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Silty Soil Stabilization Using Bituminous Emulsion

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Abstract:
The application of asphalt emulsion technology to the silty soil Stiffness has been in the process. Since 1987 several research efforts were made by different agencies in different countries to improve the silty sub-grade soil strength by using bituminous emulsion. The present research work has been undertaken to investigate the possibility using bituminous emulsion of stabilization of silty soil. Silty soil sample has been obtain the nadergull, ranga reddy district. Several laboratory tests were conducted to characterize the soil and determine its soil class including its permeability and CBR strengths. Medium setting type bituminous emulsion has been used in the present study for stabilizing the silty soil. After several combinations of bituminous emulsion content it has been found that the soil sample tested was improved with reference to CBR value load decreased the rate of permeability. Economic analysis was also carried out and find the benefit of reduction in over the cost of the pavement by using emulsified siltysoil results of the tests presented demonstrate the degree of effectiveness of the stabilization process totally the stabilization of soil with bitumen emulsion is to increase the strength of the soil. The soil strength were increased with use of medium setting bituminous emulsion.

Keywords:
Silty Soil, Bituminous Emulsion, CBR.

I. INTRODUCTION:

Stabilization of soils to improve strength and durability properties often relies on cement, lime, fly ash, and asphalt emulsion [1]. These materials are inexpensive, relatively easy to apply, and provide benefits to many different soil types.

However, there are a variety of non-traditional soil stabilization/modification additives available from the commercial sector such as polymer emulsions, acids, lignin derivatives, enzymes, tree resin emulsions, and silicates. These additives may be in liquid or solid form and are often touted to be applicable for most soils [2]. Earlier research studies in this area have demonstrated that many soil additives have little to no benefit for silty, sandy soil types Sandy soils are problematic for stabilization and often require cement and/or asphalt emulsion to provide cohesion for the soil [3]. Generally, lime works well with most clay soils, and cements and asphalt emulsions can be used for a wide range of soils. For clay soils, the clay fraction may often be altered through chemical reaction or ion exchange (such as with lime). Stabilization of soils using polymer emulsion is a straightforward process in that the liquid is simply diluted to the proper amount [4]. The dilution amount is selected to achieve the target additive quantity at the desired moisture content required for the most efficient compaction of the soil [5]. For field applications, the emulsion is best applied with a spray bar mounted inside the cowling of a reclaimer/stabilizer machine [6]. The application conditions must be well controlled to insure that the proper amount of stabilizer is delivered into the soil and to achieve the proper moisture content for compaction [7]. It should be noted that field mixing is rarely as efficient as laboratory specimen preparation; therefore, the results presented herein are likely to be a “best-case” scenario for stabilization. He results presented herein are analyzed in terms of CBR and permeability testing.

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The use of the CBR test was selected to allow for determination of strength performance of silty soil types [8]. It is well recognized that the CBR (California Bearing Ratio) with emulsions impart significant stiffness and impermeability to the stabilized soils.

Purpose:

This section discusses criteria for improving the engineering properties of silty soils used for pavement subgrade, by the use of additives which are mixed into the silty soil to effect the desired improvement. This criterion is useful for applicable to silty soil roads with bituminous emulsion.

Scope of Project:

This discussion covers the determination procedure of optimum emulsion content to be used with silty soil type and procedures for determining a design treatment level with bituminous emulsion.

