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EXPERIMENTAL STUDY ON IMPROVING THE STRENGTH OF COHESIVE SOIL BY BITUMINOUS EMULSION

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Abstract - *Soil is one of the nature's most abundant construction materials. Almost all type of construction is built with or upon the soil. If the sub grade is not enough good the whole structure will face failure such as cracks. Therefore the sub grade is normally replaced with stronger soil material so as to improve the strength but this is not economical. In this project the strength of soil is increased by adding bituminous emulsion instead of replacing with stronger soil. The initial strength of the soil is determined by conducting soil tests such as specific gravity, plastic limit, liquid limit, unconfined compression strength test, tri-axial test and California bearing ratio tests. The results obtained are then compared with the soil treated with 5%, 10% and 15% of bitumen emulsion. The process of soil stabilization helps to achieve the require properties in a soil needed for the construction work.*

Key Words: Cohesive Soil, Bitumen Emulsifier, index properties, Shear strength.

1.INTRODUCTION

In this thesis, the strength of the soil is improved by using bituminous emulsion. Bitumen emulsion is a mixture of water & bitumen. As bitumen is an oil product it cannot be mixed with water. Hence an emulsifier (a surface active agent) is added with water before bitumen. Addition of emulsifier with water before adding bitumen into minute particles and keeps it dispersed in suspension. The term emulsion means that dispersion of small droplets of one liquid in another liquid. Types of emulsion are oil –in-water (continuous phase is water and the disperse phase is an oily) and water-in-oil (continuous phase is an oil and the disperse phase is water). Here the emulsifier is used as kerosene with water. Initially the properties of soil are determined by using conducting sieve analysis, plastic limit, liquid limit and specific gravity. The strength of soil is determined by UCC, triaxial test and CBR test.

1.1 Objective

To increase the shear strength of soil.

To improve the soil strength using bitumen emulsion.

To compare the test results of normal soil and bitumen emulsion added soil.

Verdict the variation of strength in the soils by using the bitumen emulsion performance different proportions applied and determining the variation in properties of soil

2. MATERIALS USED

2.1 Soil

Cohesive soil means clay (fine grained soil), or soil with a high clay content, which has cohesive strength. Cohesive soil does not crumble, can be excavated with vertical slide slopes, and is plastic when moist. Cohesive soil is hard to break up when dry, and exhibits significant cohesion when submerged.

Table.1 Properties of soil

S.NO	PROPERTIES	TEST VALUE
1	Specific gravity	2.79
2	Liquid Limit (%)	50.4
3	Plastic Limit (%)	12
4	Plasticity Index (%)	38.4

2.2 Properties of Bitumen

Molecular weight wise, bitumen is a mixture of about 300-2000 chemical components .Elementally it is around 95%carban and hydrogen (87% carbon 8% hydrogen) and up to 5% sulphur, 1% nitrogen, 1% oxygen and 2000ppm metals. Bitumen is composed mainly of highly condensed polycyclic aromatic hydrocarbons. They also contain several elements.

2.3 PROPERTIES OF KEROSENE (EMULSIFIER)

Kerosene is a thin, clear liquid formed from hydrocarbons obtained from the fractional distillation of petroleum between 150°C and 275°C, resulting in a mixture with a density of 0.78-0.81 g/cm3 composed of carbon chains that typically contain between 6 and 16 carbon atoms per molecule.

2.3.1 ADVANTAGES OF USING BITUMENOUS EMULSION

- Emulsifier improves the handling of bitumen at room temperature.
- Promotes surface interaction.

- Economical and saves human energy.
- Reduced atmospheric pollution.
- Water can also added before use to dilute as per requirements
- Rains cannot affect it at the time of use and after use

3. DETERMINE THE INDEX PROPERTIES OF SOILS WITH AND WITHOUT BITUMEN EMULSION

3.1. Specific gravity

To determine the specific gravity of laterite soil by using density bottle. Specific gravity G is defined as the ratio of the weight of an equal volume of distilled waters at that temperature both weights taken in air.

