STABILIZATION OF LATERITIC SOIL USING GUAR GUM FOR PAVEMENT APPLICATIONS

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Abstract : In developing countries like India the biggest handicap is limited finances available to build road by the conventional methods to provide a complete network of road system. Therefore there is a need to resort to adopt suitable cost effective road construction method, followed by a process of stage development of the roads, to meet the growing needs of the road traffic. The economy in construction cost can be achieved by selecting local materials including local soils for the construction of the lower layers of the pavement such as the sub-base course or sub-grade by improving their geotechnical properties. If local soil is not adequate for supporting wheel loads, the properties are improved by soil stabilization techniques. The abundantly available lateritic soil in coastal belt of South Canara does not satisfy the requirements (Liquid Limit ≤25% and Plasticity Index ≤6 %) to be used as a construction material. Thus the soil stabilized road construction involves the effective utilization of local soils along with suitable stabilizing agents. Use of Guar gum as stabilizing agent is recently developed technique in the area of soil stabilization. Guar gum can be used as effective thickeners and stabilizers. When Guar gum is mixed with the soil and compacted, it reduces the voids between soil particles to get the maximum compaction and increases the density of soil. The laboratory studies using Guar gum are reported in this project. Lateritic soil is treated with three dosage of Guar gum in ml per m3 of soil. The effect of Guar gum as stabilizer on geotechnical properties such as Unconfined Compressive Strength (UCC), California Bearing Ratio (CBR) and Compaction were investigated by conducting laboratory tests as per relevant codes. Test result indicated that there is considerable improvement in the geotechnical properties of soil..

***Index Terms* - Lateritic soil, Soil-subgrade, Guar gum, UCC test, CBR value.**

I. INTRODUCTION

The growth of the population has created a need for better and economical vehicular operation which requires good highway having proper geometric design, pavement condition and maintenance. The highways have to be maintained so that comfort, convenience and safety are provided to the travelling public. The pavements along the national and state highways in the coastal belt of Karnataka are damaged due to the poor strength of soil used. Hence, it is necessary to have a proper diagnostic study of the soil to be used as sub-base or sub-grade. Cost effective roads are very vital for economical growth in any country. There is an urgent need to identify new materials to improve the road structure and to expand the road network. Commonly used materials are fast depleting and this has led to an increase in the cost of construction. Hence, the search for new materials and improved techniques to process the local materials has received an increased impetus. When poor quality soil is available at the construction site, the best option is to modify the properties of the soil so that it meets the design requirements. This has led to the development of soil stabilization techniques. Since the nature and properties of natural soil vary widely, a suitable stabilization technique has to be adopted for a particular situation after considering the soil properties. Soil improvement by mechanical or chemical means is widely adopted. In order to stabilize soils for improving strength and durability, a number of chemical additives, both inorganic and organic, have also been used. Recently Non conventional material have emerged as a new chemical for soil stabilization. Guar gum is natural resin and some research work has been initiated to find the suitability of guar gum as stabilizing agent. Soil stabilization is the process of treating the soil in such a manner as to maintain alter or improve the performance of the soil as a construction material. The changes in the soil properties are brought either by the incorporation of additives by blending with different soil types..

The locally available lateritic soil in this region has very poor geotechnical properties, thus the main objective of this present work is to study variation of geotechnical properties when blended with one stabilizing agent called Guar gum. The use of Guar gum to stabilize the soil is the very recent technique and investigation are going on in this area. The main focus of this project is on study of improvement in the dry density, CBR value and UCC value so that to get the effectiveness of this stabilized soil as a sub-grade material in the design of flexible pavements.

II. MATERIALS AND METHODOLOGY

The main materials used are locally available lateritic soil and non convectional additive material, called Guar gum. The soil samples are collected near to college campus. Geotechnical properties of the sample have been studied in the laboratory. The Guar gum is natural resin which has moisture content of 8.8%, protein of 3.64% and gum content of 74.65%.

