Improvement of CBR characteristics of well Graded Gravel Soil Stabilized with Cement as Base Course Material

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Abstract – *Gravel soils with high CBR values can be used as sub- base and base course materials. Sometimes improper compaction and poor quality of gradation hinders the functions of above courses. Strong stabilizer like cement improves the strength and durability characteristics of gravel soil as base courses. The present study utilizes OPC cement of 53 grade in improving CBR values of gravel soil of well graded nature. Individually gravel soil can be used as sub base course and a small percentage i.e 5-6% of dosage of cement increased CBR values greater than 100 can be used as base course material. Use of 1-2% of cement avoids the problem of gradation and plasticity characteristics in gravel soils to use as sub –base and bases courses for low traffic volume roads.*

Keywords*: Cement, Gravel, Sub base, Base courses. Low traffic volume roads.*

I. INTRODUCTION

Gravel soils are promising material in the construction of civil Engineering works especially in road networks. Presence of small percentages of silt and clay particles reduces the life of the road network and decreases the strength and increases deformation on saturation. To reduce the quantity of materials used in the construction and to improve the function of the respective component layers of the pavement, cement is preferred as stabilizer.

In the present study gravel soil of well graded nature is tested for CBR clauses at various percentages of cement i.e 1 to 15% and verified their CBR clauses w.r.t 7 days curing period including 3 days moist curing and 4 days in water curing. The test results are compared with MORTH specification requirements to suit as base course material in pavement.

Some of the earlier researchers contributed their experimentations on the work of gravel soils in the construction of various civil Engineering projects. Earlier studies for the utilization of gravel soil Gourley et al (1997) studied the use of Laterite Gravel as Road Base Materials, in Southern Africa, Nunan et al (1990) made a review and experimentation of Gravel stabilization methods. Satyanarayana et al (2013) studied High Plastic Gravels stabilized with crusher dust as sub base material. Ramana murthy. v.et.al (2003, 2004), studied utilization of gravel and morrum in geo technical applications. Jain P.K et.al, (2010) studied the stabilization of morrum and their strength characteristics in terms of CBR as a road construction material. The present work is aimed to assess the performance of gravel mixed with cement w.r.t. CBR characteristics.

II. MATERIALS

The present study aims at in improving strength parameter interims of CBR values of gravel soils treated with cement at 7 days curing period.

Gravel soil works collected from local quarries and dried and served through 4.75 mm. The particles above 4.75 mm is of 95% and particles less than 4.75 mm is of 5%. The total quantity of soil is tested for different dosage of cement. Cement is of OPC 53 grade which is added 15 gravel soil by percentages such as 1,2….15% by dry weight of the gravel soil.

Table 1 Engineering Properties of Gravel soil

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S.No	*Soil property*	*Value*
1	***Grain Size Analysis***	
	a) Gravel size (%)	*95*
	b) Sand size (%)	*5*
	c) Fines (%)	*0*
2	***Plasticity Characteristics***	
	a) Liquid limit (%)	*Non-Plastic*
	b) Plastic limit (%)	*Non-Plastic*
	c) Plasticity index (%)	*Non-Plastic*
3	***Compaction Characteristics***	
	a) Optimum Moisture Content (%)	*4.80*
	b) Maximum Dry Density (g/cc)	*2.12*
4	***Soaked C.B.R (%)***	*38*
5	***Differential Free Swell Index (%)***	*0*

Cement

The cement used in the study is 53 grade Ordinary Portland Cement(OPC). The properties of cement determined from
laboratory tests are presented in Table 2.