Objectives of the study

Sieve analysis

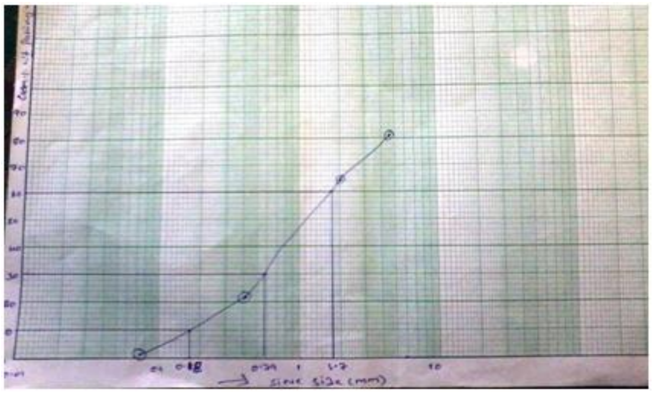
- To characterize the selected silty soil by sieve analysis and soil classification
- To determine relationship between MDD vs. OMC
- To improve the existing strength of the silty soil by conducting CBR tests by using bituminous emulsions with different proportions
- To determine loss of permeability due to addition of bituminous emulsion to the silty soil
- To determine optimal content of the bituminous emulsion based on the above test results
- Economic evaluation of the proposed siltysoil stabilization using medium setting bituminous emulsion.

II. ANALYSIS OF TEST RESULTS AND DATA

1. Sieve analysis

si.no	size(mm)	Wt. Of retained (gm.)	% wt. Of retained	Cumulative % wt. retained	Cumulative wt passing
1	4.75	112.1	18.68	18.68	81.32
2	2	103.33	17.22	35.9	64.1
3	0.425	252.83	42.138	78.038	21.962
4	0.07	120.65	20.108	98.146	1.854
5	Pan	10.95	1.845	100	0

Table 1: Determination of cumulative % wt. of passing



Graph 1: Graph between sieve size and cumulative % wt. passing

Observations:

From Graph

$D_{10}=0.18, D_{30}=0.79, D_{60}=1.7$

Coefficient of uniformity

$C_u=\frac{D_{60}}{D_{10}}=9.44$

Coefficient of curvature

$C_c=\frac{(D_{30})^2}{D_{60}D_{10}}=2.039$

Conclusion Remarks:

From the result we get that the taken soil is well graded

2. Compaction test using water

To determine the optimum moisture content and corresponding maximum dry density of a taken soil using standard proctor test

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si.no	Description (%)	6	9	12	15	18
1	wt. Of mould+ compacted soil (gm.)	4035	4217	4269	4216	4145
2	wt. of empty mould (gm.)	2058	2058	2058	2058	2058
3	wt. of compacted soil (gm.)	1900	2159	2211	2158	2087
4	bulk density	1.73	1.97	2.02	1.97	1.9

Table 2: Determination of bulk density using water

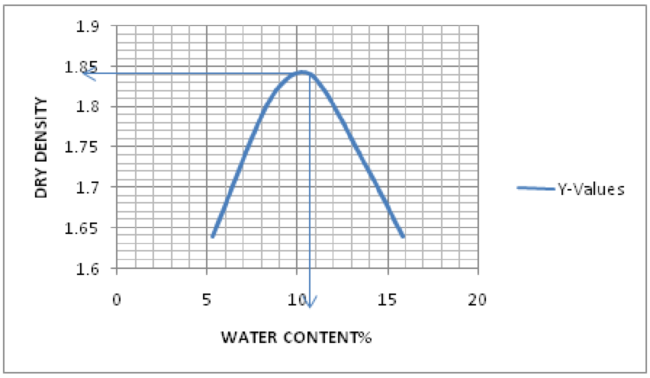
Bulk density = $\frac{W}{V}$ gm/c.c

W = water content

V= wt. of mould

si.no	Water content (%) adding	6	9	12	15	18
1	container number	26	6	3	11	24
2	Wt. Of empty container (gm.)	15.58	16.55	8.99	18.18	19.1
3	wt. of empty container+ wet soil(gm.)	52.27	52.64	40.12	51.37	62.52
4	Wt. of empty container+ dry soil(gm.)	50.15	49.82	37.1	47.35	56.59
5	wt. of wet soil(w2) (gm.)	36.39	36.09	31.13	33.19	43.42
6	Wt. of dry soil(w1) (gm.)	34.57	33.27	28.11	29.17	37.49
7	wt. of water content (w)	5.26	8.47	9.7	13.7	13.81
8	dry density	1.643	1.81	1.84	1.73	1.64

