Use of Nanomaterials and Cement for Improvement of Soil in Rural Roads

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***Abstract*- In line with other countries abroad, rural road construction in India may also adopt soil stabilization technique, at least in the areas, where stone aggregates is not available near construction sites and leads for carrying hard stone is uneconomical. Cement is a very popular stabilizer all over the world particularly for coarse grained soils. A mixture of other propertary additives is also being used for stabilization of various types of soils. In this, cement stabilization is used to modify soil properties along with small quantity of nanomaterials. This additive eliminates capillary rise and water ingress from top, and reduces water permeability. In this, stabilization has been done using cement and dose of nanomaterials.**

- **To improve engineering properties of soil and to reduce the thickness of the pavement layers.**
- **To improve load bearing capacity of soil to sustain under increasing traffic load condition.**
- **In this cement along with small quantity nano-materials was used for chemical stabilization of soil.**

So, Main aim for this is to improve load bearing capacity, improve engineering properties of soil, and reduce the cost of the construction. To construct the road with low cost, with the help of nano materials, to construct the road with zero bitumen. Materials used here are soil, cement, chemical solutions (nano material).

1. INTRODUCTION

Due to depletion of the sources of stone, cost of the road construction material increases. Therefore, it is necessary to use alternative material for construction which would reduce the overall cost of construction.

- Nanotechnology based stabilizers works well with the combination of cement and makes the soil stiff, so that in low traffic area stabilized gravel road can be constructed and this combination also improves the physical and mechanical properties of the soil.
- Stabilization is being used for a variety of engineering works, the most common application being in the construction of road and airfield pavements, where the main objective is to increase the strength or stability of soil and to reduce the construction cost by making best use of locally available materials.

1.1 NEED OF STUDY

- Local soils often have low CBR, and are not useful for road construction.
- Good soils and aggregates are limited and may have to be brought from a long distance.
- Surface waterproofing with Terrasil and ZycoBond ensures reduction in water permeability.

1.2 SCOPE OF STUDY

- Study of IS: 4332(Method of Soil stabilization) and relevant IS codes required for our project.
- Various Soil test (as per IS: 2720) are to be carried out in laboratory.
- Compare Test results of treated soil and untreated soil.

1.3 Objectives

- The main objective of the study is to carryout laboratory investigations on the use of nonmaterial's to increase the durability of the soil sub grades and implement technology on rural road construction.
- In this, cement along with small quantity of nano-material was used for chemical stabilization of soil.

- To improve engineering properties of soil and to reduce the thickness of the pavement layers.
- To reduce the cost of construction, by laying stabilized gravel road in low traffic volume areas.

2. SOIL TEST REQUIRED

Various soil test to be carried test to be carried out are listed below.

No.	Soil Test	Is code
1	Sieve Analysis	IS2720-Part 4
2	Modified Proctor	Is2720Par t8
3	Free Swell Index	Is2720-Part 2
4	Atterberg's Limit	Is2720-Part 5
5	C.B.R Test	Is2720-Part 16

Table 2.1 Various type of soil with IS Codes

2.2 VARIOUS TEST OF SOIL

2.2.1 SIEVE ANALYSIS

OBJECTIVE

Determination of quantitative size distribution of particles of soil down to fine-grained fraction.

APPARATUS

1. Set of sieves (4.75mm), B
2. Balance (0.1g accuracy),
3. Drying oven, Rubber pestle, Cleaning brush,
4. Mechanical shaker.

Fig.2.1.1

2.2.2 MODIFIED PROCTER TEST

OBJECTIVE

To determine moisture content and dry density relationship using heavy compaction or modified compaction method.

APPARATUS

1. Metal mould (volume = 1000 cm3)
2. Balance (capacity = 10 kg, least count = 1g)
3. Oven (105 to 1100C)
4. Sieve (19 mm)
5. Metal rammer (weight = 4.9 kg)

Fig.2.2.2

2.2.3 FREE SWEEL INDEX

OBJECTIVE

Free swell index, is the increase in volume of soil without any external constraint when to submergence in water.