Table 2 Properties of Cement

S.No	**Property**	**Value**
1	Specific Gravity	3.10
2	Initial setting time (min)	95
3	Final setting time (min)	240
4	Compressive strength (N/mm2)	
	i) at 3 Days	31
	ii) at 7 Days	45

III. METHODOLOGY& APPLICATIONS

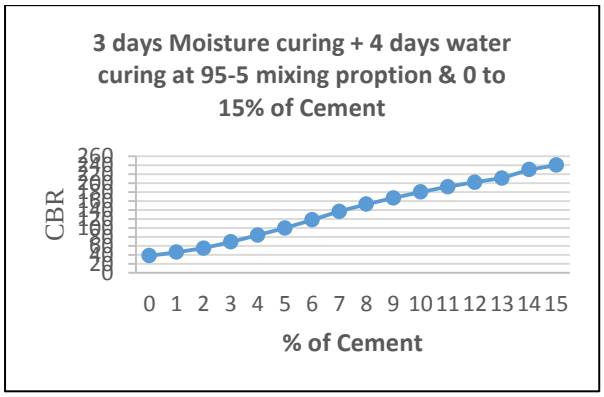
To know the CBR characteristics of gravel – cement mix, various gradation 95-5 is mixed with different percentages of cement and CBR samples are prepared at their OMC & MDD values using Modified Proctor test. These samples are cured for 7 days by keeping the CBR sample for 3 days under wet gunny bags know as moist curing and remaining four days these samples were kept in water known as soaking (water curing) i.e. 3 days moist curing followed by 4 days' water curing.

After completion of required curing periods these sample are tested for CBR values as per IS-2720-part-16. The test results are shown in table. -3 and fig-1

Table-3

CBR values of 3 days Moisture curing + 4 days Water curing		
S.No	***% of Cement***	***Gradation of Mix Soil(26.50 mm to 4.75 mm)+Soil(4.75mm to 2.0 micron)***
		95-5
	0	38
1	1	46
2	2	55
3	3	69
4	4	84
5	5	100
6	6	118
7	7	137
8	8	153
9	9	167
10	10	180
11	11	192
12	12	202
13	13	211
14	14	230
15	15	240

FIG-1



CBR characteristics of gravel grade (G95-5)-Cement Mixes

3 days Moisture curing + 4 days' water curing

Test results of test results of gravel grade 95-5 with different percentages of cement (1,2,3, ----15) under 3 days' moisture curing + 4 days' water curing are the following test results are show in table and fig. The following are observed.

Table-4

G 95-5				
S.no	**% of Cement**	**3 days Moisture curing + 4 days water curing**		
		CBR Value	**Improvement Ratio**	**% of Increase**
1	0	38		
2	1	46	1.21	21
3	2	55	1.45	45
4	3	69	1.82	82
5	4	84	2.21	121
6	5	100	2.63	163
7	6	118	3.11	211
8	7	137	3.61	261
9	8	153	4.03	303
10	9	167	4.39	339
11	10	180	4.74	374
12	11	192	5.05	405
13	12	202	5.32	432
14	13	211	5.55	455
15	14	230	6.05	505
16	15	240	6.32	532

95-Soil (26.50 mm to 4.75 mm) , 5- Soil (4.75mm to 2.0 micron)

Increasing the percentage of cement increase CBR values. Initial dosages 1 to 4% a slow rate of increase was observed, 5-10% a rapid rate increase whereas 11-15% again a slow rate of increase was observed. Initially the CBR value of gravel /soil (95-5) is 38% addition of 4% of cement it value rose to 84 at 10% of cement it is 180, whereas at 15% of cement it is 240.

4 to 5% of dosage of cement exhibited CBR Value in the range of 84 to 100, 6 to 8% of dosage of cement exhibit CBR Values in the range of 118 to 153, 8 to 10% of dosage of cement exhibited 153-180 and 10-12% of dosage of cement exhibited CBR values in the range of 180-202.

The cement stabilized gravel grade is also explained with improvement ratios and also their percentage increase in CBR values at various percentages of cement w.r.t their untreated gravel soil.

$$\text{Improvement ratio} = \frac{\text{(CBR) Treated}}{\text{(CBR) untreated}}$$

$$\text{Percentage increase} = \frac{\text{(CBR) T - (CBR) un}}{\text{(CBR)un}}$$

From the improvement ratios it is identified that improvement ratio is increasing with increasing the percentage of cement in the gravel mix.