Table 3: Determination of dry density using water



Graph 2: The graph between optimum moisture content and maximum dry density

Observations:

Bulk density (γ) = $\frac{W}{V}$ = 1.73 gm/c.c

Water content (W) = $\frac{W_{2-W_1}}{W_1}$*100

Dry density = $\frac{\gamma}{1+W}$ = 1.643 gm/c.c

Conclusion Remarks:

A compaction curve is plotted between the water content and corresponding dry density as ordinate. The dry density goes on increase as water content is increased till max density is reached. The water content corresponding to max density is called optimum moisture content.

- the optimum moisture content is 10.6%
- Maximum dry density is 1.84 gm./c.c

3. Compaction test with bituminous emulsion

To determine the optimum bituminous emulsion content and corresponding maximum dry density of a taken soil using standard proctor test

S.no	description	6%	9%	12%	15%	18%
1	container number	140	13	16	66	21
2	wt. of container+wet soil(gm.)	47.34	45.86	41.65	60.74	49.04
3	wt. of container+drysoil(gm.)	45.58	43.56	39.16	57.95	46.48
4	wt. of empty container(gm.)	20.18	13.15	7.94	20.37	19.03
5	wt. of water present	1.76	1.9	2.49	1.79	2.55
6	wt. of dry soil(gm.)[W1]	25.4	30.41	31.22	37.58	27.45
7	Water content (%)	6.92	7.53	7.975	8.673	10.41
8	dry density(gm.)	1.668	1.753	1.856	1.825	1.731
9	wt. of wet soil(gm.)[W2]	27.16	32.70	33.71	40.37	30.21

Table 4: Determination of dry density using bituminous emulsion

S.no	Description (%)	6	9	12	15	18
1	wt. of mould+ compacted soil (gm.)	4010	4122	4249	4204	4150
2	wt. of empty mould (gm.)	2058	2058	2058	2058	2058
3	wt. of compacted soil (gm.)	1952	2064	2191	2146	2092
4	bulk density	1.784	1.86	2.0027	1.961	1.9122

Table 5: Determination of bulk density using bituminous emulsion

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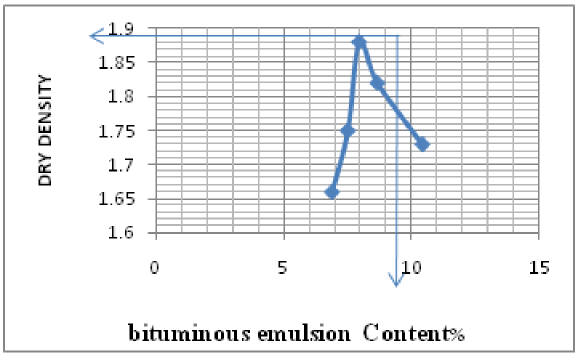


Graph 3: Graph between optimum bituminous emulsion content and maximum dry density

Observations:

Bulk density (γ) $=\frac{w}{v}$ gm./cc

W = water content

V=wt. of mold

Bulk density $=\frac{w}{v}$ = 1.78 gm. /cc.

Water content (w) = $\frac{w_{2-w}}{w_1}$* 100

Dry density = $\frac{\gamma}{1+w}$ = 1.86 gm./cc

Conclusion Remarks:

A compaction curve is plotted between the bituminous content and corresponding dry density as ordinate.