APPARATUS

1. Sieve (425 micron IS sieve)
2. Glass Graduated Cylinders- Two, 100-ml capacity

Fig.2.3.3

2.2.4 ATTERBERG'S LIMIT

OBJECTIVE

The method of taste covers the procedure for determination of liquid limit and plastic limit of soil.

The liquid limit of soil is the water content, expressed as a percentage of the weight of the oven dried soil. At the boundary between liquid and plastic state of consistency of the soil that corresponds to the moisture content of a paste which would give 25mmpenetration of cone.

The plastic limit of the soil is the water content, expressed as percentage of the weight of oven dry soil. At the boundary between the plastic and the semi solid states of consistency of the soil. It is the percentage of moisture content at which 3mm dia. Thread crumbled.

APPARATUS

The app. Required for the test is as follows:

1) Uppal's cone penetrometer
2) Oven (Maintain the temp. betn. 105- 110*C
3) Balance (cap 210gm, accuracy 0.01gm)
4) 3mm dia. Steel rod
5) Nickel Crucible

ATTERBERG'S LIMIT

A) Liquid limit:

1. Take oven dry soil sample passing throughout 425 micron sieve.
2. Make a paste by required distilled water and transfer it to the cylindrical cup such that there is no air bubble.
3. Adjust the moisture content such that penetration reading is in between 16-26 mm.
4. Determine moisture content.

B) Plastic limit:

1. Make paste by adding required distilled water.
2. Make a thread of 3mm dia.
3. When 3mm dia. Thread starts crumbling, collect representative solid thread in crucible.
4. Determine moisture content.

2.2.5 CALIFORNIA BEARING RATIO

OBJECTIVE

The ratio expressed in % of force per unit area required penetrating soil mass with a circular plunger of 50diameter at the rate of 1.25mm/min to the required for corresponding penetration in standard material.

APPARATUS

1. CBR Mould
2. Space disk
3. Loading Machine
4. Penetration plunger
5. Two dial Guages
6. Sieves (4.75 and 19mm)
7. Oven
8. Expansion measuring device

SAMPLE NO 1

Load Penetration Test Data				
Penetration mm	C/S Area of Plunger in Cm2	Proving Ring Constant	Proving Ring Reading	Corrected Load in Kg/cm2
0.0	19.625	6.219	0	0.00
0.5			5	1.58
1.0			8	2.54
1.5			11	3.49
2.0			13	4.12
2.5			15	4.75
3.0			16	5.07
4.0			18	5.70
5.0			21	6.65
7.5			26	8.24

Summary table of dry Density & C.B.R

Condition of Sample	Mould No.	Dry density gm/cc	Moisture content %	Average corrected load from Graph kg/cm^2		Average C.B.R.		C.B.R value reported
				2.5 mm	5 mm	2.5 mm	5 mm	

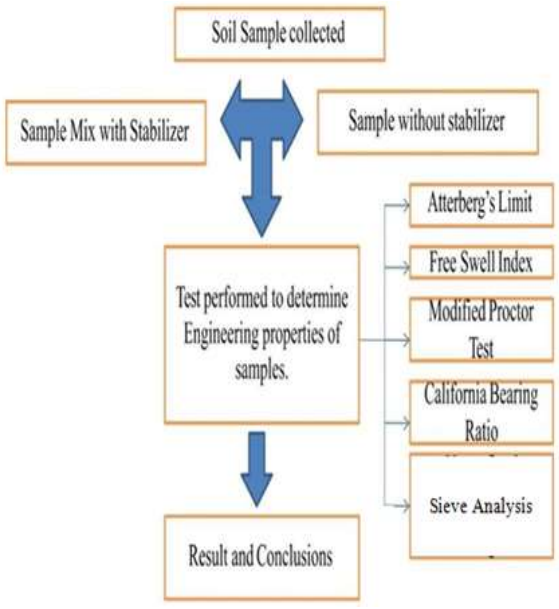
Soaked	47	1.6555	26.52%	4.753	6.655	6.79	6.34	8

