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A Study on Performance of Crusher Dust in Place of Sand as A Sub-Grade and Fill Material in Geo-Technical Applications

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Abstract

Conventional materials like natural soils, broken rock pieces, sand are popularly used in the construction of structures like roads, embankments, reclamation of grounds etc.,. Procurement of such materials in huge quantities have been becoming very difficult and presence of plastic fines in the soils causes excess deformations which proves to be costly for the maintenance of structures.Keeping this in mind and utilization of waste products in bulk quantities has been searched from which crusher dust was selected as an alternate material in place of sand. To evaluate the performance of crusher dust and sand mixes, tests like compaction, strength, seepage etc, were performed to study the engineering parameters like density, CBR and angle of shearing resistance etc. From the test results it is identified that crusher dust – sand mixes attained high densities, high CBR values (>10%) and shear strength values ($\phi > 36^0$).Hence, it is concluded that 30-40% addition of sand to crusher dust yields satisfactory results and can be used as sub-grade and fill materials in various geotechnical construction activities.

Keywords: Crusher dust, Sand, CBR, Sub-grade.

1. INTRODUCTION

India has a road network of 3.3 million kilometres under various road networking programmes. Conventional materials for construction of roads need huge quantities of materials. Most of the materials are natural soils, kankar, rock fragments etc. Natural soils containing plastic fines like silt and clay particles cause huge amount of deformation under heavy loads at saturated conditions and their settlement leads to several failures. Areas like sub-grades, embankments and low lying areas require good quality of material for their effective functioning with respect to strength and drainage. Crusher dust and sands are such materials obtained from crushing plants and natural river beds respectively can be used in geotechnical applications.

A number of researchers have made their contributions for the utilization of above said materials in various geotechnical applications. SridharanA et.al (2005, 2006)[8,9] conducted studies on quarry dust and reported that high CBR and shearing resistance values can enhance their potential use as sub-base material in flexible pavements and also as an embankment material. Praveen Kumar et.al (2006)[5] conducted CBR tests on stone dust as a sub-base material.Ashok kumar.r,et.al(2013)[1] studied the Utilization of Crusher Dust in Roads,Embankments, and Fill material,Pradeep.N, et.al(2013)[4] studied the Performance of Crusher Dust in High Plastic Gravel Soils As Road Construction Material,Satyanarayana.P.V.V et.al(2013)[6,7] studied the Use Of Crushed Stone Aggregate And Crusher Dust Mixes In Flexible Pavements. Wood et.al (1993)[10] identified that the physical properties, chemical composition and mineralogy of quarry dust varies with aggregate type and source. IllangovanRet.al(2006)[3] studied quarry dust as fine aggregate in concrete. Collins R.J et.al (1994)[2] studied quarry dust in highway constructions. In the present investigations various percentages of sands such as 10%, 20%, etc., were added to crusher dust particles and the mixes were prepared and tested for compaction and strength to suit as sub-grade and fill materials.

2. MATERIALS AND THEIR CHARACTERIZATION

2.1 Crusher dust

Crusher Dust was obtained from local stone crushing plants near Srikakulam, Andhra Pradesh and subjected to various geotechnical characterizations. The results are shown in table-1 and figure-1 & 2.

Table 1 Geotechnical properties of Crusher dust

Property	**Values**
Gravel (%)	5
Sand (%)	87
Fines (%)	8
a. Silt(%)	8
b. Clay(%)	0
Cu	23
Cc	2.78
Liquid Limit (%)	NP
Plastic Limit (%)	NP
I.S Classification	SW
Specific gravity	2.64

