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Engineering Properties of Red Gravel Soils in North Coastal Districts of Andhra Pradesh

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Abstract: *North coastal Districts of Andhra Pradesh, India has been connected with number of industrial infrastructural projects. Red gravel soils are well promising geotechnical construction material which can be widely used in civil engineering application, especially in infrastructure projects. In this region Red gravel soil are prominent resource material on which several construction activities have been running. To consider the above, 75 gravel soil samples were collected and tested for various geotechnical characteristics. Based on the test results these gravel soils are characterized and can make suitable for geotechnical applications in various civil engineering projects.*

Keywords*: gravel soils, suitability, characterization*

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I. Introduction

Flexible pavement layers transmit vertical compressive stresses to the lower layers by grain to grain point of contact. The thickness of the component layers depend on the quality of materials used in these layers. Usually the component layers such as Sub-grade, Sub-base, Base courses are made up of natural soils, sand, broken stones, gravel etc. A well graded compacted gravel soil with wide range of particles can effectively transfer the compressive stresses through a wide area and thus forms a good flexible pavement layer. The load spreading ability depends on the type of material and its composition with respect to grain size distribution, density, plasticity characteristics etc. Therefore taking the above characteristics in to consideration gravel soils are to be characterized to suit as sub-grade, sub-base and base courses etc.

A limited Research has been carried on Red gravel soils, i.e Priyani(1958) reported that locally available coarse grained soils, murrum are commonly used as sub-base and base course materials. Gourely (1997) studied case of laterite gravels as base course material in South African roads. Nunan.T. (1990) studied improved gravels for construction. Ramana Murthy.V. (2003) studied use of morrum in pavement construction. Omar .M (2003) studied compaction characteristics of coarse gravel soils. Pradeep Muley(2010) studied utilization of murrum for hard shoulder material. MORTH(2012) specified that gravel soils low plasticity characteristics can have wide application in road construction. Rehman.Z.U (2017) studied coarse grained soil for compaction, gradation and CBR values. Patel A.K.(2013) studied CBR characteristics of SC soils. NCHRP (2001) studied compaction, CBR, plasticity characteristics.. Satyanarayana et.al (2013) studied high plastic gravels and their stabilized materials can be used as sub-base courses in pavement construction.

In the present investigation 75 gravel soils from north coastal districts of Andhra Pradesh were collected and tested for their geotechnical characterization. Based on these values, their effective utilization in geotechnical applications has been verified.

II. Materials

To study the geotechnical characterization of red gravels in north coastal districts of Andhra Pradesh, India is divided in to four regions consists of East Godavari, Visakhapatnam, Vizianagaram and Srikakulam regions respectively. These gravel samples were collected at a depth of 1.0-1.5m from the ground level and the collected samples were dried and subjected for geotechnical characteristics such as grain size distribution, plasticity, compaction and strength as per IS 2720.

III. Tests &Results

3.1) Grain size distribution;

The collected red gravel samples were dried and tested for grain size distribution by performing dry sieve analysis (IS-2720-Part 4-1985) and wet sieve analysis (hydrometer analysis) and the results are shown in table 1.

Table 1: RED SOIL RANGE OF VALUES IN NC OF AP

Location / Property	East Godavari region	Vishakhapatnam region	Vizianagaram region	Srikakulam region	North coast of Andhra Pradesh (Range)
Gravel (%)	25-58	22-73	26-58	21-62	21-73
Sand(%)	28-48	14-52	22-45	21-56	14-56
Fines(%)	14-32	12-33	16-32	16-32	12-33
Silt(%)	10-20	08-20	10-20	10-22	08-22
Clay(%)	04-12	04-13	05-12	04-12	04-13
Liquid limit (W_L)%	25-33	25-40	27-40	25-39	25-40
Plastic limit (W_P)%	18-20	18-22	18-21	18-20	18-22
Plasticity index(I_P)%	07-13	07-18	08-18	07-16	07-18
IS classification	GC/SC	GC/SC	GC/SC	GC/SC	GC/SC
Optimum moisture content (OMC)%	8.0-9.5	8.2-11	8.8-11.2	8.0-11.2	8.0-11.2
Maximum dry density (MDD)g/cc	2.05-2.10	2.04-2.13	2.03-2.09	2.04-2.13	2.03-2.13
California bearing ratio (CBR %)	18-36	16-38	18-30	18-38	16-38
Cohesion (C): t/m^2	1.5-2.8	1.5-3.0	1.8-3.0	1.5-3.2	1.5-3.2
Angle of shearing resistance (ø)	33-36	33-38	32-37	32-38	32-38
specific gravity (G)	2.67-2.69	2.66-2.68	2.67-2.70	2.67-2.68	2.66-2.70
Free swell index(%)	10-20	15-22	10-25	10-20	10-25

