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Effect of Admixtures on Strength and Compressibility Characteristics of Different Types of Soils

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ABSTRACT:
Soft soil formations, especially those with very high water contents and clay contents are prone to large settlements and possess low shear strength. Construction of structures in such soils is difficult, uneconomic and sometimes not feasible. In such conditions stabilization of soil is one good solution. Soil stabilization can be done by adding admixtures like cement, lime, fly ash, etc to soil. Soil stabilization using cement is widely practiced and effective method. Also as a locally available and low cost material, lime addition is also a cost effective method of stabilization. In deep mixing method, cement or other materials which are usually of cementitious nature are introduced and blended into the ground either in slurry or powder form through hollow rotating shafts equipped with cutting tools and mixing paddles or augers. This work mainly investigates the effect of cement and lime on the strength and compressibility characteristics of red and black soil samples. The variables investigated in this study are water contents, curing time, type of admixture and type fsoil. Strength characteristics were determined by California bearing ratio test and compressibility characteristics were determined by compaction tests. The choice of optimum water content, can also lead to proper determination of required optimum cement content. In this study, the optimum water contents were fixed based on the literature review and California bearing ratio test of soil based on other variables were found and compared.

Keywords: Fly Ash, Lime, Red Soil, Black Cotton Soil, CBR Test.

1. Introduction:
The properties of soil, especially strength and compressibility are very important while considering the construction of engineering structures. The behavior of the structures depends on the properties of soil on which they are constructed. For the structures to be safe and sound, they should be built on good soils. Soft soil deposits which are inherently very low in strength and very high in compressibility are widespread in low land regions. As a result of extensive urbanization and industrialization, construction on such soil formations has increased highly due to unavailability of suitable land plots. So it is now required to have solutions for tackling 6 problems due to these inherent undesirable engineering characteristics of soil. Providing appropriate shallow and deep ground improvement techniques is one way to meet the engineering requirements necessary for the design and construction of the structure. Addition of admixtures to soil is one of the most widespread methods of soil stabilization, especially for soils with high water contents.

2. Objective:
- To investigate the effect of addition of cement in red soil and to find variation of strength and compressibility characteristics with water content and curing time.
- To investigate the effect of addition of cement in black soil and to find the variation of strength and compressibility characteristics with water content and curing time.
- To investigate the effect of addition of lime in red soil and to find variation of strength and

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compressibility characteristics with water content and curing time.

- To investigate the effect of addition of lime in black soil and to find the variation of strength and compressibility characteristics with water content and curing time.
- To investigate the effect of addition of fly ash in red soil and to find variation of strength and compressibility characteristics with water content and curing time.
- To investigate the effect of addition of fly ash in black soil and to find the variation of strength and compressibility characteristics with water content and curing time.
- To compare the effect of admixture type, water content, curing time, etc on California bearing ratio strength and compressibility of red and black soil.

3. Literature review

M.R. Aminur, P.K. Kolay, S.N.L. Taib.

The present paper demonstrates the stabilization of peat soil with different stabilizing agents. Peat or highly organic soils are well known for their high compressibility, natural moisture content, low shear strength and long-term settlement. In this study, the peat soil sample has been collected from Matang, Sarawak, to evaluate their index or physical and geotechnical properties. Ordinary Portland Cement (OPC), Quick Lime (QL) and some combinations of Fly Ash (FA) and QL were used as stabilizers. The amount of OPC , FA and QL added to the peat soil sample, as percentage of the dry soil mass, were in the range of 5 to 40%; 5 to 30% and 2 to 8%, respectively for curing periods of 7, 14 and 28 days.

Dr.A.V.NarasihmaRao,B.Penchalaiah,Dr.M. Chittranjan, Dr.P.Ramesh

Black cotton soil covers about one-fifth of the area of our country. Owing to its undesirable engineering properties such as high swelling and shrinkage, the soil is not good either as foundation or embankment material.

To make the best use of black cotton soil, its properties are to be modified to suit the requirements in any specific case by means of stabilization. Therefore, it is necessary to properly choose the stabilizer through careful investigation to improve the strength, compressibility and permeability characteristics. At the same time, the economics of the process of the stabilization should also be considered. In this paper the results obtained by studying the compressibility behavior of black cotton soil admixed with lime and rice-husk ash is presented. For the purpose of comparison similar studies have been carried out with admixtures such as lime and rice-husk separately.

4. Methodology:

Soil samples of two types were collected from the construction site of Engineering college premises. For experimental studies, soil sample were taken and noted as S1 and S2 respectively. S1 was red brown in colour and seemed to be lateritic.S2 was grayish black in colour and saw clay in nature.S2 was found to be under high water conditions. The soil samples were collected in plastic containers and tested in laboratory for their properties. It was found that the soils, especially S2 had poor strength and compressibility characteristics. So with the aid of literature available, the scope of stabilization of these soils using cement, lime and fly ash admixtures were investigated.

