SOIL STABILISATION USING FLY-ASH & LIME

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ABSTRACT

The California Bearing Ratio Test (CBR Test) is a test first developed by California State Highway Department (U.S.A.) for evaluating the bearing capacity of sub-grade soil for design of flexible pavement. The CBR value of the sub grade soil is being used widely since a long time in design of pavement structure and is critical in deciding the overall thickness of the pavement. Additionally, for good drainage, atypical specification for the pavement foundation design requires the value of permeability coefficient of the sub grade material to be specified. Thus, permeability and CBR constitute two important parameters in the design and assessment of long term performance of the pavement. In this project only strength aspects of pavement sub-grade have been considered. In this study, laboratory investigations have been carried out on soil samples by adding different materials.

Keyword : - *CBR, Soil Stabilization, Fly Ash, Lime, Pavement.*

1. INTRODUCTION

A pavement is a durable surface having materials laid down on an area subjected to sustain mainly the vehicular traffic, such as a road or highway. A pavement is typically a structure of various layers resting over soil either in embankment or in cutting. In the past, cobble stones and granite sets were extensively used, but these surfaces have mostly been replaced by asphalt or concrete now-a-days. A pavement is classified in general in two categories, i.e.namely a flexible pavement and a rigid pavement. The flexible pavement consists of granular layers of superior quality in upper layers with a preferably bituminous topping, while a concrete pavement consists of a cement concrete slab over occasional granular layers. The design of pavement has seen several modification so verthe years. Traditionally the design of either kind of pavement is based on the strength of the compacted soilin the pavement, called sub-grade. The design of the pavement layers laid over the sub-grade soil starts off with the determination of sub-grade strength and the traffic volume which is to be carried.

The design of pavement is very much dependent on the sub-grade strength of soil. Design criteria mainly needs thickness of layers. Weaker sub-grade needs thicker layers where as stronger sub-grade needs thinner pavement layers. The Indian Road Congress (IRC) provides the exact procedures for the pavement layers design which based upon the sub-grade strength. The strength of a sub-grade soil is normally expressed in terms of the California Bearing Ratio (CBR).Due to variable nature of soil, the sub-grade strength changes in consistently, as a result engineers faces of many difficulties or challenges during the design of a pavement. The sub-grade strength is very much dependent on moisture content. As the sub-grade is intended to variation of moisture due to flood, precipitation so rall other climatic changes, so it is necessary to enable or understand the sub grade according to the variation of moisture.The CBR is the only test which can figure out the strength of a sub grade. By this test we can compare the strength of different sub-grade materials. The CBR test is done in a standard manner by which one can find out or design the strength or thickness of sub-grade layer. CBR value is inversely proportional to thickness of the pavement layer. If the sub-grade is stronger, the higher is the CBR value, so lesser thickness is required and vice-versa.

1.1 Objectives:

i) This project attempts to understand and investigate the variations of CBR with addition of various materials such as fly ash & lime to sub-grade soil (black cotton soil) at various percentages. The moisture content were kept constant throughout the analysis.

ii) This project also analyzes the variations in thickness of pavement on addition of the above materials into sub-grade soil as compared to normal sub-grade soil. Detailed analysis of results has to be carried out to get this inference.

1.2 Black cotton soil:

Black cotton soils are also known as expansive soils or swelling soils, these soils expand when moisture content of the soils is increased and shrink when the moisture content decreases. These soils are found in central India and a part of the south India. The clay mineral montmorillonite is mainly responsible for expansive characteristics of the soil these are generally residual soils left at the place of their formation after chemical decomposition of the rock such as basalt and trap. Black cotton soils are clays of high plasticity the shearing strength of soils is extremely low, these soils are highly compressible and have very low bearing capacity. Structures built on such soils may experience cracking and damage due to differential heave. The depth of the expansive soil in which periodic changes of moisture content occur to cause swelling and shrinkage is known as active zone, zone usually varies from 3 to 4m. Sub-grade soils are an essential component of pavement structures, and inadequate sub-grade performance is the cause of many premature pavement failures. Clay sub-grade sin particular may provide inadequate support, particularly when saturated. Soils with significant plasticity may also shrink and swell substantially with changes in moisture conditions. These changes in volume can cause the pavement to shift or heave with changes in moisture content, and may cause a reduction in the density and strength of the sub-grade, accelerating pavement deterioration. There is a substantial history of use of soil stabilization admixtures to improve poor sub-grade soil performance by controlling volume change and increasing strength. Lime has been used successfully for many decades, and more recently fly ash has been used as an economical alternative to improve sub-grade performance.