OMC (%)	12
MDD (g/cc)	2.02
ϕ(deg)	36
CBR (%)	10

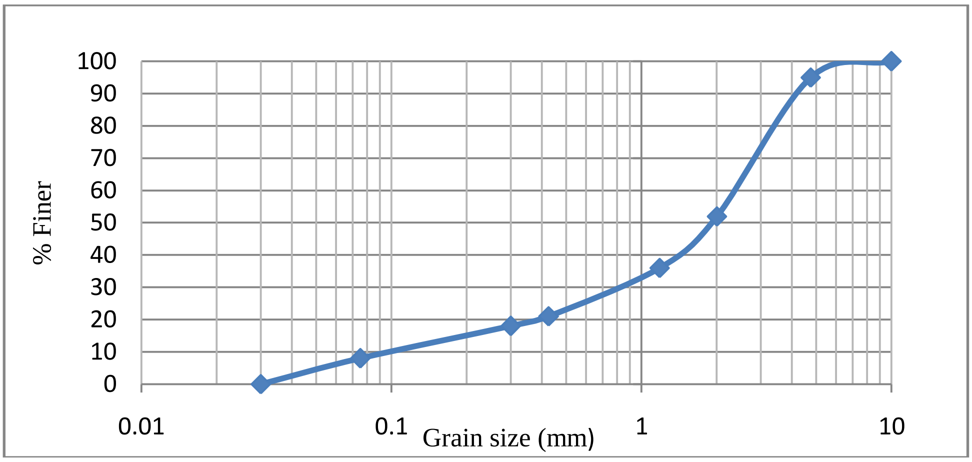

Fig 1 Grain size distribution curve

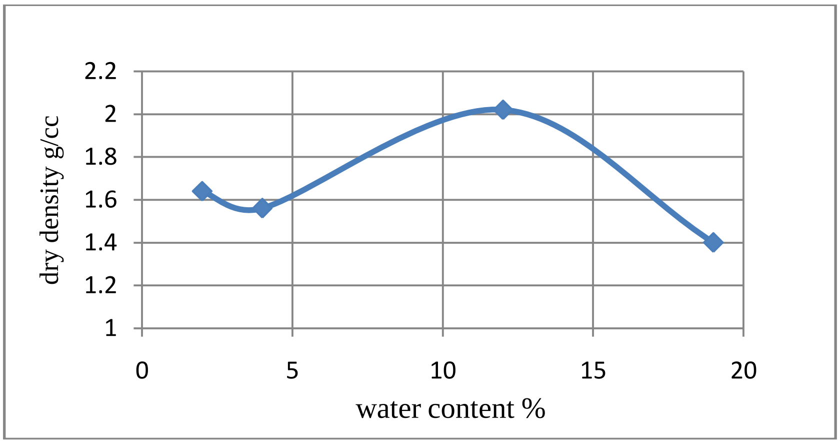

Fig 2: Compaction curve of Crusher dust

2.2 Sand:

Sand was collected from river Nagavali,Srikakulam, Andhra Pradesh. The collected sand was dried and subjected for various geo-technical characterizations such as gradation, compaction characteristics, strength, permeability etc., and the test results are shown in table-2 and Fig 3 &4.

Table 2: Geotechnical properties of sand

Property	**Values**
Gravel (%)	0
Sand (%)	99
Fines (%)	1
Cu	3.25
Cc	0.94
Liquid Limit (%)	NP
Plastic Limit (%)	NP
I.S Classification	SP
Specific gravity	2.66
OMC (%)	6
MDD (g/cc)	1.82
ϕ(deg)	35
CBR (%)	8