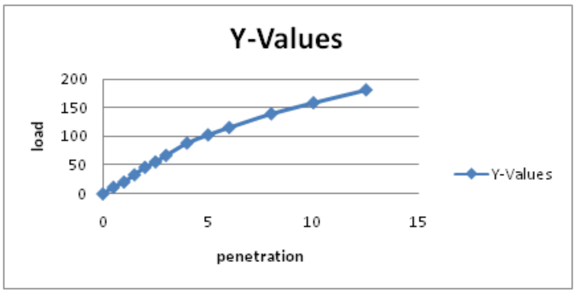
- The optimum bituminous content is 7.975%
- Maximum dry density is 1.856 gm./c.c

4. CALIFORNIA BEARING RATIO TEST (WATER)

To determine the strength of the taken silty soil

Dial Gauge Reading	Proving Ring Reading	Load(Kg)=Prr*2000/874
0	0	0
0.5	5	11.44
1	9	20.59
1.5	14.5	33.17
2	20.2	46.21
2.5	24.5	55.59
3	29.2	66.80
4	38.6	88.31
5	44.8	102.50
6	50.4	115.31
8	60.8	139.11
10	69.2	158.3
12.5	79	180.75

Table 6: Details of CBR test results using water



Graph 4: A CBR load-penetration curve using water.

Observations:

$CBR_{2.5mm} = \frac{55.59}{1370}$*100=4.05%

$CBR_{5mm} = \frac{102.50}{2055}$*100=4.98%

Conclusion Remarks:

- The CBR value calculated at 5mm penetration is constantly found to be more than the CBR value calculated at 5.0mm.for flexible pavement design purpose.
- If the CBR calculated at 5.0mm penetration is constantly more than the value at 2.5mm penetration. The CBR at 5.0mm should be taken as the design value.
- Hence we repeat the test for three timesthe obtain CBR values at 5.0mm are 5.21%,5.46%,4.98% from this values we take the least value 4.98%

5. CALIFORNIA BEARING RATIO TEST WITH BITUMINOUS EMULSION

To determine the strength of the taken silty soil by bituminous emulsion

Dial Gauge Reading	Proving Ring Reading	Load(Kg)=Prr*2000/874
0	0	0
0.5	7	15.96
1	17.6	40.36
1.5	35.5	80.30
2	50.4	115.36
2.5	72.2	165.19
3	86.8	198.54
4	112.5	257.40
5	131.5	300.87
6	149.6	342.28
8	184	420.99
10	215.6	493.29
12.5	251.5	575.4

Table 7: Details of CBR test results using bituminous emulsion

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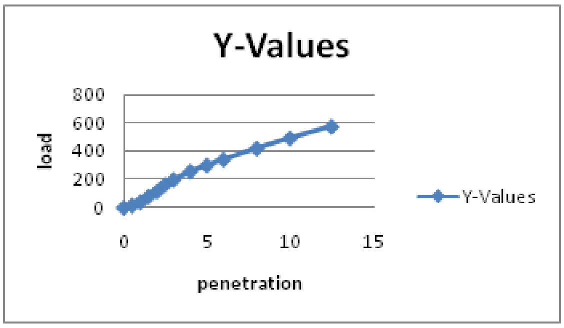

Graph 5: A CBR load-penetration curve using bituminous emulsion.

Observation:

$CBR_{2.5mm} = \frac{165.19}{1370} * 100 = 12.05\%$

$CBR_{5mm} = \frac{300.87}{2055} * 100 = 14.64\%$

Zero correction is 0.6

$CBR_{3.1mm} = \frac{203.12}{1370} * 100 = 14.82\%$

$CBR_{5.6mm} = \frac{328.32}{2055} * 100 = 15.97\%$

Conclusion Remarks:

- TheCBR value calculated at 5mm penetration is constantly found to be more than the CBR value calculated at 5mm.for flexible pavement design purpose.
- Hence we repeat the test for three timesthe obtain CBR values at 5.0mm are 14.96%,15.24%,14.64% from this values we take the least value 14.64%, after zero correction the obtain CBR value is 15.97%

6. Falling head with water

To determine the coefficient of permeability of given soil by falling head method

- The constant head permeability test is used for course grained in a given time.