FORMULA:

G = (W2-W1) / (W4-W1)(W3-W2)

Table 2. Specific gravity

S.NO	SAMPLE	SPECIFIC GRAVITY
1	Cohesive soil	2.79
2	Soil with 5% bitumen emulsion	2.83
3	Soil with 10% bitumen emulsion	2.88
4	Soil with 15% bitumen emulsion	2.84

3.2. Liquid Limit

The Liquid Limit (LL) is often conceptually defined as the water content at which the behavior of a clayey soil changes from plastic to liquid. Actually, clayey soil does have very small shear strength at the liquid limit and the strength decreases as water content increases; the transition from plastic to liquid behavior occurs over a range of water contents.

Fig 1. Liquid limit

Table 3 Liquid limit of cohesive soil

Weight of the soil sample taken is 120gm

S.NO	WATER CONTENT IN %	NO OF BLOWS
1	46	56
2	48	38
3	50	26
4	52	21
5	54	18

Table 4 liquid limit of cohesive soil with 5% bitumen emulsion

Weight of soil taken 150gm

Sieve size 75µ

Soil with 5% bitumen emulsion

S.NO	WATER CONTENT IN %	NO OF BLOWS
1	46	52
2	48	34
3	50	27
4	52	19
5	54	17

Table 5 liquid limit of cohesive soil with 10% bitumen emulsion

Weight of soil taken 120gm

Sieve size 75µ

Soil with 10% bitumen emulsion

S.NO	WATER CONTENT IN %	NO OF BLOWS
1	46	50
2	48	35
3	50	26
4	52	18
5	54	16

Table 6 liquid limit of cohesive soil with 15% bitumen emulsion

Weight of soil taken 120gm

Sieve size 75µ

Soil with 15% bitumen emulsion

S.NO	WATER CONTENT IN %	NO OF BLOWS
1	46	47
2	48	32
3	50	24
4	52	16
5	54	12

3.3 plastic Limit

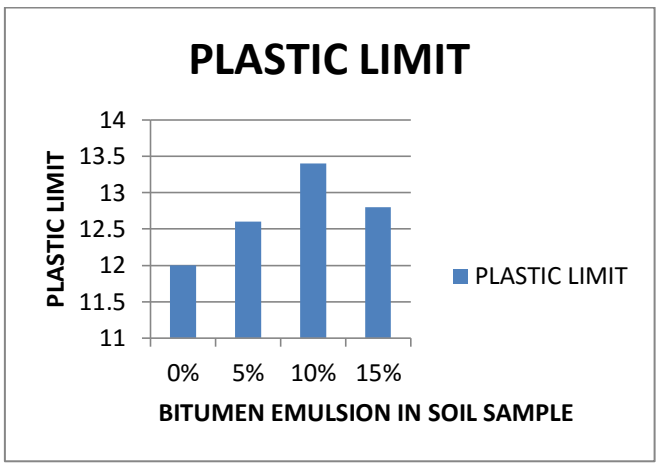
The plastic limit is defined as the moisture content where the thread breaks apart at a diameter of 3.2 mm (about 1/8 inch). A soil is considered non-plastic if a thread cannot be rolled out down to 3.2 mm at any moisture.

Fig 2. Plastic limit

Table 7 Plastic limit of cohesive soil with and without bitumen emulsion

Weight of soil sample taken 50 gram
Sieve size 75µ

S.NO	SAMPLE	PLASTIC LIMIT
1	Cohesive soil	12
2	Soil with 5% bitumen emulsion	12.6
3	Soil with 10% bitumen emulsion	13.4
4	Soil with 15% bitumen emulsion	12.8



Percentage of variance for 0% and 10% sample is 11.6.

Chart1. Plastic limit value for different proportion of bitumen emulsion in soil.

4. SHEAR STRENGTH OF SOIL WITH AND WITHOUT BITUMEN EMULSION

4.1Unconfined compressive strength

The unconfined compressive strength (q_u) is the load per unit area at which the cylindrical specimen of a cohesive soil falls in compression.