The experiments conducted on the field soil are:
Specific gravity

- Liquid limit
- Plastic limit
- Sieve analysis
- Compaction
- California bearing ratio.

The experiments conducted on admixtures are:

- Specific gravity
- Compaction
- California bearing ratio

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5. Results and Discussions

5.1 Test results of admixtures and soil samples

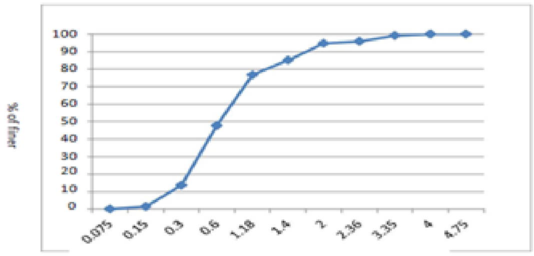
5.1.1 Sieve analysis test results

Soil samples of two different types were studied. First soil sample (S1) understudy is of lateritic type, reddish brown in color with specific gravity 2.69. The plot of particle size distribution and liquid limit graph shown in Tables

Table 5.1 illustrates the values of % finer of red soil

IS Sieve	% retained	% retained on sieve	cumulative % of retaining	% finer
4.75	0	0	0	100
4	0	0	0	100
3.35	0.44	0.88	0.88	99.12
2.36	1.98	3.296	4.176	95.824
2	0.57	1.14	5.316	94.68
1.46	4.8	9.6	14.916	85.084
1.18	4.14	8.28	23.196	76.804
0.6	14.52	29.04	52.236	47.77
0.3	17.02	34.04	86.276	13.73
0.15	6.1	12.2	98.476	1.53
0.075	0.72	1.44	99.916	0.084

Graph: 5.1 Particle size distribution graph for soil sample S1

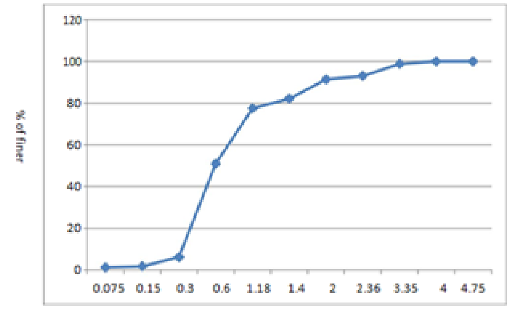


The second soil sample (S2) black color and specific gravity 2.56 .The plot of particle size distribution and liquid limit graph curve are shown in Tables and Graphs.

Table 5.2 illustrates the values of % of finer of black soil

IS Sieve	% retained	% retained on sieve	cumulative % of retaining	% finer
4.75	0	0	0	100
4	0	0	0	100
3.35	0.62	1.24	1.24	98.76
2.36	2.82	5.64	6.88	93.12
2	0.65	1.8	8.68	91.32
1.46	4.6	9.2	17.88	82.12
1.18	2.31	4.62	22.5	77.5
0.6	13.28	26.56	49.06	50.94
0.3	22.43	44.86	93.92	6.08
0.15	2.18	4.36	98.28	1.72
0.075	0.26	0.52	98.8	1.2

Fig 4.2 Particle size distribution graph for soil sample S2.



5.2 Liquid limit & Plastic limit black soil with cement

The table shows liquid limit and plastic limit of soil increases gradually with the increases in percentage of cement content. This improvement of liquid limit attributed that more water is required for the cement treated soil to make it fluid and the increase of plastic limit implies that cement treated soil required more water to change it plastic state to semisolid state. This change of atterberg limit is due to the cations exchange reaction and flocculation–aggregation for presence of more amount of cement, which reduces plasticity index of soil.

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A reduction in plasticity index causes a significant decrease in swell potential and removal of some water that can be absorbed by clay minerals.

Table 5.3 Illustrates the values of liquid limit of cement for black soil

Cement	liquid limit
0	46
5	50
7.5	51
10	52
12.5	53

Table 5.4 Illustrates the values of Plastic limit of Flyash for black soil

fly ash	Plastic limit
0	14.5
10	13
20	12.8
30	11.3
40	11

Table 5.5 Illustrates the values of Liquid limit of Lime for black soil

Lime	Liquid limit
3	38
6	42
9	43
12	44

6. Properties of soil samples

Table 6.1 illustrates the properties of soil sample

Properties	Black soil	Red soil
Specific gravity	2.69	2.56
Dry density	13.64	14.56
Moisture content	18	16
Liquid limit %	24	22