Guar gum is a native to the Indian subcontinent. Guar gum is grown mainly in India, Pakistan, United States and also in some part of Africa and Australia. In old times, Guar gum was only used as rich protein to feed cattle. It is also used as green vegetable in India. After Second World War there was major shortage of locust bean gum which adversely affected the textile and paper industries. At that time Guar Gum was found as the most suitable substitute for scarce locust bean gum. In 1953 the extraction technology of guar gum was commercialized in USA and India after decade of period. Guar gum, also called Guaran, is a Galactomannan. It is primarily the ground endosperm of Guar beans. The Guar seeds are dehusked, milled and screened to obtain the Guar gum. It is typically produced as a free-flowing, off-white powder. In this work three dosages of guar gum were used and studied the geotechnical properties of the soil.

Following are the major soil properties analyzed during the present investigation. Grain size analysis(wet), Field density of soil by core cutter method, Specific gravity of soil, Consistency limit determination, Compaction(Modified Proctor), UCC, and CBR value of the soil.

Fig 1 Collection of Lateritic Soil Sample and Laboratory Testing

Dry density of natural soil in-situ by Core cutter method was found as per IS code 2720(Part XXIX) - 1975. The results shown that the in-situ density is obtained as 1.65 g/ cc and the corresponding dry-unit weight was around 1.43 g/cc. Specific gravity of soil grains of soil sample is determined using pycnometer method, following procedure as per IS code 2720(Part III) - 1964. The average values obtained was 2.26.

Grain size analysis (GSD) is carried out for soil sample the experiment was carried out as per IS code 2720(Part IV) - 1965. The liquid limit of the soil sample is found using Casagrande liquid limit apparatus and Plastic limit was found as per IS code 2720(part V) - 1970. Table 2.1 shows the result of the GSD, Casagrande limit and indices.

Table 2.1: Results of grain size analysis, Plasticity, and Compaction properties

Particulars	Results
Silt and Clay content	16.56%
Gravel content	10.88%
Sand content	72.84%
Liquid limit	36.8 %
Plastic limit	26.3%
Plasticity index	10.5 %
Maximum dry density (MDD)	1.86 g/cm^3
Optimum moisture content (w)	16.0 %
CBR value	12.2%

Three Dosages specified for Lateritic soil was 200 ml for bulk volume 2.5 m^3 to 1.5 m^3 of soil. Bulk Density of Lateritic soil = 1.64 g/cc.

For Dosage 1: 200 ml for 2.5 m^3 of soil = 1.64 x 2.5 x 1000 = 4100 kg of soil

For 3 kg = 0.146 ml of Guar gum.

For Dosage 2: 200 ml for 2.0 m^3 of soil = 1.64 x 2.0 x 1000 = 3280 kg of soil

For 3 kg = 0.183 ml of Guar gum

For Dosage 3: 200 ml for 1.5 m^3 of soil = 1.64 x 1.5 x 1000 = 2460 kg of soil

For 3 kg = 0.243 ml of Guar gum.