1.3 Lime :

The most unable effect of lime on soil is to improve workability and compatibility and reduces swelling and shrinkage potential by saturating the clay particles with calciumions. This leads to strength increase by pozzolanic and carbonation cementation processes. Cation exchange and pozzolanic reactions result in strength increase. The level of Reactivity and hence strength gained in soil-lime mixtures depends on the level of pozzolanic product created. The pozzolanic reaction occurs when water and lime in soil mass produce a high pH system, the degree of soil-lime reactivity varies among soils.

1.4 Fly Ash :

Fly-ash is a waste product of coal combination in thermal power plants. It possess problem for safe disposal and cause economic lost of the power plants. Thus utilization of fly-ash in large scale geotechnical constructions as a replacement to conventional earth material needs special attention. The inherent strength of fly-ash can be improved either by stabilizing the material with cement, lime etc. and by reinforcing the same. Fly-ash is a more well-graded material having low specific gravity compared to conventional earth material. Fly-ash possesses no plasticity, indicating that the inter-particular forces are either absent or negligible.

2. METHODOLOGY

The entire investigations have been conducted on, effect of lime and fly ash on subgrade soil. Soil sample collected from Sangamner vicinity, fly ash “Ek-lahere Power Plant“”and lime from “Chemical Shop”.
The value of CBR of Black Cotton Soil is determined using CBR test with varying percentages of Fly-ash and Lime.

Fig -1: CBR Test Assembly

3. RESULTS

3.1 Experimental Analysis

For Subgrade soil:

Test 1.1 Weight of mould =3970 gm.
Weight of mould+Soil = 7400 gm.
Weight of soil =3430 gm

Table -1: Subgrade soil

Penetration (mm)	Proving Ring Reading (N)	Load on Plunger (kN)	Standard Load (kN)
0	0	0	
0.5	4	0.23	
1	8	0.46	
1.5	10	0.58	
2	14	0.82	
2.5	16	0.93	13.12
3	18	1.05	
3.5	19	1.11	
4	20	1.17	
4.5	21	1.23	
5	23	1.34	20.15
5.5	24	1.40	
6	27	1.58	
6.5	30	1.76	
7	33	1.93	
7.5	36	2.11	
8	39	2.28	
8.5	42	2.46	
9	44	2.58	
9.5	46	2.69	
10	49	2.87	
10.5	53	3.11	
11	55	3.22	
11.5	59	3.46	
12	62	3.63	
12.5	65	3.81	

For Subgrade soil + Fly-ash (10 %) :
Test 2.1 Weight of mould =3970 gm.
Weight of mould+Soil = 7300 gm.
Weight of soil =3330 gm

Table -2: For Subgrade soil + Fly-ash (10 %)

Penetration (mm)	Proving Ring Reading (N)	Load on Plunger (kN)	Standard Load (kN)
0	0	0	
0.5	3	0.176	
1	7	0.410	
1.5	10	0.58	
2	14	0.821	
2.5	17	0.997	13.12
3	19	1.11	
3.5	21	1.23	
4	22	1.29	
4.5	24	1.40	
5	26	1.52	20.15
5.5	29	1.70	
6	33	1.93	
6.5	36	2.11	
7	38	2.23	
7.5	39	2.28	
8	41	2.40	
8.5	44	2.58	
9	47	2.75	
9.5	51	2.99	
10	54	3.17	
10.5	57	3.34	
11	60	3.52	
11.5	64	3.75	
12	68	3.99	
12.5	73	4.28	

For Subgrade soil + Fly-ash (20 %) :
Test 2.1 Weight of mould =3970 gm.
Weight of mould+Soil = 7180 gm.
Weight of soil =3210 gm

Table -3: For Subgrade soil + Fly-ash (20 %)

Penetration (mm)	Proving Ring Reading (N)	Load on Plunger (kN)	Standard Load (kN)
0	0	0	
0.5	4	0.23	
1	9	0.52	
1.5	13	0.76	
2	17	0.99	
2.5	20	1.17	13.12
3	22	1.29	
3.5	24	1.40	
4	26	1.52	
4.5	28	1.64	
5	30	1.76	20.15