6.1 Properties of soil- admixture sample

Tests were conducted to study the effect of water content and curing period on the unconfined compressive strength, by the addition of admixtures such as cement, fly ash and lime. The parameter combinations which showed the optimum conditions were chosen and consolidation test was done to determine the effect of added admixtures on compressibility characteristics of each type of soil. Unconfined compression was taken as the primary strength test and Consolidation test was taken as the primary compressibility test. The soil samples were added with 15% cement and 6% lime, 7% fly ash one at a time, using different water contents based on the liquid limit of the soils. Curing periods adopted were 3 days, 7 days, 14 days and 28 days. So by varying the watercon tents and curing period, total 64 specimens were molded. After curing, unconfined compression tests were done on the samples. Fig 4.5 shows the samples under unconfined compression test. The optimum water content required was found for cement admixed and lime admixed samples of both the

Table 6.1 Soil admixture specimen designation

Type of soil	liquid limit test	plastic limit test	Compaction test		CBR test
			OMC	MDD	IN soaked condition
black soil	38.90%	14.40%	15.73%	1.76%	2.17%
black soil+10%fly ash	37.80%	13.20%	16%	1.72%	3.07%
black soil+20%fly ash	35%	12.76%	18.50%	1.70%	5.05%
black soil+30%fly ash	32.90%	11.20%	19.50%	1.64%	6.68%
black soil+40%fly ash	29.70%	10.90%	20%	1.60%	7.95%
black soil+3%fly ash	39.27%	17.77%	13.83%	1.80%	2.88%
black soil+6%fly ash	40.50%	21.42%	15.79%	1.79%	3.25%
black soil+9%fly ash	41.70%	23.80%	16.90%	1.78%	3.97%
black soil+12%fly ash	42.98%	25.89%	18.27%	1.76%	5.60%
black soil+0%cement	46%	27%	22%	28.00%	20.50%

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black soil+5%cement	50%	32%	23%	27.00%	22%
black soil+7.5%cement	51%	33%	24%	26.50%	24.30%
black soil+10%cement	52%	35%	27%	26.00%	25%
black soil+12.5cement	53%	37%	28%	25.00%	27%

Type of soil	Liquid limit test	plastic limit test	compaction test		CBR test
			OMC	MDD	IN soaked condition
red soil	37%	12%	13%	1.81%	2.18%
red soil+10%fly ash	35%	11.00%	14%	1.65%	2.99%
red soil+20%fly ash	33%	10.00%	16%	1.85%	4.66%
red soil+30%fly ash	32%	9%	17%	1.91%	5.71%
red soil+40%fly ash	27%	8%	18%	1.75%	6.56%
red soil+3%lime	37%	15%	11%	1.87%	2.56%
red soil+6%lime	38%	19%	13%	1.95%	2.34%
red soil+9%lime	39%	21%	14%	1.71%	3.74%
red soil+12%lime	40%	24%	16%	1.69%	4.46%
red soil+0%cement	44%	25%	20%	1.78%	19.55%
red soil+5%cement	47%	30%	21%	1.65%	21%
red soil+7.5%cement	49%	31%	22%	1.88%	22%
red soil+10%cement	50%	33%	25%	1.72%	23%
red soil+12.5%cement	51%	35%	28%	1.82%	25%

Mix designation	S_1C	S_2C	S_1L	S_2L	S_1F	S_2F
Soil	Soil1	Soil2	Soil1	Soil2	Soil1	Soil2
Admixture	Cement	Cement	Lime	Lime	Fly ash	Fly ash

- The optimum percentage of cement at 12.5% gave the best result for soil sample.
- The optimum percentage of lime at 12 % for gave the CBR value 5.6.
- The optimum percentage of cement at 12.5% gave the best result for soil sample.
- The optimum percentage of fly ash at 40% for gave the best result for soil sample.

CONCLUSION:

Introduction of additives in soils greatly improves the strength and compressibility of soil. The different soil samples and a combination of the samples with cement lime and fly ash at varying percentages magnitude and nature of improvement of characteristics depend on the admixture type and other factors like water content, type of soil, curing period and amount of admixture added. A detailed study of two was conducted. The following conclusions were made

- There was an increase in strength and compressibility characteristics of both the soils due to addition of cement, lime and fly ash . It was found that as the curing time increases the strength of the mixes goes on increasing.
- Liquid limit and plastic limit of soil decrease with increasing % fly ash. But Liquid limit and plastic limit of soil increase with increasing % lime. And also liquid limit and plastic limit of soil increases with increase of % cement.
- Compaction characters of soil sample affected by varying % of cement , i.e. OMC of Soil sample increase with increasing % cement and MDD decrease with increase of cement.
- Compaction characters of soil samples also affected by varying % of lime, i.e. OMC of BC Soil increase with increasing % lime and MDD decrease with increase of lime .
- Compaction characters of soil sample also affected by varying % of fly ash, i.e. OMC of Soil sample increase with increasing % fly ash and MDD decrease with increase of fly ash.
- CBR value of soil sample increases with increasing % cement.
- CBR value of soil sample also increases with increasing varying % lime.
- CBR value of soil also increase with increasing varying % fly ash.

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