Sino	Time't'sec	Initial Head H1cm	Final Head H2cm	H1\H2	Log10h1\H2	K(Cm/Sec)*10^{-3}
1	40.1	100	50	2	0.301	1.794
2	20	50	20	2.5	0.397	4.745
3	23	100	60	1.66	0.22	2.286
4	47	60	5	12	1.079	5.488
5	9.37	100	70	1.428	0.154	3.92
6	27	70	40	1.75	0.243	2.151
7	54.4	100	40	2.5	0.397	1.744
8	73	100	30	3.33	0.5224	1.711

Table 8: Details of permeability test results using water

Observations

$K = \frac{2.303 * a * l}{A * t}$ $\log_{10} \frac{h_1}{h_2}$

K=coefficient of permeability.

A=area of stranded pipe.

L=length of specimen.

h_1 =head at time t_1.

h_2 =head at timet_2.

A=cross sectional area of specimen.

$T = t_2 \sim t_2$ in sec.

$K = \frac{2.303*0.785*10.6}{80.15*20} * 0.397 = 1.794 * 10^{-3}$

Conclusion Remarks:

- The average value of coefficient of permeable of silty soil sample by variable head method is $k = 2.979 * 10^{-3}$ cm/sec.,obtained at 95% of MMD

7. Falling head with bituminous emulsion

To determine the coefficient of permeability of given soil by falling head method

- The constant head permeability test is used for course grained in a given time. However the falling head test is used for relatively less permeable soils where the discharge is small.

S.No.	Time 'T' Sec	Initial Head h_1 Cm.	Final Head h_2 Cm.	$\frac{h_1}{h_2}$	$\log_{10} \frac{h_1}{h_2}$	K(Cm/Sec)*10^{-3}
1	39	100	70	1.428	0.154	0.944
2	30	70	50	1.4	0.146	1.163
3	56	50	25	2.5	0.3	1.283
4	43	25	10	2.5	0.39	2.168
5	15	100	85	1.176	0.07	1.115
6	42	85	45	1.88	0.27	1.532
7	57	45	10	4.5	0.65	2.726
8	5	10	5	2	0.301	1.09

Table 9: Details of test results using bituminous emulsion

Observation:

$K = \frac{19.163}{80.15*39} * 0.154 = 9.44 * 10^{-4}$ cm/sec.

Conclusion Remarks:

- The average value of coefficient of permeable of silty soil sample by variable head method is $k = 1.502 * 10^{-3}$ cm/sec.

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- Decease in permeability (%) = $\frac{(2.297-1.503)*10^{-3}}{1.503*10^{-3}}$*100 =52%

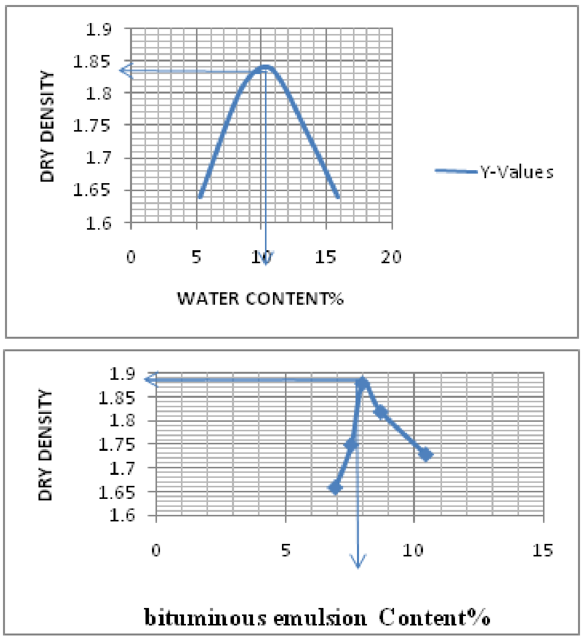
III. CONCLUSION AND RECOMMENDATION

Conclusion

- Advantages and uses of using cationic bituminous emulsion. For stabilization subgrade soil gives good strength
- ➢ Increasing of CBR value gives good strength, stiffness and cohesiveness to subgrade soil. Decreasing of permeable value gives good permeability to the sub grade soil
- Test results with water and bituminous emulsion
- ➢ Optimum moisture content(OMC) is 10.6%
- ➢ Maximum dry density (MDD) is 1.842gm/cc.
- ➢ Optimum bituminous content(OBC) is 7.95%
- ➢ Maximum dry density(MDD) is 1.856gm/c

