Parameters Affecting the Efficiency of Red Gravel Soils as Road Construction Material

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Abstract

North Coastal Districts of Andhra Pradesh is a rapid industrial and fast developing area in which lot of infrastructural activities are going on. Red gravel zones are the prominent soil areas in this region known for various construction activities related to foundation bases, road component layer and fill materials etc. In this occasion to improve the structural stability and durability it is necessary to understand the behaviour of existing soils. In the pavement investigation 28 number of gravel soils and their engineering characterization have been identified with respect to their utilization in civil engineering construction activities.

Key words: *Red gravel, Utilization, Stability, Foundation.*

I. INTRODUCTION

Pavements transfer the wheel load stresses through a wide area on to the soil (subgrade) below through the pavement layers such as base and sub base courses. A good pavement layer is on which distribute the wheel load stresses through a larger area per unit depth of the layer and keeps the elastic deformation within permissible limits under repeated load applications during the design life. Usually these layers are made up of sands, broken stones, gravel soils etc. presence of plastic fines make the component layers for excess deformations and loss of strength under saturation. The strength of these sub-base and base course can be obtained by performing CBR tests.

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 grained 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 28 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 studied.

II. MATERIALS

In the present study 28 gravel soil samples were collected from different locations of North Coastal districts of Andhra Pradesh at a depth of 1.5m from the ground surface out of which 16 soil samples are gravel fraction (>4.75mm) dominating soil and 12 soil samples are sand fraction (4.75-0.075 mm) dominating soil. These gravel soil samples were tested for the grain size distribution (IS: 2720-Part-4-1985), plasticity characteristics (IS: 2720-Part-5-1985), compaction characteristics (IS: 2720-Part-8-1983) and CBR values (IS: 2720-Part-16-1989). These characteristics are analysed and suitable identifications are made.

III. TESTS AND RESULTS

A. Grain size distributions (IS: 2720-Part-4-1985)

A known quantity of dried soil mass was washed through 75µm sieve size and the fine particles can be subjected for sedimentation analysis (Hydrometer method) and coarser portion was dried and subjected for sieve analysis. Based on the above test data grain size distribution was generated and the results are shown in Table 1 and 2.

B. Plasticity characteristics (IS: 2720-Part-5-1985)

Dried soil sample passing through 425 µm sieve subjected for liquid limit (W_L) using Casagrande method (IS: 2720-Part-5-1985), and Plastic limit (W_P) and Plasticity Index, (I_P)as difference of these two (W_L-W_P) and the results are shown in Table 1 & 2.

C. Compaction characteristics (IS: 2720-Part-8-1983)

Modified proctor tests were performed on oven dried soil samples by performing 5 layers with 25 blows for each with a Rammer of 4.89kg and the results are shown in Table 1&2.

D. CBR characteristics (IS: 2720-Part-16-1974)

Gravel soil samples were prepared at their OMC & MDD under modified proctor test and these samples were kept in soaking for 4 days. After completion of the required time period these samples were tested for loads at different penetration values and then CBR values are calculated at standard amount of penetration and the results are tabulated as shown Table-1&2.

IV. RESULTS AND DISCUSSIONS

A. Geotechnical characterization of Red gravel soils:

Results based on the test conducted as mentioned above with respect to IS 2720 are shown below table 1 & 2 and their characterization described.

Table 1: Geotechnical properties of Gravel soils dominated by Gravel fraction

Properties / Location	G (%)	S (%)	F (%)	Silt (%)	Clay (%)	W_L (%)	W_P (%)	I_P (%)	OMC (%)	MDD (g/cc)	CBR (%)	IS
Etcherla	53	31	16	12	4	26	19	7	8.8	2.12	36	GC
Narasannapeta	38	32	30	20	10	38	21	17	11.0	2.05	22	GC
Pathapatnam	48	39	23	16	7	26	18	8	8.8	2.10	32	GC
Tekkali	38	30	32	22	10	30	20	10	10.5	2.07	24	GC
Vizag (APSEB)	54	28	18	12	6	28	19	9	9.0	2.08	28	GC
Dassannapeta	50	29	26	12	9	40	21	19	11.2	2.05	25	GC
Bhogapuram	46	30	24	16	8	30	20	10	10.0	2.07	26	GC
Pydi bhimavaram	38	34	28	20	8	27	18	9	10.0	2.08	25	GC
Yendada	42	25	33	20	13	35	20	15	10.5	2.06	21	GC
Duvvada	56	26	18	10	8	40	22	18	11.0	2.07	24	GC
Seethammadhara	67	14	19	12	7	30	20	10	10.0	2.12	35	GC
Autonagar	52	30	18	12	6	28	19	9	8.5	2.11	28	GC
MMTC	56	28	16	10	6	26	18	8	8.6	2.12	34	GC
Madhurawada	60	26	14	10	4	25	18	7	8.2	2.13	38	GC
Lankelapalem	40	32	28	18	10	27	19	8	9.3	2.06	30	GC
Parawada	46	30	24	16	8	26	18	8	9.0	2.07	32	GC