$q_u = P/A$

P= axial load at failure,
A= corrected area
$A=A_o/(1-e)$
A_o= initial area of specimen
e= axial strain

The undrained shear strength (s) of the soil is equal to the one half of the unconfined compressive strength,

$S=q_u/2$

Fig 3. UCC test

Table 8 UCS test for cohesive strength

Weight of soil sample taken 280gm
Sieve size 75µ
Water content 48ml
Size of the mould:
Height 9cm Diameter 4.5cm

load	Deflection (mm)	strain	1-e	A= Ao/(1-e) (cm2)	Stress P/A (N/cm2)
8	0.9	0.100	0.900	17.65	0.4532
12	1.2	0.133	0.864	18.28	0.6564
16	1.9	0.211	0.789	20.13	0.7948
20	3.8	0.422	0.578	27.49	0.7278
24	4.4	0.488	0.512	31.03	0.7734
24.8	4.9	0.544	0.456	34.84	0.7118

UCS value=0.3974

Table 9 UCS test for soil with 5% bitumen emulsion

Weight of soil sample taken 300gm
Bitumen emulsion 5% added soil (15ml)
Sieve size 75µ
Water content 33ml
Size of the mould:
Height 9cm Diameter 4.5cm

load	Deflection (mm)	strain	1-e	A= Ao/(1-e) (cm2)	Stress P/A (N/cm2)
12.8	1.4	0.155	0.845	18.80	0.6808
16.8	1.7	0.188	0.812	19.56	0.8588
20.8	2	0.222	0.772	19.91	1.0447
24.8	2.6	0.288	0.712	22.31	1.1116
28.8	3.6	0.4	0.6	26.48	1.0876
32	4.4	0.488	0.512	31.03	1.0312

UCS VALUE = 0.5558 N/cm2

Table10 UCS test for soil with 10% bitumen emulsion

Weight of soil sample taken 300gm
Bitumen emulsion 10% added soil (30ml)
Sieve size 75µ
Water content 18ml
Size of the mould:
Height 9cm Diameter 4.5cm

load	Deflection (mm)	strain	1-e	A= Ao/(1-e) (cm2)	Stress P/A (N/cm2)
20	2.6	0.288	0.712	22.31	0.8964
24	2.9	0.322	0.678	23.43	1.0243
28	3.2	0.355	0.645	24.63	1.1368
32	4.1	0.455	0.545	29.19	1.0977
36	4.5	0.5	0.5	31.78	1.1327
40	5.3	0.588	0.412	38.56	1.0373

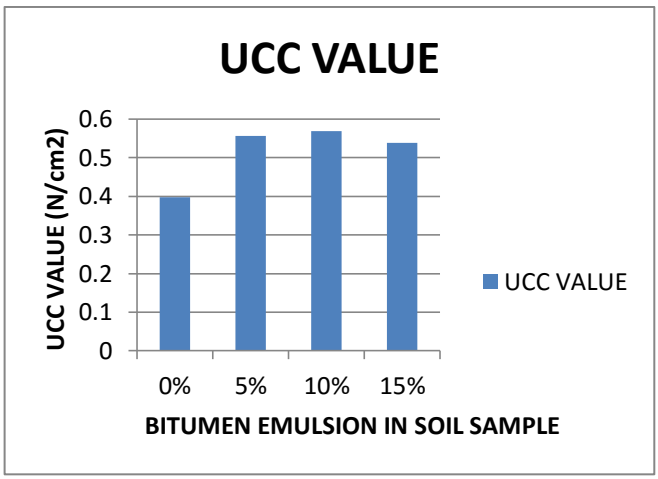
UCS VALUE = 0.5684 N/cm2

Table11 UCS test for soil with 15% bitumen emulsion

Weight of soil sample taken 280gm
Bitumen emulsion 15% added soil
Sieve size 75µ
Water content 3ml
Size of the mould:
Height 9cm Diameter 4.5cm

load	Deflection (mm)	strain	1-e	A= Ao/(1-e) (cm2)	Stress P/A (N/cm2)
24	3	0.333	0.666	23.82	1.0075
28	3.7	0.411	0.588	26.97	1.0381
32	4.2	0.466	0.533	29.97	1.0756
36	5.3	0.588	0.511	31.09	1.0579
40	6.9	0.711	0.288	54.98	0.7275
46.4	7	0.778	0.222	71.57	0.6483