Soil admixture with water	Soil admixture with bituminous emulsion
Optimum moisture content(OMC) is 10.6% Maximum dry density (MDD) is 1.842gm/cc.	Optimum bituminous content(OBC) is 7.95% Maximum dry density(MDD) is 1.856gm/cc

Table 10: Comparing of OMC and MDD using water and bituminous emulsion values



Graph 6: Coparising of water content and maximum dry density

- ➢ CBR@2.5mm is 4.05%
- ➢ CBR@ 5mm is 4.98%
- ➢ After trail we take CBR@ 5mm is 4.98%
- ➢ CBR@2.5mmis 14.82%
- ➢ CBR@5mm is 15.97%
- ➢ After trial and zero correction we take CBR@5mm is 15.97%

Soil admixture with using water	Soil admixture using bituminous emulsion
CBR@2.5mm is 4.05% CBR@ 5mm is 4.98% After trial we take CBR@ 5mm is 4.98%	CBR@2.5mmis 14.82% CBR@5mm is 15.97% After trial and zero correction we take CBR@5mm is 15.97%

Table 11: Comparing of CBR values using water and bituminous emulsion

Percentage increase of CBR value

$= \frac{14.64-4.98}{4.98}$=193.97%

The silty soil strength has been increasing by about 193% due to using bituminous emulsion at Optimum content as 7.95 %. From the above results it is concluded that stabilization with bituminous emulsion will increase strength and durability of subgrade soil.

- The rate of permeability of silty soil decreased by using bituminous emulsion and the following summary of the test details indicate the same.

Soil admixture with water	Soil admixture with bituminous emulsion
The avg.coefficient of permeability Is $2.979*10^{-3}$cm/sec, obtained at 95% of MMD .	The avg. Coefficient of permeability is $1.502*10^{-3}$cm/sec.

Table 12: Comparing of permeable values using water and bituminous emulsion

- **Permeability test results with water**
  The average coefficient of permeable k=$2.297*10^{-3}$cm/sec.

- **Permeable test with bituminous emulsion**
  The average coefficient of permeable k=$1.502*10^{-3}$cm/sec
- ➢ From above values
  $2.297*10^{-3} - 1.502*10^{-3} = 1.477*10^{-3}$

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Decease in permeability (%) = $\frac{(2.297-1.503)*10^{-3}}{1.503*10^{-3}}$*100=52%

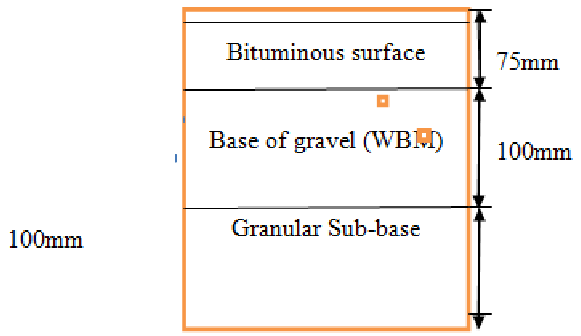
Economic analysis of the bituminous emulsion stabilization of the soil is compared with the conventional soil water stabilization and it is found that the construction cost of construction also decreased. The following are the details of the economic comparison made with and without using bituminous emulsion.

