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Relative Performance of Red Mud over Red Soils as Construction Material

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Abstract: *Natural soils are prominent material for construction activities. Red soils are widely distributed in north coastal districts of Andhra Pradesh, which are strong in dry conditions and compressed under saturated conditions. Presence of non-plastic fines and honey combing structure make the soils poor with respect to strength. In this aspect industrial wastes can be used in place of these collapsible soils. Red mud is an industrial waste from aluminum industry which can be an alternative to the soils. In the present investigations. In this aspect Red mud is one such alternative for its use in civil engineering infrastructure. In the present work characterization of Red mud is made by performing grain size distribution, compaction, strength, Seepage, CBR and other engineering properties to assess its performance with respect to similar natural soils. It is concluded that Red mud performed effective as an alternative material in place of natural soils.*

Keywords - *Red mud, Red soil, CBR, Collapsible, Strength*

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I. INTRODUCTION

Industrial activities generate huge quantities of industrial wastes. These require hectares of land for disposal to reduce thrust on the environment and their use in place of natural soils in bulk quantities, several civil engineering applications have been under progress. Red mud is a residue which is obtained during the production of alumina from Bauxite. Huge quantities of Red mud is produced annually and its disposal in an effective methods are essential.

In recent times several attempts have been made to use Red mud in civil engineering applications. Yang (1996) studied Red mud, Flyash, lime as grout material in filling up of mines. Qi (2005) studied Red mud in highways as construction material. Yang J.K (2006) studied the use of Red mud in pavements. Hanumanth Rao. C.H.V (2012) studied the use of GGBS stabilized Red mud in road construction as sub-base and base course material. Satyanarayana. P.V.V (2012) studied the use of lime stabilized red mud in road construction as sub-base and base course materials. Kusum Deelwal (2014) studied Red mud as Geotechnical material in civil engineering construction.

II. Materials

Red mud: Red mud is a residue obtained from aluminium industry which is collected from red mud ponds of NALCO, Dhamanjodi, Orissa, India.
Red soils: Three red soils were collected from Engineering college campus of Andhra University Visakhapatnam, Andhra Pradesh, India.
Sand: Sand was collected from sand reaches of river Godavari.

III. Experiments:

Red mud, Red soils and Sand samples were dried and the dried samples were tested for physical properties and engineering properties such as gradation as per IS2720-part-4-1985, consistency as per IS2720-part-5-1985, compaction as per IS2720-part-8-1983, shear strength as per IS2720-part-13-1986, CBR as per IS2720-part-16-1987, Seepage as per IS2720-part-17-1986, Swell as per IS2720-part-40-1977,and Compression characteristics as per IS2720-part-15-1986.

IV. Results & Discussion:

The test results of Red mud, Red soils and Sand for the above characteristics are tested & shown in below tables and graphs.

Table 1: Grain size distribution Red mud, Red soils & Sand

property	Red Mud	SC	SM-SC	SM	SW
Gravel (%)	0	0	0	0	0
Sand (%)	0	68	84	76	98
Fines (%)	100	32	16	24	2
Silt (%)	90	18	10	22	2
Clay (%)	10	14	6	2	0

