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"STUDY OF STRENGTH CHARACTERISTICS OF CEMENT STABILIZED GRAVELLY SOIL"

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Abstract: *Quality aggregates are becoming increasingly scarce and expensive in many localities. In an increasing number of cases, locally available aggregates are not meeting applicable specifications, and aggregates that meet the specifications must be imported to the site at considerable expense. The use of locally available gravel as aggregates in flexible pavement and any other field of construction is one of the best alternate for high cost of construction and a lack of quality aggregate sources .There are many methods have been tried for improving the characteristics of gravelly soil to make it suitable for intended purpose. But among various methods Stabilization of soils in order to improve strength and durability properties often relies on additives such as cement. Among various available stabilization techniques, Cement stabilization is one of the best options as it suits to any type of soil. Cement stabilized soils are widely used as construction material in sub base and base courses of pavements due to high strength and durability (Mitchell and Freitag, 1959; PCA, 1992; Ramana Murthy et al, 2006; James Isiwu Aguwa, 2009; Portelinha et al, 2012; Reddy and Prasad, 2015).*

In the present work cement stabilized gravelly soil is assessing for use as an alternative concrete. Comprehensive laboratory work is carried out to study the geotechnical properties of cement stabilized gravelly soil i.e. compaction and strength characteristics of gravelly soil with cement proportions of 6%, 10%, and 14% by dry weight of the soil. The strength of cement stabilized gravel soil has been assessed after 7, 14 and 28 days of curing. Based on the results of study, the possible fields of application for use of gravel concrete are discussed. For the construction and maintenance of rural roads catering to low volumes of traffic, local soil is not only the cheapest but also the highly versatile road material.

***Keywords**: Cement Stabilization, Sub grade, Sub base layer, Base layer, Pavements, well graded gravel*

INTRODUCTION

Gravel is an important commercial product, with a number of applications. Many roadways are surfaced with gravel, especially in rural areas where there is little traffic. As majority of the local soils, in their natural form lack the desired strength and durability required for intended constructions, they are to be improved through the process of stabilization to make them suitable as construction material. Among the available stabilization techniques, Cement stabilization is one of the best options as it suits to any type of soil. Cement stabilized soils are widely used as construction material in sub base and base courses of pavements due to high strength and durability (Mitchell and Freitag, 1959; PCA, 1992; Portelinha et al, 2012; Satyanarayana Reddy and Prasad, 2015). In the present work, laboratory tests have been conducted on gravel stabilized with different proportions of cement to determine the minimum amount of cement required to achieve targeted compressive strength. The hydrated products of cement binds the soil particles, the strength developed depending on the concentration of cement and the intimacy with which the soil particles are mixed with cement. However, a smaller proportion of

cement can improve the CBR value also, and the material going by the term "cement-modified soil" can be advantageously used as sub-base/base for rural roads.

EXPERIMENTAL INVESTIGATION

Materials Used

Gravel

The soil investigated in the study is collected from gravel quarry in Gandhi gram Panagar

city, Jabalpur district in (M.P), Panagar is located at 23.3°N 79.98°E. The properties of soil determined from laboratory study are presented in Table 1. The grain size distribution curve of soil is presented in Fig.1. Based on the gradation properties, the soil is classified as well graded gravel (GW) as per BIS soil classification system. The maximum particle size in the gravel soil collected is below 20mm size. The heavy compaction test (modified proctor test) is conducted on the soil as per IS 2720: Part 8: 1983[1] to evaluate compaction characteristics. The California Bearing Ratio (CBR) test is carried out as per IS 2720: part 16 (1997) [2] on gravel specimen compacted under IS heavy compaction condition. The Soaked CBR value determined after soaking period of 96 hours.

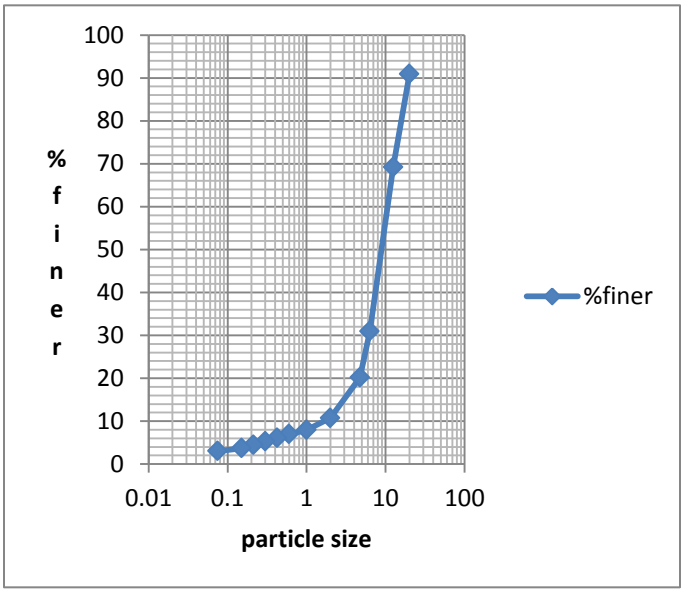


FIG. 1

Table 1: Properties of Gravel

S. No.	Soil property	Value
1.	Grain Size Analysis	
	a) Gravel (%)	80
	b) Sand (%)	17
	c) Fines (%)	3
	d) Uniformity Coefficient	5.1
	e) Coefficient of Curvature	1.76
2.	Plasticity Characteristics	
	a) Liquid limit (%)	NP
	b) Plastic limit (%)	NP
	c) Plasticity index (%)	NP
3.	Classification of soil	GW
4.	Compaction Characteristics	
	a) Optimum Moisture Content (%)	6.80
	b) Maximum Dry Density (g/cc)	2.10
5.	Soaked C.B.R (%)	30