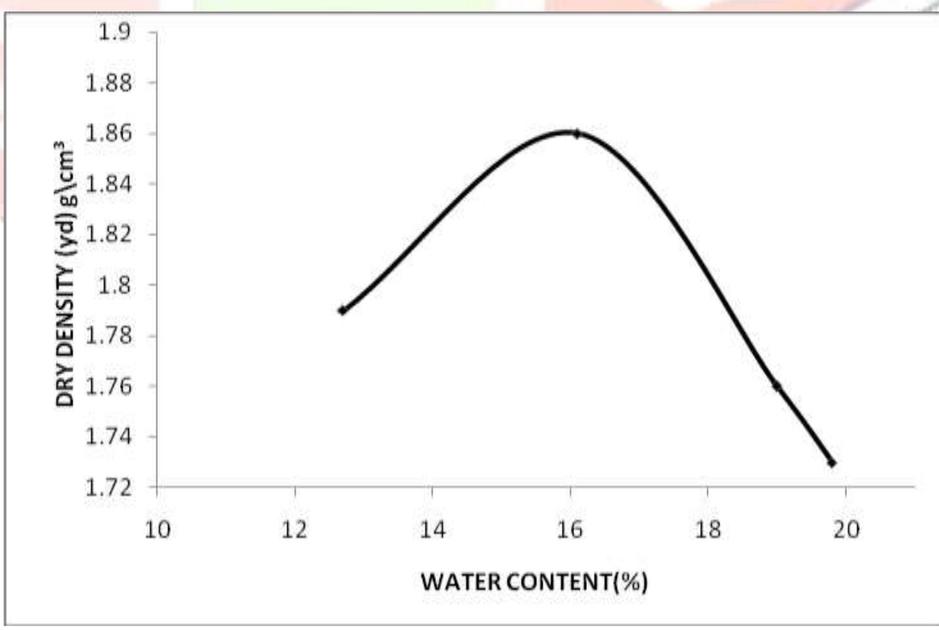

Fig-2 Compaction Curve (Untreated Soil)

III. RESULTS AND DISCUSSIONS

The consistency properties of treated soil is given in Table 3.1 to 3.2. The standard proctor compaction (heavy) test was carried out for soil sample as per IS code 2720(part VIII) – 1965 the results are shown for untreated soil, 0.1% Dosage 1, 0.1% Dosage 2, 0.1%

Dosage 3, 0.2% Dosage 1, 0.2% Dosage 2, 0.2% Dosage 3,. The values of optimum moisture content and maximum dry density that obtained from graph are shown in Table 3.3 and 3.4

Table 3.1. Results of liquid limit and plastic limit treated with three dosages of 0.1% of Guar gum

Particulars	**Water content (%)**		
	Dosage 1	**Dosage 2**	**Dosage 3**
Liquid limit	33.5	32	34.2
Plastic limit	24.83	27.28	28.75
Plasticity index	8.67	4.72	5.45

Table 3.2. Results of liquid limit and plastic limit treated with three dosages of 0.2% of Guar gum

Particulars	**Water content (%)**		
	Dosage 1	**Dosage 2**	**Dosage 3**
Liquid limit	32	28	32.8
Plastic limit	27.45	23.69	28.25
Plasticity index	4.55	4.31	4.65

Table 3.3. Results of heavy compaction treated with three dosages of 0.1% of Guar gum

Particulars	**Soil Sample**		
	Dosage 1	**Dosage 2**	**Dosage 3**
Maximum dry density (Y_{dmax}) g/cm^3	1.915	1.942	1.885
Optimum moisture content (w) %	11.2	14.8	11.3

Table 3.4. Results of heavy compaction treated with three dosages of 0.2% of Guar gum

Particulars	**Soil Sample**		
	Dosage 1	**Dosage 2**	**Dosage 3**
Maximum dry density (Y_{dmax}) g/cm^3	1.876	1.972	1.911
Optimum moisture content (w) %	14.6	12.4	12.0

California bearing ratio (CBR) test was conducted for soil sample after obtaining O.M.C. from heavy compaction test. Stabilization of soil sample is carried out with three dosages of 0.1% and 0.2% Guar gum. CBR test was conducted as per IS code 2720(Part XVI) – 1965 and the results are shown in the Table 3.5 for untreated soil, 0.1% Dosage 1, 0.1% Dosage 2, 0.1% Dosage 3, 0.2% Dosage 1, 0.2% Dosage 2, 0.2% Dosage 3.

Table 3.5. Results of CBR treated with three dosages of 0.1% and 0.2% of Guar gum

Particulars	**Soil Sample**

	Dosage 1	Dosage 2	Dosage 3
CBR Value (%) for 0.1% gum	28.7	33.73	25.79
CBR Value (%) for 0.2% gum	34.3	51.58	48.6

Unconfined compression (UCS) test was conducted for soil sample after obtaining O.M.C. from heavy compaction test. Stabilization of soil sample is carried out with three dosages of 0.1% and 0.2% Guar gum. UCC test was conducted as per IS code 2720(Part X) – 1973 and the results are shown in the table 3.6 for 0.1% Dosage 1, 0.1% Dosage 2, 0.1% Dosage 3, 0.2% Dosage 1, 0.2% Dosage 2, 0.2% Dosage 3. For untreated soil the c value of 0.21 kg/ sq.cm and a friction of 8degrees is observed.