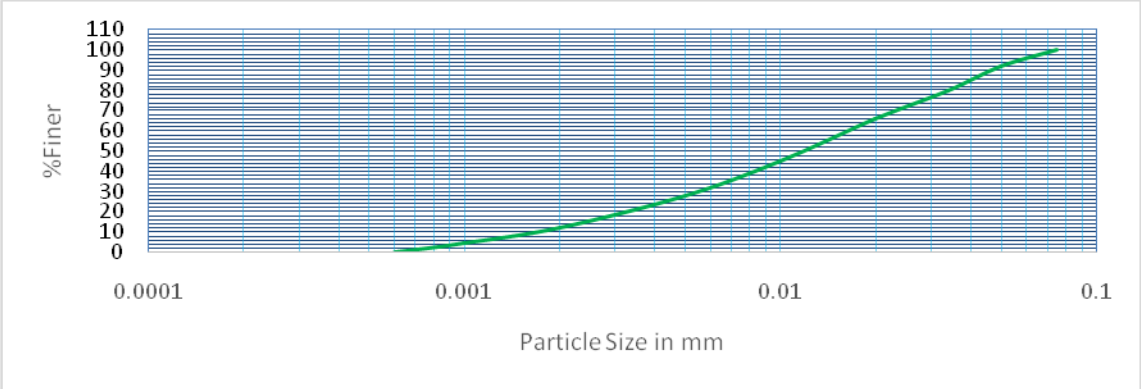

Fig 1: Grain size distribution curve of Red mud

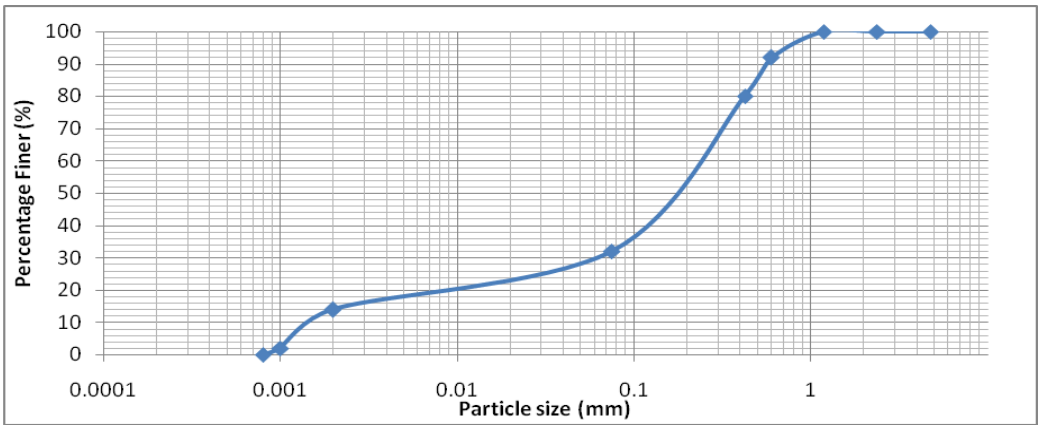

Fig 2 : Grain size distribution curve of SC soil

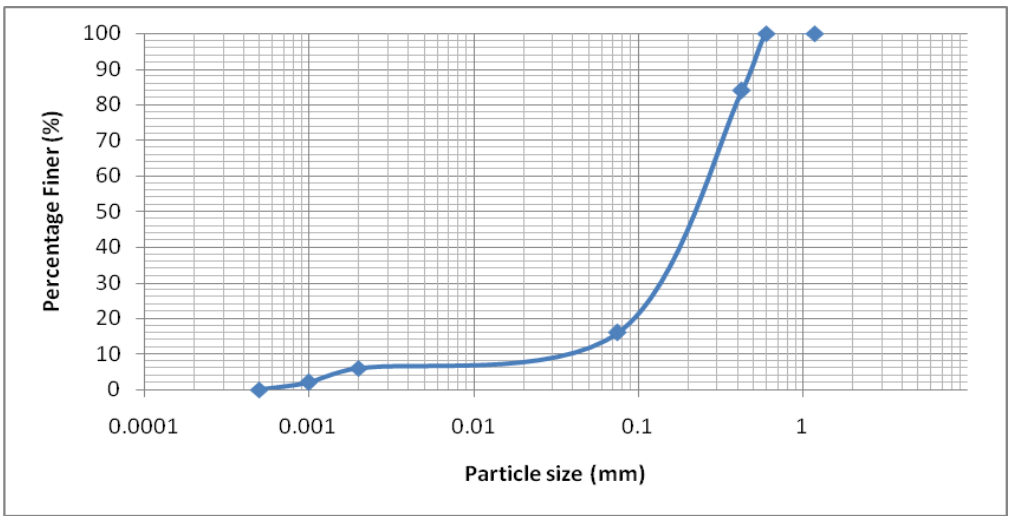

Fig 3: Grain size distribution curve of SM-SC soil

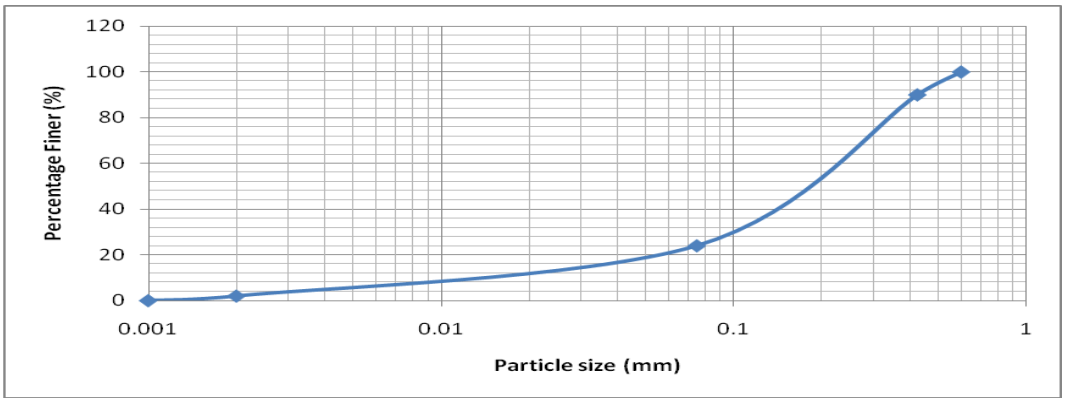

Fig 4: Grain size distribution curve of SM soil

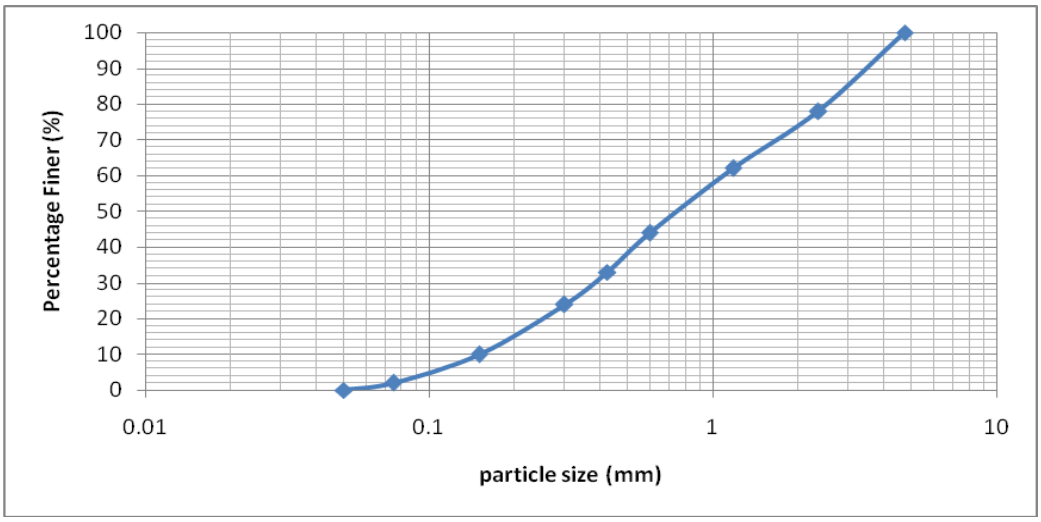

Fig 5: Grain size distribution curve of SW soil

Based on the grain size distribution of Red mud it is identified as a fine grained material dominated by silt size ($75\mu m - 2\mu m$) particles of 90% and clay size ($< 2\mu m$) particles of 10% and absence of sand size ($4.75mm - 75\mu m$) and gravel size (>4.75mm) particles. From the grain size distribution of Red soils it is identified that SC soils dominated by sand particles (1mm-0.075mm) of 68%, silt size ($75\mu m - 2\mu m$) particles of 18% and clay size ($< 2\mu m$) particles of 14%, SM-SC soils dominated by sand particles (1mm-0.075mm) of 84%, silt size ($75\mu m - 2\mu m$) particles of 10% and clay size ($< 2\mu m$) particles of 6% and SM soils dominated by sand particles (1mm-0.075mm) of 76%, silt size ($75\mu m - 2\mu m$) particles of 22% and clay size ($< 2\mu m$) particles of 2% and Godavari sand has dominated by sand particles (4.75mm-0.075mm) of 98%, silt size ($75\mu m - 2\mu m$) particles of 2% and absence of clay size ($< 2\mu m$) particles.

Table 2: Consistency Characteristics of Red mud, Red soils & Sand

Property	Red Mud	SC	SM-SC	SM	SW
W_L	32	32	24	20	Non-plastic
W_p	24	19	18	18	Non-plastic
W_s	19	17	18	2	Non-plastic
I_p	8	13	6	2	Non-plastic

