for soil stabilization. The test was conducted using Shedi soil, optimum GGBS and 1% of Sodium salts such as Sodium Chloride (NaCl), Sodium Sulphate ($Na_2SO_{4)}$ and Sodium Hydroxide (NaOH).

Table 4.6: Unconfined compressive strength test GGBS (30%), Salts (1%) and Shedi soil for different days

SL. NO	MIX	0-Days	7-Days	30-Days
1	SS+ OPT GGBS+1% NaCl	77.34	118	78.31
2	SS+ OPT GGBS +1% Na2SO4	92.98	51.77	70.47
3	SS+ OPT GGBS+1% NaOH	372.85	1229.60	1575.07

From the above results we have found that NaOH has the maximum strength compared to other salts and hence the Atterberg limits are carried out onlyfor NaOH.Therefore from table it is clear that liquid limit first increase for 0 day curing and then decreases for 7 and 30 day.

Table 4.7: Atterberg's Limits of Shedi Soil, GGBS &NaOH

Curing period	**0 days**			**7 days**			**30 days**		
Attterberg's limits	**LL**	**PL**	**SL**	**LL**	**PL**	**SL**	**LL**	**PL**	**SL**
SS+30% GGBS+1% NaOH	43.50%	30.55%	23.62%	40.10%	31.25%	24.18%	40.10%	38.46%	36.15%

LL-Liquid limit, PL- plastic limit, SL-Shrinkage limit

V CONCLUSIONS

Based on the result obtained the following conclusions are drawn.

1. Detailed tests onlithomargicsoil around Mudipu region indicate the soil is sandy loam as per textural classification and MI-OI, SM-SC as per UCS system. Its liquid limit ranges between 40-60 and plastic limit ranges between 35-40. These results show that lithomargic soil is a weak soil.

2. Addition of ingredients like lime, GGBS, and chemicals like Nacl, NaoH, Na_2SO_4 at certain percentage of shedi soil improves the unconfined compressive strength of lithomargic soil to a certain limit.

3. Addition of GGBS to lithomargic soil increases the strength. With the addition of GGBS, the cementitious compound formed during pozzolonic reaction acts as a bonding material for soil portion. Addition of GGBS content up to 30% to lithomargic soil increase the strength, further increase in the dosage of GGBS content decreases the strength gradually. It is found that the UCCS value is Maximum for 30% of GGBS and shedi soil cured for 7 days and 30 days compared to the UCCS values of the same mix for 0 days.

4. It has been observed that 5% lime and 30% of GGBS by weight of Shedi soil is found to be optimum dosage for obtaining maximum UCS values after 0,7,30days. Further, it is observed that addition of 1% NaOH and 30% of GGBS by weight of Shedi soil is found to increase the UCCS.

5. The strength of shedi soil + 30% GGBS+1% of Nacl and NaOH added separately enhances the UCCS values for the longer curing periods.

6. Addition of GGBS content up to 30% to lithomargic soil increase the strength, further increase in the dosage of GGBS content decreases the strength gradually. It is Found that the UCCS value is Maximum for 30% of GGBS and shedi soil cured for 7 days and 30 days compared to the UCCS values of the same mix for 0 days

7. Addition of GGBS (10%-60%) to Shedi soil decreases the maximum dry density and increases the optimum moisture content. The decreases in maximum dry density with the addition GGBS to Shedi soil are due to the decreased strength in particle level.

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