From the test results it is identified that soils in majority of the locations are dominated by gravel particles particularly Visakhapatnam and Srikakulam regions followed by East Godavari and Vizianagaram which touches 73 % of the total composition of gravel soils. Similarly some of the locations are dominated by coarse sand particles with their range as 14-56%, regarding fines, these soils are having considerable range which varies 12-33, out of which silt particles are in dominating quantities compared to clay particles.

3.2) <u>Plasticity characterization:</u>

To know the plasticity characteristics, liquid limit by casagrande's method (IS 2720-Part-5-1985), plastic limit (IS 2720-Part-5-1985) were performed and plasticity index were calculated for all the red gravel soils and the results are tabulated in table 1 and Fig 1-3.

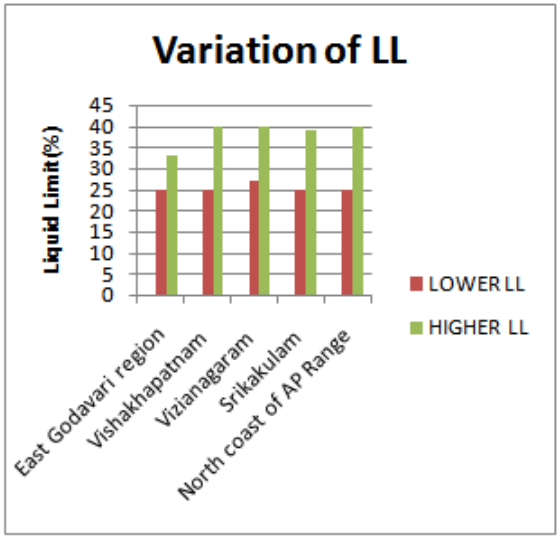

Fig 1: Variation of Liquid Limit (%)

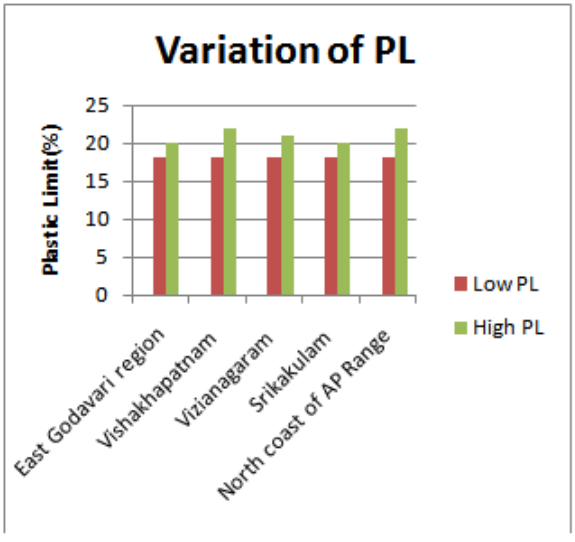

Fig 2: Variation of Plastic Limit (%)

From the test results it is identified that liquid limit touches a maximum value of 40% and plasticity index value as 18. High liquid limit values are identified in all the regions of North costal districts of Andhra Pradesh.