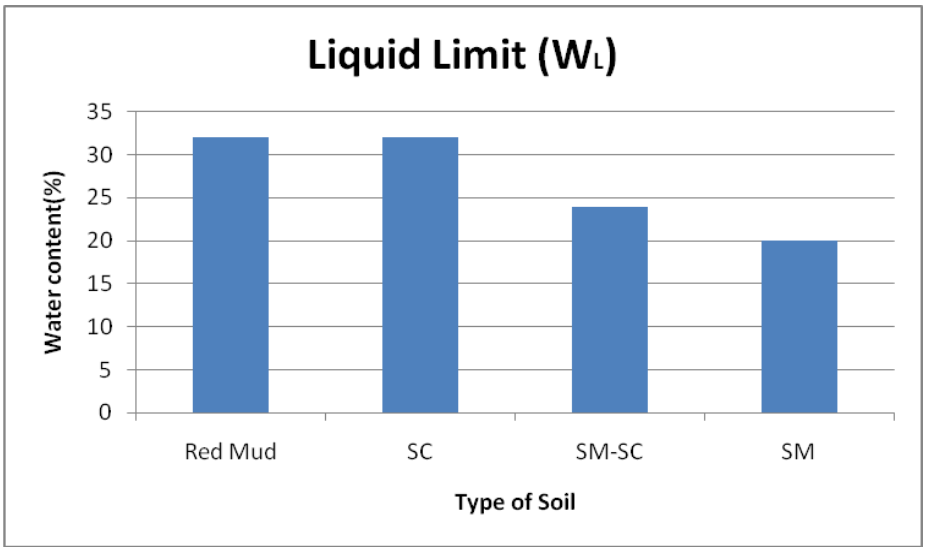

Fig 6: Liquid limit of Different types of Soils

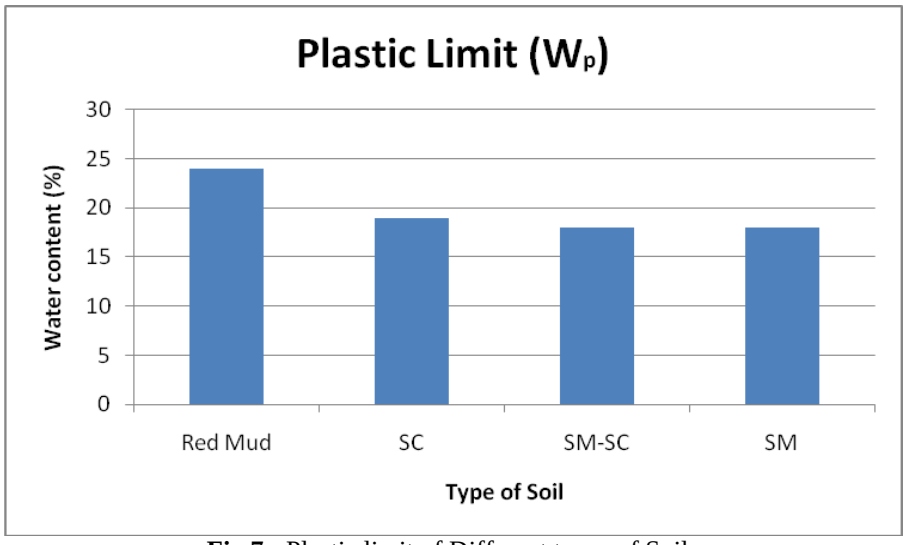

Fig 7 : Plastic limit of Different types of Soils

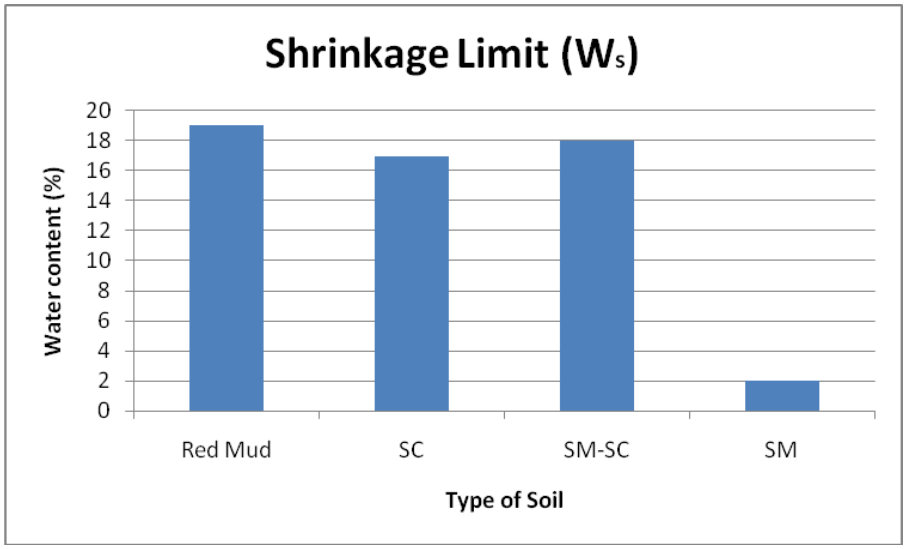

Fig 8: Shrinkage limit of Different types of Soils

Consistency test of data Red mud shows that it is a low compressible (W_L<35) and low plastic material (I_p<7) and it is classified as silts of low compressible nature (ML). Red soils such as SC is also a low compressible and intermediate plasticity soil, SM-SC is also a low plastic and low compressible soil where as SM soil is very low plastic soil and sand is well graded and non plastic soil.