UCS VALUE = 0.5378 N/cm2



Percentage of variance for 0% and 10% sample is 43

Chart2. UCC value for different proportion of bitumen emulsion in soil

4.2 TRI AXIAL COMPRESSION TEST

Fig 4. Tri axial test

Table 12 Tri axial test for cohesive soil

Load	Deflection (mm)	strain	1-e	A=Ao/(1-e) (cm2)	Stres P/A (N/cm2)	cohesion C
20	1.1	0.122	0.878	18.09	1.1056	0.553
24	1.4	0.155	0.845	18.73	1.2813	0.640
28	1.7	0.188	0.812	19.56	1.4315	0.715
32	2.2	0.244	0.756	21.02	1.5223	0.761
36	4.1	0.455	0.545	29.16	1.2346	0.617
40	5.8	0.644	0.356	44.63	0.8962	0.448

Tri axial value = 0.7612 N/cm2

Table 13 Tri axial test for soil with 5% bitumen emulsion

Load	Deflection (mm)	strain	1-e	A=Ao/(1-e) (cm2)	Stres P/A (N/cm2)	cohesion C
52	2.1	0.233	0.767	20.72	2.509	1.254
56	2.3	0.255	0.745	21.33	2.625	1.312
60	2.5	0.277	0.728	21.82	2.750	1.375
64	2.8	0.311	0.689	23.06	2.775	1.387
68	3.3	0.367	0.633	25.10	2.710	1.355
72	4.2	0.467	0.533	29.81	2.415	1.207

Tri axial value = 1.3875 N/cm2

Table 14 Tri axial test for soil with 10% bitumen emulsion

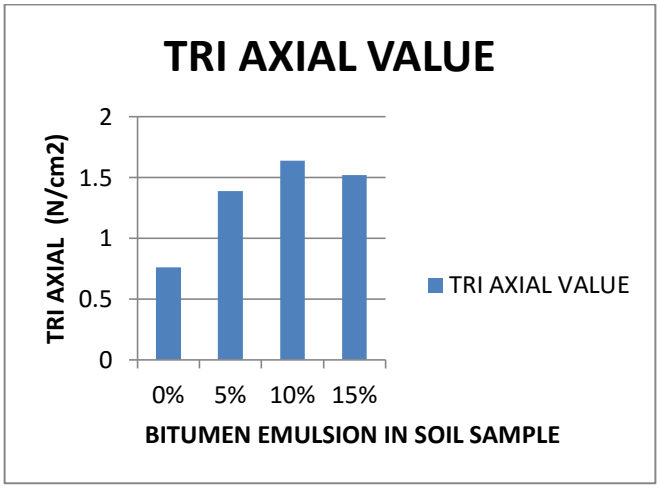
load	Deflection (mm)	strain	1-e	A=Ao/(1-e) (cm2)	Stres P/A (N/cm2)	cohesion C
68	2.2	0.22	0.756	21.02	3.235	1.617
72	2.5	0.277	0.723	21.98	3.275	1.637
76	3	0.333	0.664	23.93	3.176	1.588
80	3.6	0.400	0.600	26.48	3.021	1.511
84	3.9	0.433	0.564	28.02	2.998	1.499
88	4.1	0.456	0.544	29.20	3.014	1.507

Triaxail value =1.6375 N/cm2

Table 15 Tri axial test for soil with 15% bitumen emulsion

load	Deflection (mm)	strain	1-e	A=Ao/(1-e) (cm2)	Stres P/A (N/cm2)	cohesion C
61	2.3	0.255	0.75	21.31	2.871	1.435
66	2.6	0.289	0.711	22.35	2.935	1.467
71	2.9	0.322	0.678	23.44	3.036	1.518
76	3.5	0.389	0.611	26.01	2.937	1.468
81	3.9	0.433	0.567	28.02	2.884	1.442
84	4.3	0.78	0.522	30.44	2.760	1.380

Triaxail value =1.518 N/cm2



Percentage of vairence for 0% and 10% sample is 37.