5.5	34	1.99	
6	37	2.17	
6.5	40	2.34	
7	43	2.52	
7.5	46	2.69	
8	48	2.81	
8.5	52	3.05	
9	55	3.22	
9.5	58	3.40	
10	61	3.58	
10.5	64	3.75	
11	67	3.93	
11.5	70	4.10	
12	72	4.22	
12.5	75	4.40	

For Subgrade soil + Fly-ash (30 %) :

Test 2.1 Weight of mould =3970 gm.

Weight of mould+Soil = 7140 gm.

Weight of soil =3170 gm

Table -4: For Subgrade soil + Fly-ash (30 %)

Penetration (mm)	Proving Ring Reading (N)	Load on Plunger (kN)	Standard Load (kN)
0	0	0	
0.5	8	0.46	
1	12	0.70	
1.5	16	0.93	
2	20	1.17	
2.5	24	1.40	13.12
3	27	1.58	
3.5	29	1.70	
4	32	1.87	
4.5	34	1.99	
5	36	2.11	20.15
5.5	39	2.28	
6	41	2.40	
6.5	43	2.52	
7	46	2.69	
7.5	48	2.81	
8	51	2.99	
8.5	53	3.11	
9	56	3.28	
9.5	59	3.46	
10	62	3.63	
10.5	65	3.81	
11	68	3.99	
11.5	72	4.22	
12	75	4.40	
12.5	77	4.51	

For

Subgrade soil + Lime (3 %) :

Test 2.1 Weight of mould =3970 gm.

Weight of mould+Soil = 7400 gm.

Weight of soil =3430 gm

Table -5: For Subgrade soil + Lime (3%)

Penetration (mm)	Proving Ring Reading (N)	Load on Plunger (kN)	Standard Load (kN)
0	0	0	
0.5	10	0.58	
1	14	0.82	
1.5	17	0.99	
2	20	1.17	
2.5	22	1.29	13.12
3	24	1.40	
3.5	26	1.52	
4	28	1.64	
4.5	31	1.81	
5	33	1.93	20.15
5.5	36	2.11	
6	39	2.28	
6.5	41	2.40	
7	44	2.58	
7.5	48	2.81	
8	51	2.99	
8.5	54	3.16	
9	57	3.34	
9.5	61	3.57	
10	63	3.69	
10.5	66	3.87	
11	70	4.10	
11.5	73	4.28	
12	76	4.46	
12.5	79	4.63	

For Subgrade soil + Lime (5 %) :

Test 2.1 Weight of mould =3970 gm.

Weight of mould+Soil = 7380 gm.

Weight of soil =3410 gm

Table -6: For Subgrade soil + Lime (5%)

Penetration (mm)	Proving Ring Reading (N)	Load on Plunger (kN)	Standard Load (kN)
0	0	0	
0.5	12	0.70	
1	16	0.93	
1.5	20	1.17	
2	24	1.40	
2.5	29	1.70	13.12
3	32	1.87	
3.5	36	2.11	
4	38	2.23	
4.5	41	2.40	
5	44	2.58	20.15
5.5	47	2.75	

6	49	2.87	
6.5	51	2.99	
7	54	3.16	
7.5	56	3.28	
8	59	3.46	
8.5	62	3.63	
9	64	3.75	
9.5	66	3.87	
10	69	4.04	
10.5	72	4.22	
11	76	4.46	
11.5	78	4.57	
12	81	4.75	
12.5	84	4.92	

For Subgrade soil + Lime (10 %) :
Test 2.1 Weight of mould =3970 gm.
Weight of mould+Soil = 7340 gm.
Weight of soil =3370 gm

Table -7: For Subgrade soil + Lime (10%)

Penetration (mm)	Proving Ring Reading (N)	Load on Plunger (kN)	Standard Load (kN)
0	0	0	
0.5	9	0.52	
1	12	0.70	
1.5	15	0.88	
2	18	1.05	
2.5	21	1.23	13.12
3	23	1.34	
3.5	25	1.46	
4	27	1.58	
4.5	29	1.70	
5	31	1.81	20.15
5.5	34	1.99	
6	37	2.17	
6.5	40	2.34	
7	43	2.52	
7.5	46	2.69	
8	49	2.87	
8.5	51	2.99	
9	54	3.16	
9.5	57	3.34	
10	61	3.57	
10.5	65	3.81	
11	69	4.04	
11.5	72	4.22	
12	75	4.40	
12.5	78	4.57	

3.2 Percentage reduction in sub-grade thickness:

Thickness of black cotton soil as sub-grade is found to be 28.16 cm.