Load Penetration Test Data

Penetration mm	C/S Area of Plunger in Cm2	Proving Ring Constant	Proving Ring Reading	Corrected Load in Kg/cm2
0.0	19.625	6.219	0	0.00
0.5			9	2.85
1.0			14	4.44
1.5			18	5.70
2.0			20	6.34
2.5			23	7.29
3.0			25	7.92
4.0			28	8.87
5.0			33	10.46
7.5			41	12.99

Condition of Sample	Mould No.	Dry density gm/cc	Moisture content %	Average corrected load from Graph kg/cm^2		Average C.B.R.		C.B.R value reported
				2.5 mm	5mm	2.5 mm	5 mm	
Soaked	48	1.708	23.24%	7.289	10.457	10.41	9.96	13

3. METHODOLOGY



4. SURVEY OF PROBLEM IDENTIFICATION

Fig.4.2 Survey of Problem Identification

- Unpaved roads may generate a lot of dust during dry periods. This dust can alter roadside vegetation, and has been considered to harm human health.
- Dirt roads may only be passable by trucks or four-wheel drive vehicles especially in wet weather.
- Dust problem in unpaved road
- a)roadway safety problems due to impaired visibility,
- b) reduced roadway longevity due to a loss of surfacing/binding materials,
- c) reduced vehicle life, and
- d) Environmental health issues due to the many negative impacts of particulate matter in the atmosphere.
- Dust and drainage problem effect the human body and environment.

5. SOIL TEST OF TREATED SAMPLES

5.1 INTRODUCTION

Table 5.1 Various type of soil with IS Codes.

Various soil test to be carried test to be carried out are listed below.

No.	Soil Test	Is code
1	Sieve Analysis	IS2720-Part 4
2	Modified Proctor	Is2720Par t8
3	Atterberg's Limit	Is2720-Part 5
4	C.B.R Test	Is2720-Part 16

Table 5.1 Various type of soil with IS Codes

Objective, Apparatus, Reference and Procedure are same as above mentioned.(As per Untreated sample) In this test nanomaterials (i.e Tio2) is added.

Fig.5.1 TiO2

5.1.1 CALIFORNIA BEARING RATIO

Objective, Apparatus, Reference and Procedure are same as above mentioned.(As per Untreated sample) In this test 5% of nanomaterials (i.e Tio2) is added.

Table 5.1.1.1 CALIFORNIA BEARING RATIO Sample No :-1

DESCRIPTION	AFTER SOAKING		
No. of blows	STATIC	STATIC	STATIC
Mould no.	1	2	3
Wt. of mould	8730	8528	8555
Wt. of mould + Compacted soil	12927.5	12725.4	12752.1
Volume of mould (V)	2250	2250	2250
Container no. for moisture	49	48	50
Wt. of container + wet soil	355.50	368.10	422.11
Wt. of container + dry soil	331.15	341.27	390.67
Wt. of dry soil	220.5	243.0	284.8
Wt. of water	24.4	26.8	31.4
Moisture Content	11.04	11.04	11.04
Wt. of compacted soil	4197.52	4197.4	4197.1
Wet density	1.866	1.866	1.865
Dry density	1.680	1.680	1.680
% of compaction	100%	100%	100%

CBR LOAD VS PENETRATION

Mould No.	1		2		3	
Penetration	Load in kg	CBR value	Load in kg	CBR value	Load in kg	CBR value
0.0	0		0		0	
0.5	235		225		231.4	
1.0	430		432		428.4	
1.5	602		598		610.1	
2.0	785		745		770.4	
2.5	903	65.91	900	65.7	902.1	65.8
3.0	1020		1032.10		1028.4	
4.0	1185		1225		1199.1	
5.0	1355	65.94	1348.4	65.6	1360.4	66.2
7.5	242.1		236.10		234.6	
10.0	255.8		245.40		250.1	
12.5	260.1		255.80		254.5	
CBR @ 2.5mm Penetration	65.9		65.7		65.8	
CBR @ 5.0mm Penetration	65.9		65.7		66.2	