Cost analysis:

- CBR@2.5mm is 4.05%
- CBR@ 5mm is 4.98%

After trail we take CBR@ 5mm is 4.98%
Traffic volume= 2msa

S_4:T_4



a)

- Bituminous surface= 3.75*0.05*1000 = 187*5 m^3
  = 3.75*0.025*1000= 93.75m^3
- 1m^{3}dense bitumen macadam=Rs5221.79

  Therefore 187.5*5221.79= Rs979085.62

- 1m^3 bitumen concrete=Rs6356.21.
  Therefore 93.75*6356.21=595894.68
- Bituminous surface cost=1574980.305

b)

- Base of gravel(water bond macadam) = 3.75*0.1*1000= 375 m^3
- 1m^{3}cost = Rs1030.43.
  Therefore 375*1030.43 = Rs386411.25.

c)

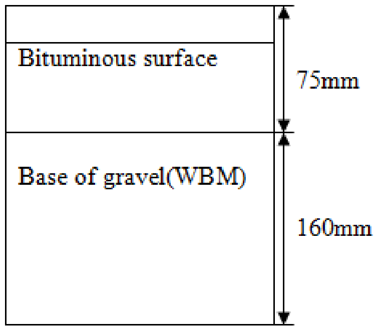
- Granular sub-base = 3.75*0.1*1000= 375m^3
- 1m^{3}cost = Rs982.72
  Therefore 375*982.7 = Rs368520

d)

- The total road cost for 1KM is Rs2329911.55
- ➢ CBR@2.5mm is 14.82%
- ➢ CBR@5mm is 15.97%

After trial we take CBR@ 5mm is 14.64%

S_5:T_4



a)

- Bituminous surface= 3.75*0.05*1000
  = 187*5m^3
  = 3.75*0.025*1000
  = 93.75m^3
- 1m^{3}dense bitumen macadam = Rs5221.79
  Therefore 187.5*5221.79 = 979085.62
- 1 m^3 bitumen concrete = Rs6356.2
  Therefore 93.75*6356.21 = 595894.68
- Bituminous surface cost = 1574980.305

b)

- Base of gravel(water bond macadam)=3.75*0.16*1000=600m^3
- 1 m^{3}cost = Rs1030.43.
  Therefore 600*1030.43 = Rs618258.

c)

- The cost of cationic bituminous emulsion for 550 liters is Rs23500

d)

- The total road cost for 1KM is Rs2219088.305

At final the cost will decrease while applying cationic bituminous emulsion.

The decreasing cost is = 2329911.55-2219088.305
= Rs113173.245

Therefore, the advantage of using bituminous emulsion per 1 KM is Rs113173.245

IV. FUTURE SCOPE:

- Occurrence of the silty soils are commonly available type of soil in around the study of sieve analysis, compaction, CBR and permeable can also be done for other type soils which are available at different locations where roads are to be laid.
- The silty soil stabilization with bituminous emulsion is also being done with foamed bituminous emulsion, lime, fly ash, cement, cinder and combinations.

REFERENCES:

[1] Ballantine RW and Rossouw AJ 1989. Stabilization of soils. PPC Lime Handbook. Johannesberg.

[2] Brown S and Needham A. 2000. A study of cement modified bitumen emulsion mixtures.

[3] Proceedings of the Association of Asphalt paving Technologists, AAPT, vol.69, Reno. USA.

[4] Giuliani F. 2001. X-Ray Diffraction method for studying cement-modified bitumen-emulsion

[5] Mixtures in asphalt pavement cold recycling. 1st International symposium on sub-grade

[6] Stabilization and in-situ pavement recycling using cement, Salamanca, Spain. October.

[7] Hodgkinson A L. 2003. Investigation into the role of cementitious binders when recycling with foamed bitumen or bitumen emulsion. MSc. (Applied Sciences) project report. University of Pretoria.

[8] Liebenberg J J E. 2003. A structural design procedure for emulsion treated pavement layers. Masters dissertation. Faculty of Engineering. University of Pretoria. April.