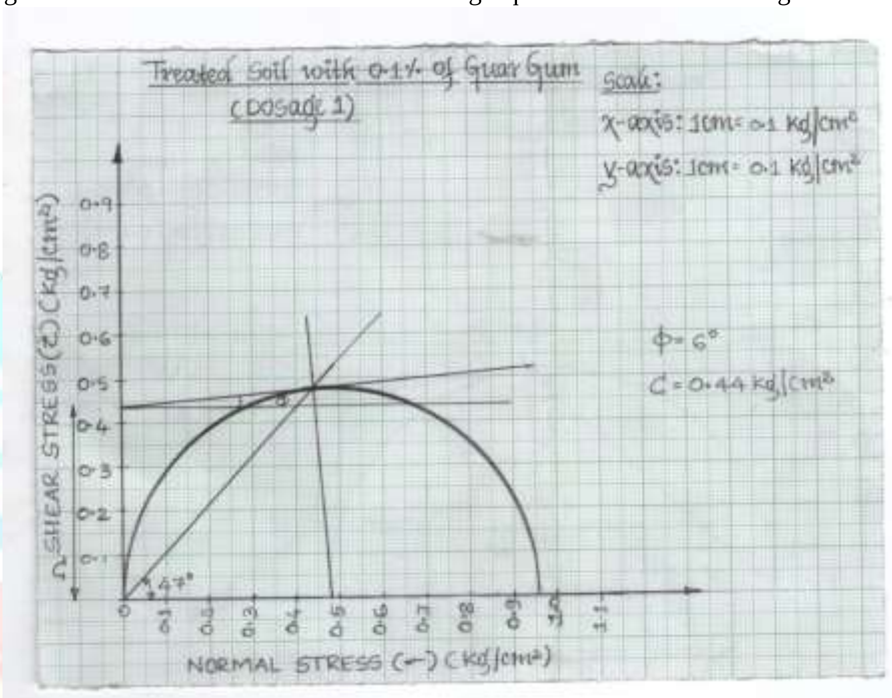

Fig 3 Typical UCC TEST graph for treated soil with 0.1% Guar Gum

Table 3.6.(a):- Results of UCC treated with three dosages of 0.1% of Guar gum

Particulars	Soil Sample		
	Dosage 1	Dosage 2	Dosage 3
Cohesion (C) kg/cm^2	0.44	0.58	0.41
Angle of internal friction (Φ) degrees	6	8	11

Table 3.6.(b):- Results of UCC treated with three dosages of 0.2% of Guar gum

Particulars	Soil Sample		
	Dosage 1	Dosage 2	Dosage 3
Cohesion (C) kg/cm^2	0.8	0.82	0.76
Angle of internal friction (Φ) degrees	12	10	10

IV. CONCLUSION

The experiments were conducted as per the relevant codes by stabilizing the lateritic soil with different dosage of Guar gum, to find its effect on geotechnical properties and the variation in these properties with different dosage of Guar gum. Based on the experiment following conclusions are made:

1. The optimum moisture content and dry densities for 0.1% and 0.2% of Guar gum is found to be increasing for dosage 1 and 2, decreasing for dosage 3 hence dosage 2 of 0.2% of Guar gum is considered as optimum.

2. The UCC test conducted for 0.1% and 0.2% of Guar gum, cohesion value is found to be increasing for dosage 1 and 2, decreasing for dosage 3 hence dosage 2 of 0.2% of Guar gum is considered as optimum.

3. The CBR value increases for dosage 1 and 2 of 0.1% and 0.2% of Guar gum and decreases for dosage 3 so dosage 2 of 0.2% of Guar gum is considered as optimum.

4. The Guar gum is a naturally available and free of cost, the use of Guar gum for stabilizing the lateritic soil and use of these stabilized soil as a sub-base material may decrease the total initial cost of the construction of flexible pavement.

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