At initial dosages of cement i.e. is 4% to 5% by improvement ratio is the range of 2.21 to 2.63, at 6-8% dosage of cement it is 3.12 to 4.03, at 8-10% dosage of cement is 4.03 to 4.74, and 10-12% dosage of cement the improvement ratio is 4.74 to 5.32 respectively.

Similarly, the percentage increase in CBR values of stabilized gravel soil w.r.t untreated gravel soil is also increasing there CBR values with increasing the dosage of cement.

These values are up to 121% for 1 to 4% dosage of cement,122-163% for 4-5% dosage of cement, 21-303% for 6-8% dosage of cement, 303-374% dosage of cement for 8-10% and 374-432% for 10-12% dosage of cement in the untreated gravel soil. (G 95-5) respectively.

IV. CONCLUSIONS

1. Individually gravel soil with CBR Value 38 can be uses as sub base course materials.
2. To use as base cause material 5-6% of cement can be added to the gravel soil.
3. The liquid limit and plasticity index (PI) of Gravel soil are satisfies CBR value greater than 100 the MoRTH criteria for cement treated soil as base course materials (MoRTH specifications for road and bridge works).

V. REFERENCES

[1] ASTM D 2487 - 17 "*Standard practice for classification of soils for engineering purposes (Unified Soil Classification System)*" ASTM International, west Conshhocken, United States.

[2] ASTM D559 (1989): "*Standard test methods for wetting and drying compacted soil-cement mixtures*". Annual Book of ASTM Standards, Vol. 04.08,

[3] ASTM C593 (2001): "*Standard specification for fly ash and other pozzolans for use with lime. Annual Book of ASTM Standards*", Vol. 04.01, ASTM, Philadelphia, Pa

[4] ASTM (1992): "*Standards on Soil Stabilization with Admixtures. American Society of Testing Material*", West Conshohocken, Pa

[5] IS2720(Part-4)-1985 "*Methods of Test for Solis"*.

[6] IS: 4332 Part3 (1995): *"Indian Standard code of Practice-Methods of tests for stabilized soils"*.

[7] IS:2720 part16(1997): "*Indian Standard code of practice Methods of tests for soils-laboratory determination of CBR"*

[8] IS 4332-Part 5 "*Methods of test for stabilised soils: Determination of unconfined Compressive Strength of stabilised soils*". Published by Bureau of Indian standard, New Delhi, India.

[9] IRC: SP: 89 - 2010 "*Guidelines for soil and granular material stabilization using cement, lime and fly ash*". Published by Indian Roads Congress, New Delhi, India.

[10] IRC: SP: 89 -2018 (Part-II) "*Guidelines for the design of stabilized pavements*". Published by Indian Roads Congress, New Delhi, India.

[11] MORTH - Specifications for Road & Bridge Works (5th Revision)

[12] Nunan, T.A and Humphrey D.N(1990), "*A Review and Experimentation of Gravel Stabilization methods, executive"*, Technical services division, Technical report 90-2, Departments of Civil Engineering, University of Maine, Orono, Maine.

[13] Ramana Murthy. And Hari Krishna, P. (2003): "*Influence of organic Additives on Properties of Morrum Soils Used in Pavement Construction*", National Seminar on Recent Advances in Civil Engineering, KITS –Warangal, pp. II 17-II 23

[14] Satyanarayana, P. V. V. Raghu P. Ashok Kumar R, Pradeep N (2013)," *Performance of Crusher Dust in High plastic gravels as road construction material*". IOSR journal of Mechanical and Civil Engineering (IOSR-JMCE), vol. 10. pp:1-5

[15] Satyanarayana, P.V.V, Raghu P, Praveen P (2013), "*Utilization of Crusher Dust Stabilized Gravel as Subbase materials*". International Journal of Engineering Research and Technology (IJERT)vol 2. Issue 11. pp:4034-4016