Table 3: Compaction & CBR characteristics of Red mud, Red soils & Sand

	Red Mud	SC	SM-SC	SM	SW
OMC	22	14	10	9	6.0
MDD	1.65	1.78	1.80	1.74	1.82
CBR	5	6	5	4	10

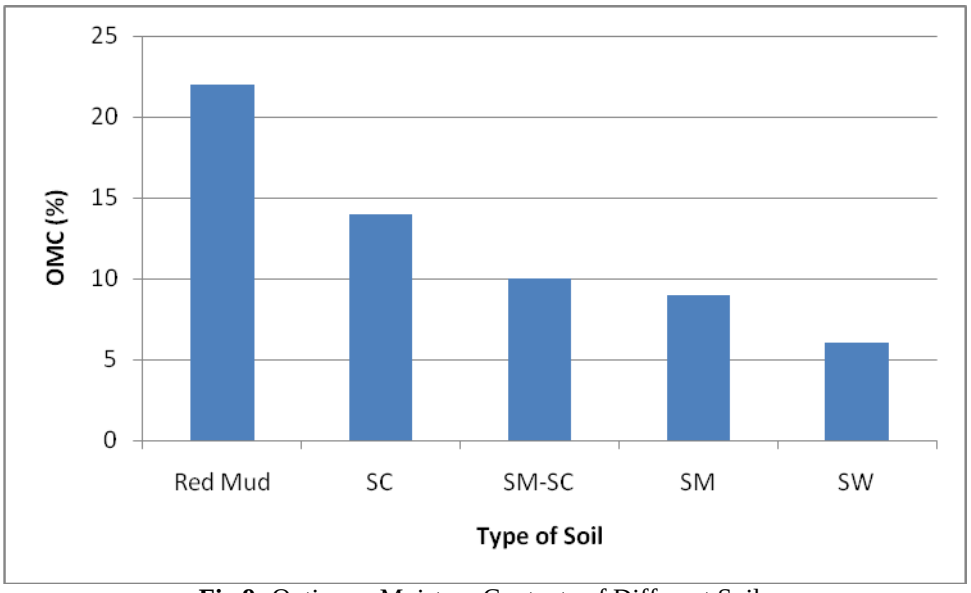

Fig 9: Optimum Moisture Contents of Different Soils

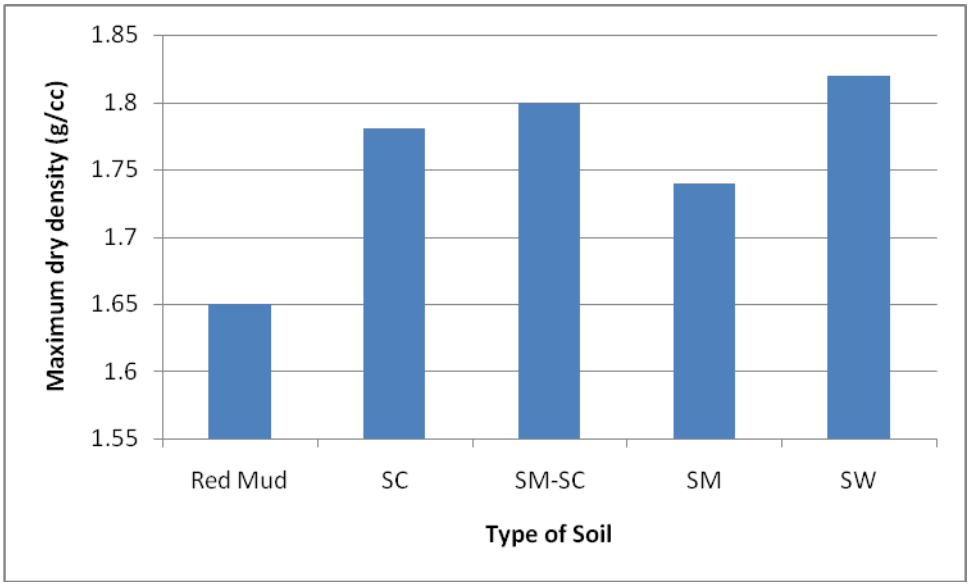

Fig 10: Maximum Dry Densities of Different Soils

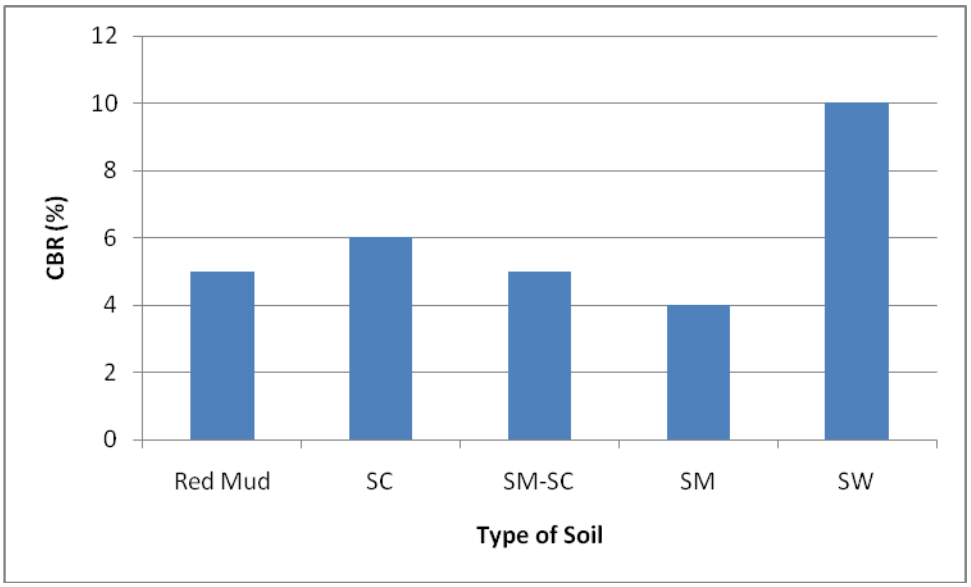

Fig 11: CBR value of different Soils

Red mud exhibited CBR of 5 % due to its fine grained nature and dominated by silt size particles along with very low percentage of clay size particles. Their composition could maintain effective interaction and helps to achieve good CBR value against loading.

CBR values of Red soils are in the range of 6-4 % whereas well graded sand exhibited CBR value of 10. High CBR value in sand is due to mobilization of high frictional resistance against penetration and representation of more number of particles with less number of voids. In red soils presence of limited number of particles which are dominated by fine sand particles and also poor representation of fine particles failed to generate shear resistance in terms of friction and cohesion under soaked condition.

Table 4: Strength characteristics of Red mud, Red soils & Sand

property	Red Mud		SC		SM-SC		SM		SW	
	UU	CD	UU	CD	UU	CD	UU	CD	UU	CD
Cohesion C (kPa)	25.0	0.0	25.0	5.0	15.0	2.0	5.0	0.0	0.0	0.0
Angle of shearing Resistance (ø)	32	38	30	28	32	26	32	30	38	36