Table -8: Comparative thickness of subgrade

Material added in Soil (%)	Thickness of Sub-grade (cm)	Reduction in Thickness of Sub-grade (%)
Fly-ash		
10	26.95	4.29
20	24.07	14.52
30	21.28	24.43
Lime		
3	22.65	19.56
5	18.3	35.01
10	23.43	16.80

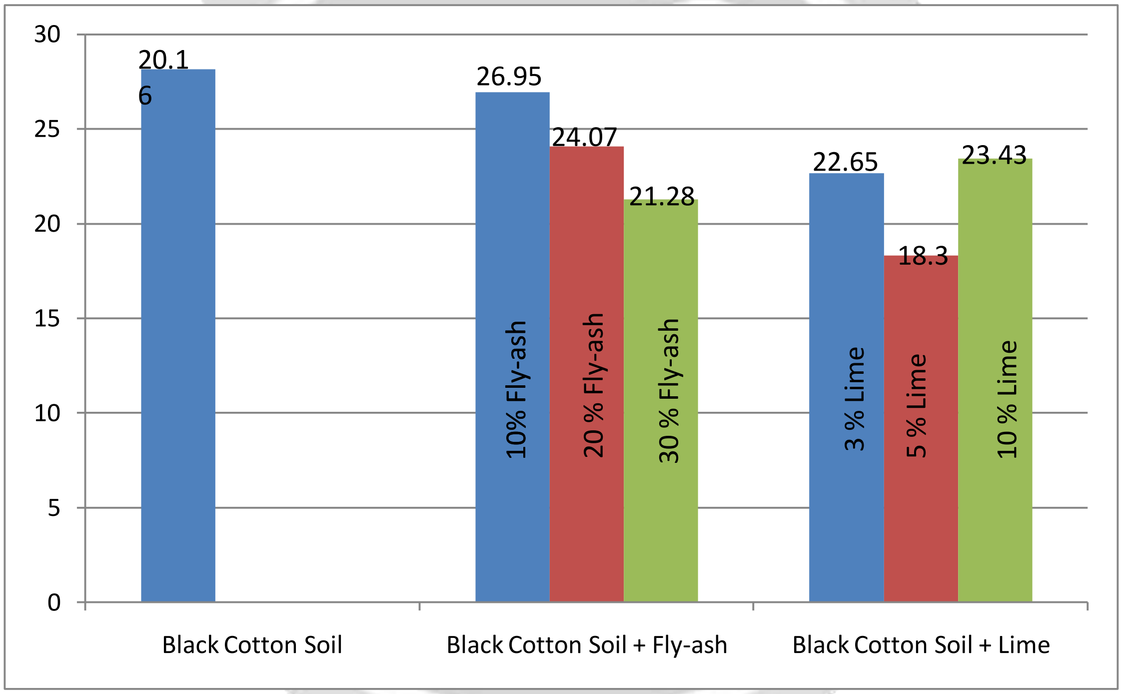

Chart -1: Comparison of sub-grade soil thickness

The above graph shows the variation in sub grade thickness by adding different material. We conclude that which material having the better binding property. When we add the 5 % of lime in soil then the strength of black cotton soil is improve.

Lime gives very high CBR value even when added in small percentages due to which thickness of sub-grade is reduced greatly.

In compare to flyash, lime shows very high CBR values at lower percentage. Reduction in soil stabilization depth (i.e. sub-grade thickness) is more in Lime than fly-ash.

4. CONCLUSION

1.We concluded that, lime shows very high CBR values at lower percentage as compared to fly-ash therefore reduction in soil stabilization depth (i.e. sub-grade thickness) is more in Lime than fly-ash.

2.We observed that, addition of 5% lime in sub-grade soil gives maximum strength than addition of 3 % or 10 % lime in sub-grade soil.

5. REFERENCES

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