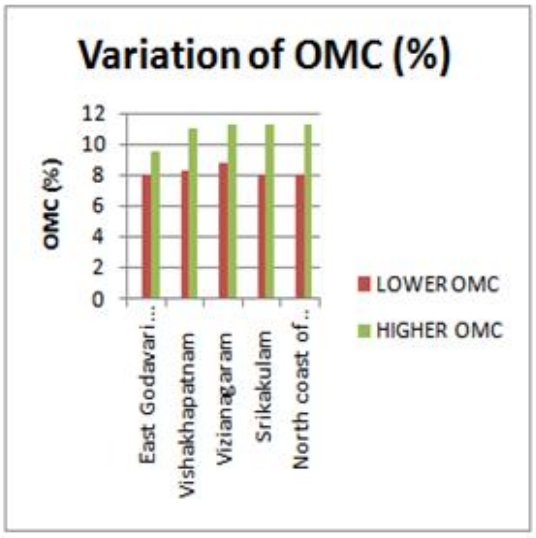

Fig 4: Variation of OMC (%)

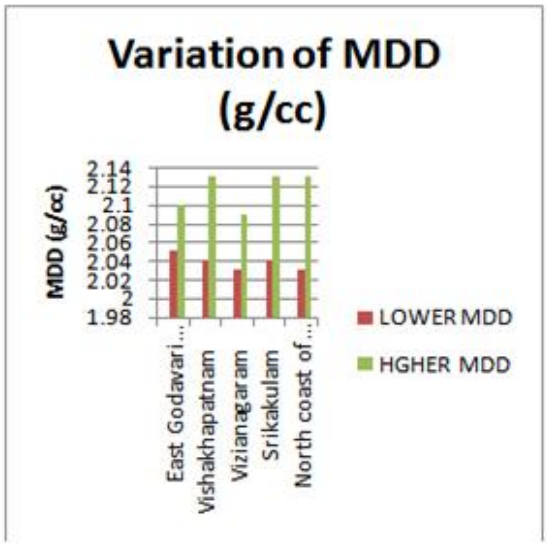

Fig 5: Variation of MDD (g/cc)

3.3) Compaction characteristics:

To know the compaction characteristics of red gravel soils modified proctor test(IS-2720-part-7-1980) was performed compacting by the gravel in to 5 layers, each is subjected by 25 number of blows with a rammer of 4.89 kg weight and height of fall of 45cm and the results are shown in table 1 & Fig 4-5.

From the test results it is identified that high dry densities are obtained and reached a highest values as 2.13 g/cc and the lowest value as 2.04 g/cc respectively.

3.4) CBR characteristics:

To know the CBR values of gravel soil samples, CBR test(IS-2720-Part-16-1979) was conducted on samples compacted at their OMC & MDD and the results are shown in table 1& fig 6.

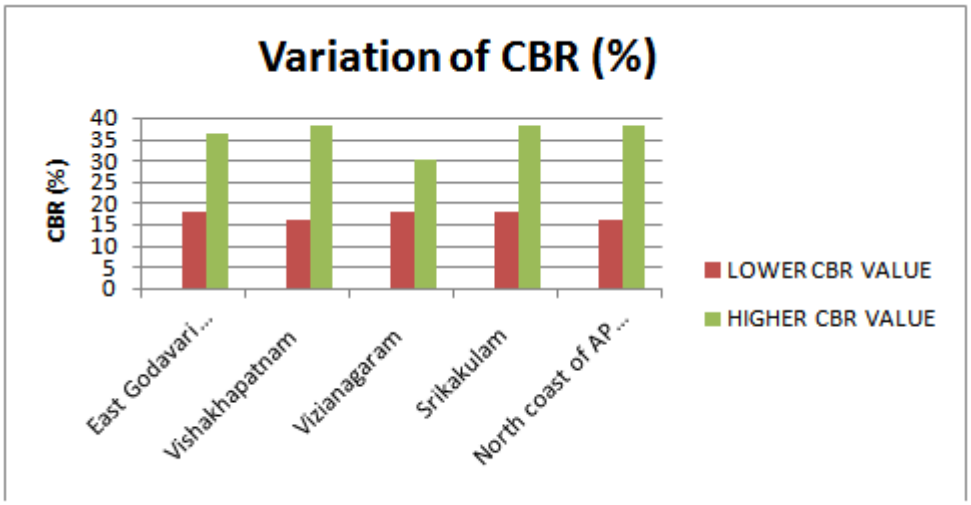

Fig 6: Variation of CBR (%)

From the test results it is identified that high CBR values are reported and these are as 30-38 and the minimum CBR value as 16 respectively.

3.5) Strength characteristics: To know the shear strength parameters such C & ø, the samples were prepared at their OMC & MDD and these were subjected for loading for undrained condition in direct shear apparatus. High shear strength value in terms C as 3.2 t/m^2 and ø as 38^0 were obtained and the results are shown in table 1& fig7-8.