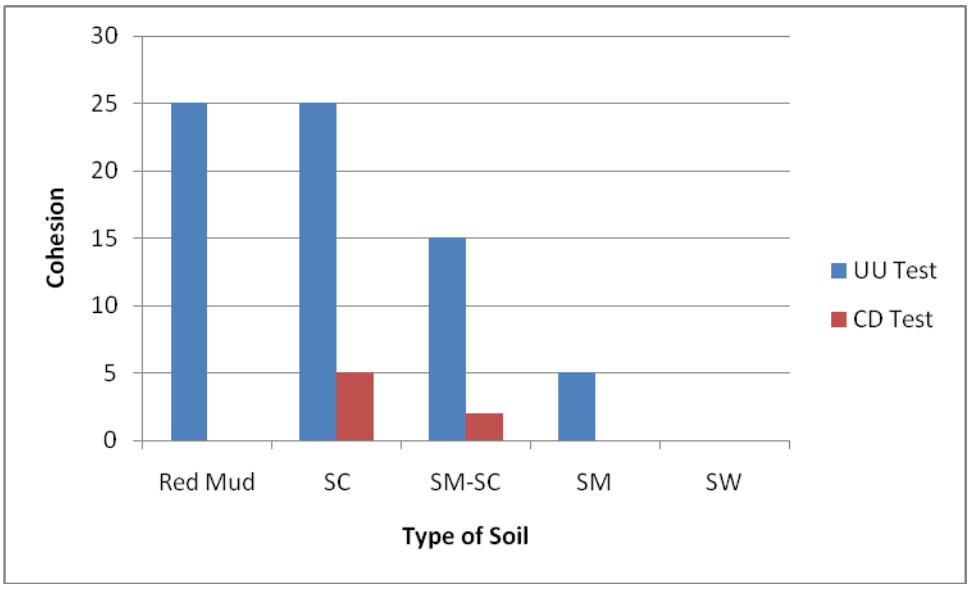

Fig 12: Cohesion value of Different Soils under UU & CD conditions

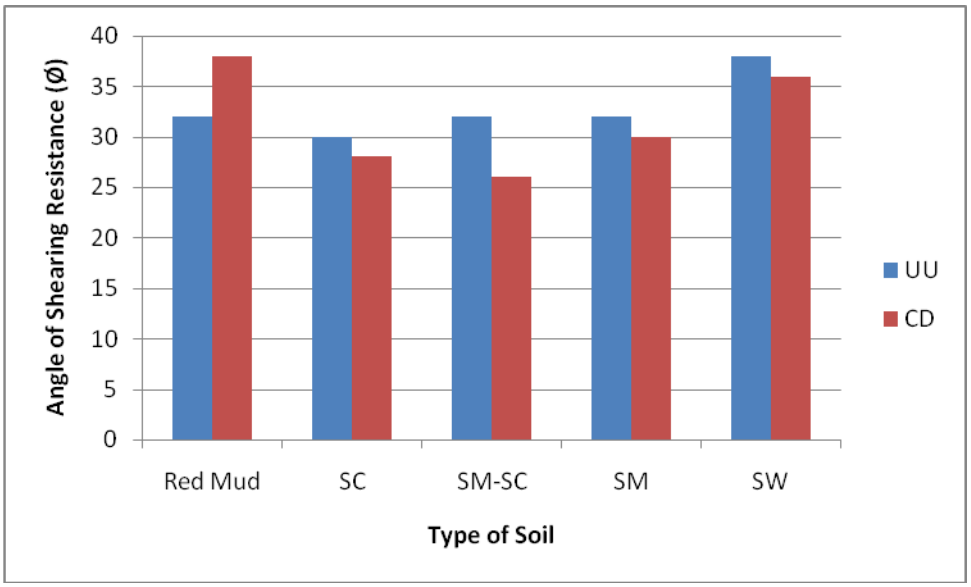

Fig 13: Angle of Shearing Resistance of Different Soils under UU & CD conditions

Based on the test results which are performed at various drainage conditions the following identifications are made. Red mud achieved high shear strength in unconsolidated undrained (UU) as well as consolidated drained tests (CD). Red soils lost their frictional and cohesive force due to their composition, nature and structure of particles. Well graded sand attained high shear parameters similar to Red mud due to non-plastic, porous and loss shear strength under effective condition due to development of excess pore water pressure is minimum. In Red mud particles the absence of clay minerals helps in increase of effective stress parameters in drained condition.

Table 5: Swell characteristics of Red mud, Red soils & Sand

	Red Mud	SC	SM-SC	SM	SW
FSI	5	10	5	0	0

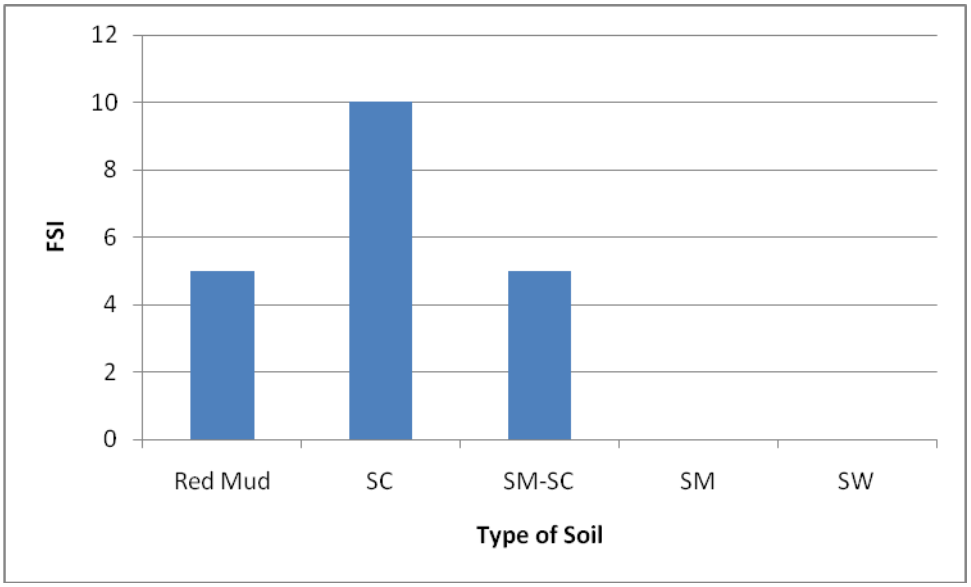

Fig 14: FSI of Different Soils

FSI test data of Red mud shows it is a non-swelling material (FSI<10) which are similar to Red soils.