	Trial-1	Trial-2	Trial-3	Average
CBR @ 2.5mm Penetration	65.9	65.7	65.8	65.8

CBR @ 5.0mm Penetration	65.9	65.6	66.2	65.9

Consider, CBR = 65.9%

Table 5.1.1.2 CALIFORNIA BEARING RATIO

Sample No :-2

DESCRIPTION	AFTER SOAKING		
No. of blows	STATIC	STATIC	STATIC
Mould no.	4	5	6
Wt. of mould	8789	8426	8614
Wt. of mould +Compacted soil	13043	12680.2	12868.4
Volume of mould (V)	2250	2250	2250
Container no. for moisture	100	184	201
Container wt.	111.84	101.23	99.41
Wt. of container+ wet soil	332.10	384.41	285.20
Wt. of container+ dry soil	310.81	357.03	267.24
Wt. of dry soil	199.0	255.8	167.8
Wt. of water	21.3	27.4	18.0
Moisture Content	10.70	10.70	10.70
Wt. of compacted soil	4254	4254.2	4254.2
Wet density	1.891	1.891	1.891
Dry density	1.708	1.708	1.708
% of compaction	100%	100%	100%

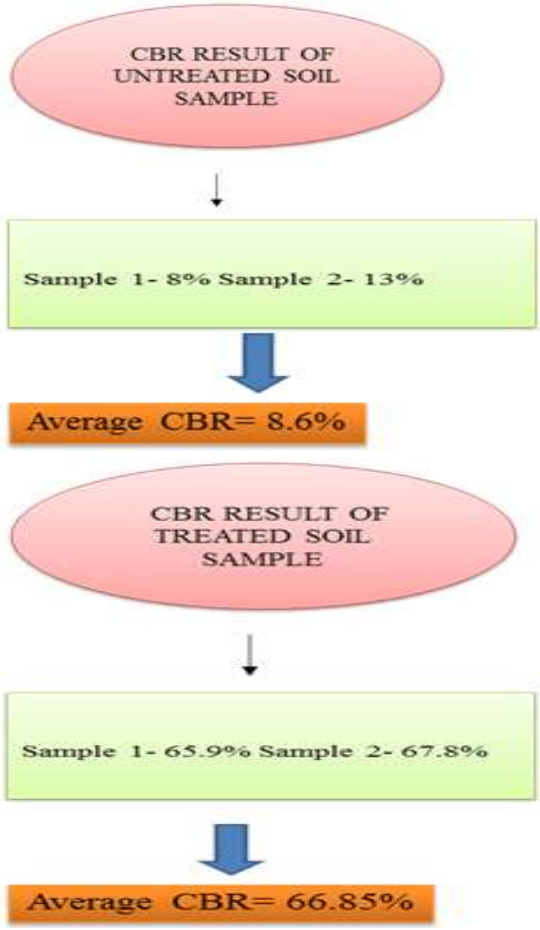
CBR LOAD VS PENETRATION

Mould No.	4		5		6	
Penetration	Load in kg	CBR value	Load in kg	CBR value	Load in kg	CBR value
0.0	0		0		0	
0.5	270.2		268		265.1	
1.0	450.1		448		452.4	
1.5	602.1		598.40		600.1	
2.0	755.4		752.80		758.6	
2.5	907.9	66.3	910.4	66.5	908.4	66.3
3.0	1030.4		1022.80		1035.0	
4.0	1208.1		1204.40		1211.0	
5.0	1392.0	67.7	1389.4	67.6	1395.4	67.9
7.5	235.4		225.40		235.1	
10.0	255.4		240.90		248.4	
12.5	272.1		250.40		260.1	
CBR @ 2.5mm Penetration	66.3		66.5		66.3	
CBR @ 5.0mm Penetration	67.7		67.6		67.9	

	Trial-1	Trial-2	Trial-3	Average
CBR @ 2.5mm Penetration	66.3	66.5	66.3	66.3
CBR @ 5.0mm Penetration	67.7	67.6	67.9	67.8

6. CBR COMPARISON & ESTIMATION

6.1 CBR COMPARISON



6.2 Estimate of 200m Length Road

Step 1: Box cutting:

- 200 (length) × 3.50 (width) × 0.30 (depth) = 210 Cmt
- 210 × 50 = 10500 Rs

Step 2: WBM:

- Two layer of WBM. 2 × (200 × 3.50 × 0.15) = 210 Cmt
- 210 × 2500 = 525000 Rs.