Table 2: Geotechnical properties of Gravel soils dominated by Sand fraction

Properties / Location	G (%)	S (%)	F (%)	Silt (%)	Clay (%)	W_L (%)	W_P (%)	I_P (%)	OMC (%)	MDD (g/cc)	CBR (%)	IS
Srikakulam	29	46	25	16	9	32	19	13	10.7	2.06	22	SC
Kota bommali	26	50	24	12	12	39	20	19	11.2	2.04	18	SC
Gajapathinaharam	34	38	28	18	10	34	20	14	10.6	2.05	22	SC
Jonnada	32	38	30	20	10	29	19	10	10.3	2.07	24	SC
Gambhiram	28	48	24	15	9	32	19	13	10	2.06	18	SC
Grey hounds	22	52	26	16	10	32	20	12	10.2	2.06	20	SC
Gajuwaka	26	50	24	14	10	38	21	17	10.5	2.04	16	SC
Rayavaram	30	48	22	14	8	31	19	12	9	2.06	22	SC
Talupulammalova	35	40	25	15	10	30	20	10	9	2.06	23	SC
Murari	32	44	24	16	8	29	19	9	9.2	2.06	22	SC
Gollaprolu	25	43	32	20	12	33	20	13	9.5	2.05	18	SC
Rajanagaram	36	42	22	14	8	30	19	11	8.8	2.07	23	SC

G:Gravel, S:Sand, F:Fines, W_L: Liquid limit, Wp: Plastic limit, I_P: Plasticity Index, OMC: Optimum Moisture Content, MDD: Maximum dry density, CBR: California bearing ratio, IS: Indian standard classification.

Red gravel soils of north coastal districts of Andhra Pradesh are dominated by gravel fraction which is in the range of 38-67% , sand particles 14-39% and fines(silt+clay) in the range of 14-32% respectively .It is also seen that these gravel soils have wide range of particles, where as Red gravel soils dominated by sand fraction have gravel particles in the range of 22-36% , sand particles 38-52% and fines are in the range of 22-32% respectively . From the grain size distribution it is identified that sand dominating soils have more number of fine particles and less number of gravel particles than gravel fraction dominating gravel soils. The compaction of different size of particles depends on the degree of weathering, mineral composition i.e quality and genesis of rock, temperature, precipitation and other environmental factors.

Gravel fraction dominating gravel soils having liquid limit in the range of 25-40% and Plasticity Index in the range of 7-17% , where as sand fraction dominating gravel soils having liquid limit in the range of 29-33% and plasticity index in the range of 9-19% . Soil with high percentage of fines exhibited high liquid limit and Plasticity Index values. From the compaction characteristics it is also identified that these soil having OMC is in the range of 8.2-11% and MDD 2.05-2.13g/cc. Gravel fraction dominating gravel soils having CBR values are in the range of 21-38%, and sand fraction dominating gravel soils having CBR values in the range of 16-24%.

B. Parametric analysis of Red gravels salient features

- Increasing the percentage of gravel particles increases the CBR values where as increasing the sand particles decreases CBR values
- Increasing the percentage of fines decreases CBR values
- Increasing the percentage of fines increases plasticity index values there by reducing CBR under soaked condition
- Increasing the percentage of fines increases the deformability conditions

there by decreasing the shear strength and penetration resistance under saturated condition (soaked condition).

- Some of the red gravel soil in this region exhibited high densities and high CBR values are due to occupation of more solids, availability of wide range of particles and less plasticity characteristics which offer more shear resistance against penetration due to inter locking of particles soil particles.
- Low CBR values are due to softening of gravel soils under soaking due to presence of high percentage of fines which offers less shear resistance against penetration.
- Domination of any single range of particles decreases dry density and CBR values.

C. Utilization of gravel soils

- Red gravel soils having CBR values greater than 30 with low plasticity index values(I_p<7) can be effectively used as sub base course materials for high traffic roads (50msa).
- Most of the CBR values of gravel soils are in the range of 20-30%, other having CBR values 16-20, which could be used as sub-base course materials for medium intensity traffic volume roads(<50 msa).
- These soils can be effectively used as sub-base courses for low volume traffic roads especially village and sub-urban roads.
- Characteristics such as high densities and low plasticity yield high shear strength of these soils can also be used as fill materials

V. CONCLUSIONS

Based on the test results of gravel soil samples these following conclusions have been drowned.

1. Soil with wide range of particles with low percentage of fines exhibited high dry densities and high soaked CBR values.
2. High dry density with low Plasticity characteristics exhibited high soaked CBR values.
3. Increasing percentage of fines with poorly graded condition increases Plasticity Index values decreases dry density values and exhibited low soaked CBR values.

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