Table 6: Compression Index (C_c)

	Red Mud	SC	SM-SC	SM	SW
C_c	0.26	0.28	0.20	0.15	0

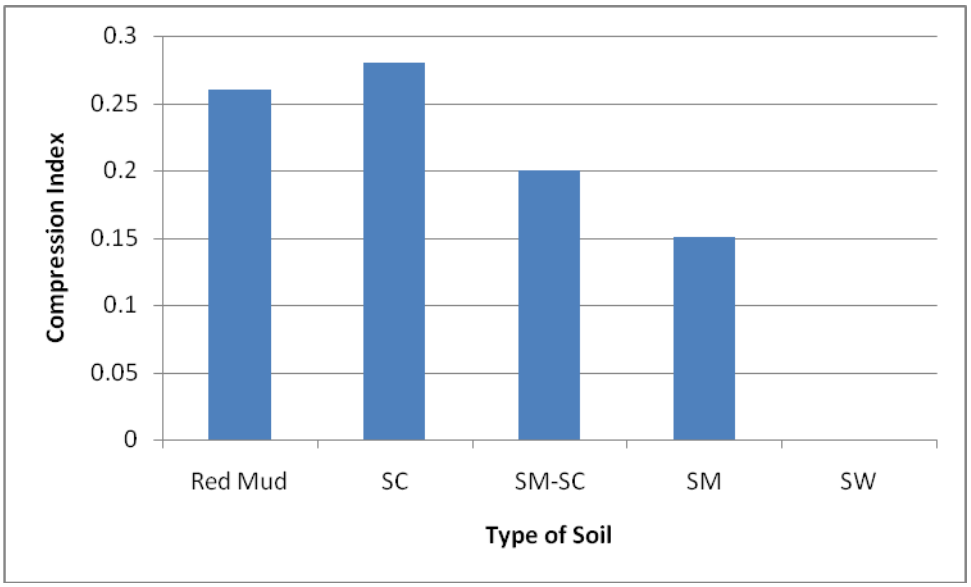

Fig 15: Compression Index of Different Soils

Test results from Consolidometer apparatus say that Red mud is a low compressible material similar to SC, SM-SC category of red soils. Comparing the C_c of Skempton's equation based on liquid limit value is also very less (1.54).

Table 7: Seepage characteristics

property	Red Mud	SC	SM-SC	SM	SW
K	6.2×10^{-7}	3.4×10^{-6}	8.3×10^{-6}	1.5×10^{-5}	4.8×10^{-2}

From the seepage results Red mud is in impervious zone relative to Red soils.
Presence of Silt size particles and low percentage of clay size particles and their shape, nature help the matrix cohesive and responsible for achieving low coefficient of permeability values.

V. Alternate Material In Place Of Red Soils And Sand

Based on the test results of grain size distribution, consistency, compaction, strength and seepage characteristics, the following identifications are made.

➢ Red mud is a fine grained material dominated by silt size particles of low plastic, low compressible nature. It achieved high density values by maintaining wide variation of moisture contents. It is also an impervious material.

➢ Considering the natural soils like Red soils which are widely distributed in south India especially in Visakhapatnam region. These are sandy nature with high to low plastic, low compressible, low swelling, semi-impervious to impervious characteristics. Some of these soils are exhibiting high void ratios, low dry densities and very low moisture contents during dry periods. Due to seasonal variations they possess great variation in the above characterization and cause volume reduction under saturation due to honey combing structure of these particles. These soils exhibited low shear strength values in saturated condition under consolidated drained test. In such location use of Red mud as partial/full replacement can be a viable solution. Comparing the results of well graded sand of Zone-II, Red mud exhibited similar strength values under drained condition.

VI. Applications:

By taking in to consideration of the above features Red mud has lot of applications in construction activities

- Red mud can be used as fill material, embankment material, foundation material, sub grade material, backfill material in reinforced and unreinforced in retaining wall.
- Reduces thrust on natural soils and used as construction material.
- Reduces Environmental pollution and disposal problems etc.
- Reduces cost of the project.
- Increases the durability of the project by maintaining strength and settlements in tolerable limits.

VII. Viiconclusion:

- Red mud is a silt size dominating industrial waste exhibited high dry density and shear strength values.
- It is impervious, low plastic and low compressible, non-swelling material.
- An alternative material to Red soils and other sandy soils in geotechnical considerations.

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