Chart 3 Tri axial values for different proportion of bitumen emulsion in soil

4.3 CALIFORNIA BEARING RATIO TEST

The C.B.R test is an empirical test and depends upon the condition of the soil at the time of testing. According to the state commission of roads and bridges (SCRB, 1999) specification the CBR must correspond to 95% of the maximum dry density of the AASHTO compaction.

CBR = Test load * 100/ standard load

Table 16 CBR TEST FOR COHESIVE SOIL

PENETRATION	LOAD Kg/cm2	CBR VALUE
0.5	160	2.28
1	165	2.35
1.5	170	2.43
2	175	2.50
2.5	180	2.57

3	190	1.80
4	210	2.00
5	235	2.23

CBR VALUE =2.57%

Table 17 CBR TEST FOR SOIL WITH 5% BITUMEN EMULSION

PENETRATION	LOAD Kg/cm2	CBR VALUE
0.5	180	2.57
1	185	2.64
1.5	190	2.71
2	195	2.79
2.5	200	2.88
3	210	2.00
4	230	2.19
5	255	2.43

CBR VALUE =2.86%

Table 18 CBR TEST FOR SOIL WITH 10% BITUMEN EMULSION

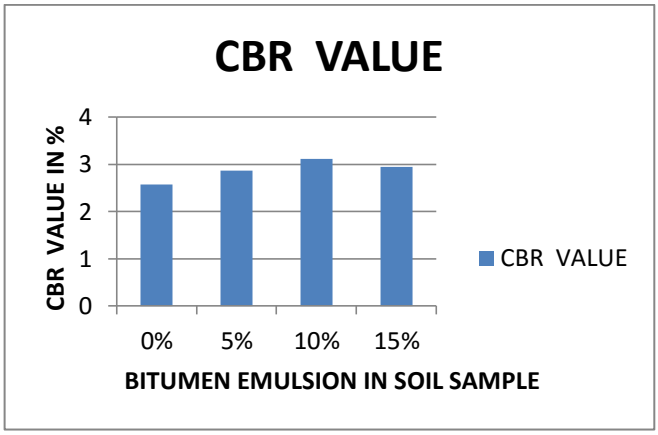
PENETRATION	LOAD Kg/cm2	CBR VALUE
0.5	200	2.86
1	205	2.93
1.5	210	3.00
2	215	3.07
2.5	220	3.11
3	230	2.19
4	255	2.43
5	270	2.57

CBR VALUE =3.11%

Table 19 CBR TEST FOR SOIL WITH 15% BITUMEN EMULSION

PENETRATION	LOAD Kg/cm2	CBR VALUE
0.5	185	2.64
1	190	2.71
1.5	195	2.79
2	200	2.86
2.5	205	2.94
3	215	2.05
4	235	2.24
5	260	2.48

CBR VALUE =2.94%



Percentage of vairence for 0% and 10% sample is 21.

Chart 4 CBR values for different proportion of bitumen emulsion in soil

5. CONCLUSION

This study made a comprehensive examination of the effectiveness of soil on the performance of bitumen emulsion. The characteristics of soil sample were known from the tests conducted and the similar tests are conducted for the soil sample mixed with three different proportions of bitumen emulsion (5%, 10%, and 15%) . The test results indicate that with the increase of bitumen emulsion in the soil sample till 10% proportion ratio the shear strength is increased and after certain percentage (15%) is getting decreased .The results are shown that the shear strength of the soil good when 10% bitumen emulsion is added.

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