Step 3: Bituminous Carpet

- 200 × 3.50 × 0.02 × 2.20 = 30.8 MT
- 30.8 × 1000 = 30800 Rs.

Step 4: Seal Coat

- 200 × 3.50 × 0.012 × 2.30 = 19.30 MT
- 19.30 × 2000 = 38600 Rs.
- 10500+525000+30800+38600 Total =604900
- Plus 15% contractor profit = 90735 Rs
- plus 1%Labour charge =6049 Rs
- Grand Total = Rs 7,01,684

Final Analysis:

- The WBM road of length 200 m costs us 7,01,684 Rs.

6.3 Cost Estimation of road made up with Nano materials

ITEMS	UNIT	QUANTITY	RATE PER UNIT	COST RS.
TERRASIL	Kg	95	1000	95000
ZYCOBOND	Kg	106	300	31800
WATER	Liter	25760	0.25	6440
CEMENT	Kg	7560	5	37800
GRIT 12.5 AND DOWN,20 mm thick ,including mixing, transport and paving	Cum	14	1500	21000
		TOTAL(A)		192040

MACHINERY	UNIT	TOTAL HOURS	RATE PER UNIT	COST IN RS.
JCB	RS/HR	7	1500	10500
TRACTOR WITH RIPER	RS/HR	3	1000	3000
TRACTOR WITH ROTOVATOR	RS/HR	5	1000	5000
TRACTOR WITH WATER TANKER	RS/DAY	2	3000	6000
TRACTOR WITH GRADER	RS/HR	2	1000	2000
VIBRO ROLLER FOR COMPECTION	RS/HR	2	1500	3000
DUMPER WITH 10T CAPACITY FOR GRIT TRANSPORTATION	RS/HR	8	700	5600
LOADER FOR MIXING/ LIFTING OF GRIT	RS/HR	3	1000	3000
		TOTAL(B)		38100

COST OF LABOUR				
WORK AREA	NO. OF DAYS	NO. OF LABOURS	RATE / DAY	COST IN RS.
REMOVAL OF BRICKS AND OTHER DEBRIS, ROAD MARKING	1	8.00	400	3200
DUMPING OF SOIL, SPREADING, GRADING, CEMENT SPREADING,CONTROL SPRAY RATE ON THE SOLUTION	1	12.00	400	4800
SPREADING OF AGG., CONTROL SPRAY RATE ON WATER TANKER	1	9.00	400	3600
TOTAL (C)		29.00		11600

TOTAL COST (A+B+C) IN RS.	PARTICULARS	TOTAL	UNIT
	MATERIAL	192040	RS.
	MACHINERY	38100	RS.
	LABOURS	11600	RS.
	TOTAL	241740	RS.

- ADD 15% FOR CONTRACTOR'S PROFIT = 36261 Rs.
- ADD 1% FOR OVERHEAD CHARGES = 2417.40. Rs.
- GRAND TOTAL =280418.40 Rs.

Final Analysis:

- The road made with nanomaterial of length 200 m costs us 280418.40 Rs.

7. CONCLUSION

- The nanomaterials utilized, and supports for the sustainable development in road construction.
- Water permeability, erosion control and other properties are also improved for use of nanomaterials.
- The nanomaterials has improved better and it is rated good after stabilization.

REFRENCES

[1] IS:4332(Method of Soil stabilization)
[2] IS:2720 Soil test
[3] IS 2720 – PART 8(1983) FOR MODIFIED PROCTOR
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