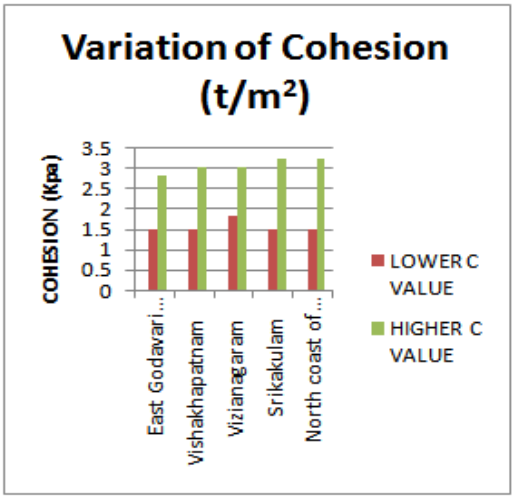

Fig 7: Variation of Cohesion (t/m^2)

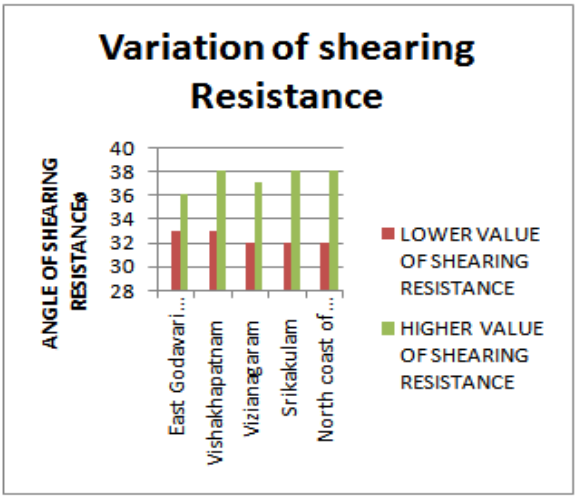

Fig 8: Variation of shearing Resistance

3.6) Swelling characteristics

All the red gravels of this region come under low swelling nature.(FSI<25%)

3.7)Affect of size, plasticity on compaction and strength characteristics of red gravel soils:

Based on the test results of 75 red gravel soil samples collected from north coastal district of Andhra Pradesh the following identifications are made

- Increasing the percentage of gravel fraction (>4.75mm) increases maximum dry density values and CBR values and reached to 2.08-2.13g/cc and 30-38 respectively. This character is accepted in all regions of North coastal districts of Andhra Pradesh.
- Increasing the percentage of sand fraction (4.75mm - 0.075mm) decreases density values and CBR values to 2.04-2.08g/cc and 20-30 respectively. This phenomena is also accepted with respect to all regions of North coastal Districts of Andhra Pradesh.
- Increasing the percentage of fines increases liquid limit (W_L) and plasticity index (I_P) values there by reducing dry density and CBR values of red gravel soils. It is further identified that a combination of increasing sand sizes, and plasticity characteristics reduces CBR values compared to low plastic soils.
- Similarly increasing gravel fraction with respect to sand fraction and decreasing plasticity characteristics (W_L& I_P) increases dry density and CBR values in these cases high CBR values are achieved (>30)
- Increasing gravel fraction with respect to sand fraction and decreasing plasticity characteristics increases shear strength values in terms of C and ø as (2-3t/m^2 and 36-38^0) respectively.

IV. Applications

- CBR values greater than 30 with low plasticity index $I_P \leq 7$ can be used as sub-base courses.
- CBR in between 20-30 can be used as sub base courses for low traffic intensity roads .
- CBR values in between 10-20 can be effectively used as sub-grade for high ways, express ways and can be used as top surface materials for weathered roads and can be used as good shoulder material.
- Based on the shear strength characteristics C & ø, and free swell Index values, these grounds can be effectively used for foundation layers for various civil engineering structures and can be effectively used for fill material.

V. Conclusions

Red gravel soils are coarse grained soils and these are effectively compacted with high density and bearing values i.e. CBR, C & ø can be effectively used in civil engineering constructions with less distress and less maintenance cost. Hence Red gravel soils are the most effective natural soil for wide applications in civil engineering projects.

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