Cement

The cement used in the study is Birla gold 43 Grade Ordinary Portland Cement. The properties of cement determined from laboratory tests are presented in Table 2.

Table: 2 Properties of Cement

Property	Value
Specific Gravity	3.16
Initial setting time (minutes)	90
Final setting time (minutes)	418
Normal consistency (%)	30
Compressive strength (N/mm^2)	
i) at 3 Days	32
ii) at 7 Days	42
iii) at 28 Days	52.28

Compaction Characteristics of Cement Stabilized Gravel

The heavy compaction tests are carried out as per IS 4332 (part 3) -1995 [3] on gravel mixed with 6, 10 and 14 percent cement content by dry weight of soil for determining compaction characteristics. Care is taken to complete the compaction test within 30 minutes from the instant of mixing of cement to soil. The OMC and MDD values of Cement stabilized GW are presented in Table 3.

Table: 3 MDD and OMC values of cement stabilized well graded gravel

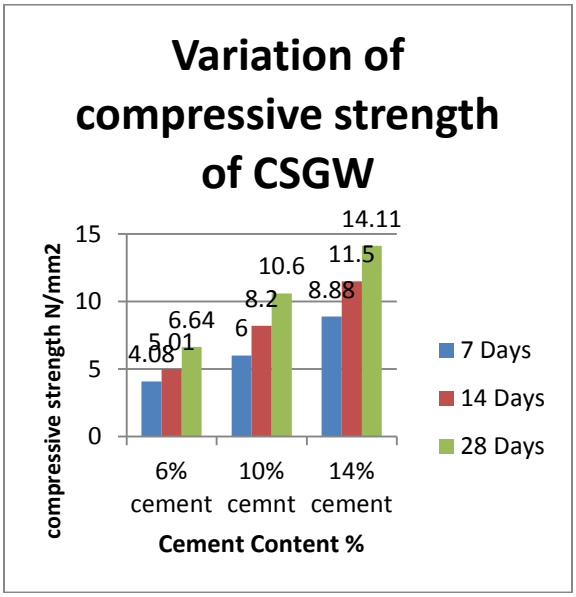
Description of Mix	OMC (%)	MDD (g/cc)
Soil + 0 % cement	6.80	2.10
Soil + 6 % cement	7.23	2.16
Soil + 10 % cement	7.72	2.18
Soil + 14 % cement	8.29	2.20

It can be seen from Table 3 that the values of M.D.D values of Cement Stabilized Well graded gravel increased with increase in percentage of cement addition. However, the increment is marginal. The increased MDD values are due to filling up of voids in soil by cement. The optimum moisture content is also increased with increasing cement content under study. It is attributed to increasing the specific surface area of cement content.

Compressive Strength

Compressive strength of Cement stabilized well graded gravel is studied by varying cement content (6%, 10% and 14%). The cube specimens of size 150mmx150mmx150mm are prepared at O.M.C and respective M.D.Ds obtained from IS Heavy compaction tests. The cube specimens are cured in water for 7, 14 & 28 days and tested for the compressive strength.

The effect of addition of cement on compressive strength of cubes measured from compression tests is presented in Fig. The results depict that the strength of cement stabilized gravel increases with increase in cement percentage used for stabilization. The compressive strength of cement stabilized gravel increased with curing period.



It can be seen from Fig .that the compressive strength of 10 percent cement stabilized gravel cubes at 28days is 10.6 N/mm^2 which is close to the strength to M10 grade conventional cement concrete. As the results of compressive strength are encouraging, cement stabilized well graded gravel may be considered for laying bed concrete below foundations and as alternate construction material to mass concrete in gravity retaining walls construction.

CONCLUSIONS

Based on the results of tests conducted on cement stabilized well graded gravel under the study, the following conclusions are drawn.

1. The well graded gravel has CBR 30% and hence, it is suitable for use in its original form in sub bases of flexible pavements in rural and urban areas.

2. The gravel under study can be effectively stabilized by Cement as percentage fines is less than 5% and it is well graded.

3. The maximum dry density of cement stabilized gravel under study increased with increase in proportion of cement.

4. The compressive strength of well graded gravel increases significantly with cement stabilization.

5. The well graded gravel under study stabilized with 10 percent cement by weight may be used as alternate to lean concrete of M 10 grade.

Hence, cement stabilized well graded gravel may be used advantageously in preparation of foundation beds, sub base courses of flexible pavements and as alternate to concrete in many possible fields.

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