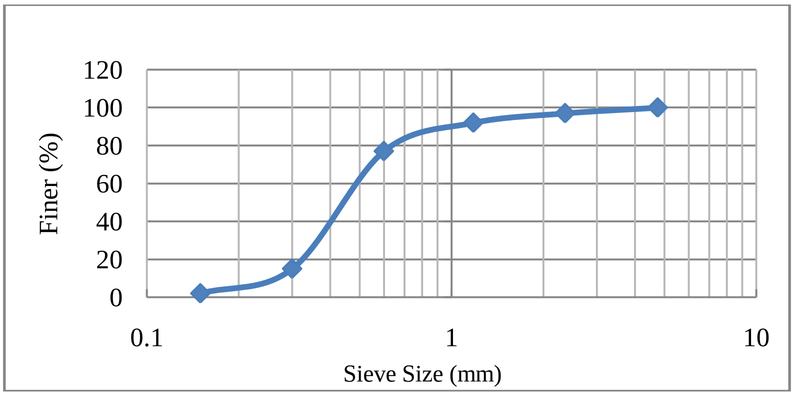

Fig 3 Grain size Distribution curve sand

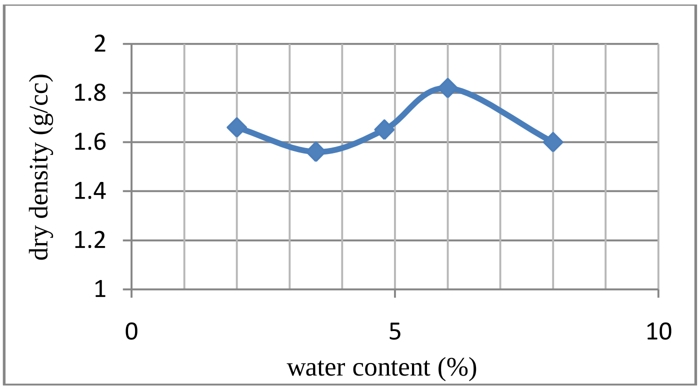

Fig 4: Compaction curve of sand

From the test results of crusher dust it is identified that Majority of crusher dust particles are coarse to medium sand ranges with rough surface texture. Based on BIS, it is classified as well graded particles with non-plastic fines (SWN) and incompressible.it consists of 87% of sand size and 8% of silt size particles. Compaction characteristics of crusher dust under modified compaction test have an Optimum Moisture Content of 12% and Maximum Dry Density 2.02 g/cc.From the compaction curve it can also be seen that crusher dust attains higher densities with wider variation of moisture contents and increases the workability at high moisture contents.Regarding strength characteristics, it has an angle of shearing resistance (Ø) of 38 degrees under undrained condition and CBR of 10% and coefficient of permeability as 3.4×10^{-3} cm/sec. From the test data it is also identified that it has good strength characteristics and drainage characteristics at soaked condition.

From the test results of Sand the following identifications are made. Majority of sand particles are under fine sand range and of angular shape with rough surface texture. The gradation also shows it comes under zone III. Based on BIS it is classified as poorly graded sand with non-plastic and incompressible in nature (SP) with C_u= 2.07and C_c= 1.44.

Compaction characteristics of Sand under modified Proctor test have OMC of 6% and MDD 1.82 g/cc. From the compaction curve it can be seen that Sand attains higher densities with less variation in moisture contents. Regarding strength characteristics it has an angle of shearing resistance (Ø) as 35 degrees under un-drained condition and CBR of 8% and has good drainage characteristics with coefficient of permeability as $6.3 * 10^{-2.}$

From the compaction curve it can be seen that sand attained a maximum dry density of 1.82 g/ccat optimum moisture content of 6%.Comparing the above characteristics of crusher dust with sand, crusher dust attained higher densities with wide variation of moisture contentsby maintaining well graded conditions with C_u as 23>6and Cc as 2.78>1.

2.3.Performance of crusher dust and sand mixes

Various percentages of sand such as 10%, 20%, 30%........100% were added to crusher dust and their mixes are listed below in table-3 and subjected for geotechnical characteristics like compaction, angle of shearing resistance and CBR tests as per IS 2720.

Table 3: Various percentages of Crusher dust and Sand mixes

Crusher dust (%)	100	90	80	70	60	50	40	30	20	10	0
Sand	0	10	20	30	40	50	60	70	80	90	100
Mixes	M_1	M_2	M_3	M_4	M_5	M_6	M_7	M_8	M_9	M_{10}	M_{11}

3. RESULTS AND DISCUSSIONS

3.1 Compaction characteristics:

Mixes of crusher dust and sand such as M1,M2......M11were subjected to heavycompaction by compacting the samples with a rammer of 4.89 kgs, five layerseach layer, each is subjected to 25 blows and their optimum moisture contents and maximum dry densities were determined as per IS 2720 part 8(1983). The results are shown in table-4 and fig 5&6.

Table 4: Variation of OMC &MDD

MIXES	Crusher dust(%)+Sand(%)	OMC(%)	MDD (g/cc)
M_1	100+0	12	2.02
M_2	90+10	11.5	2.00
M_3	80+20	10.8	1.97
M_4	70+30	10	1.94
M_5	60+40	9	1.90
M_6	50+50	8.2	1.88
M_7	40+60	7.5	1.86
M_8	30+70	7	1.85
M_9	20+80	6.6	1.84
M_{10}	10+90	6.3	1.83
M_{11}	0+100	6	1.82

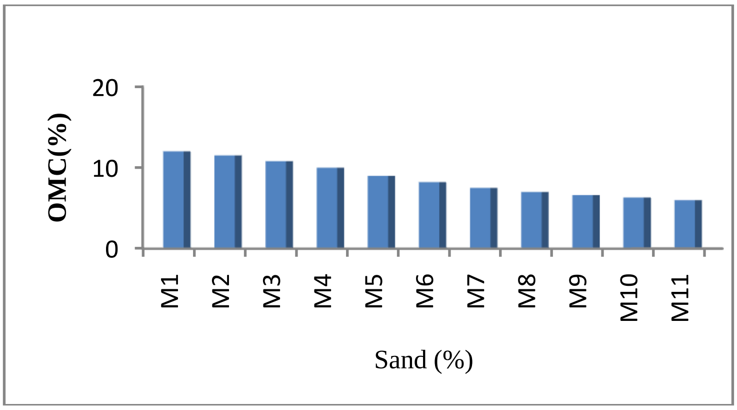

Fig 5

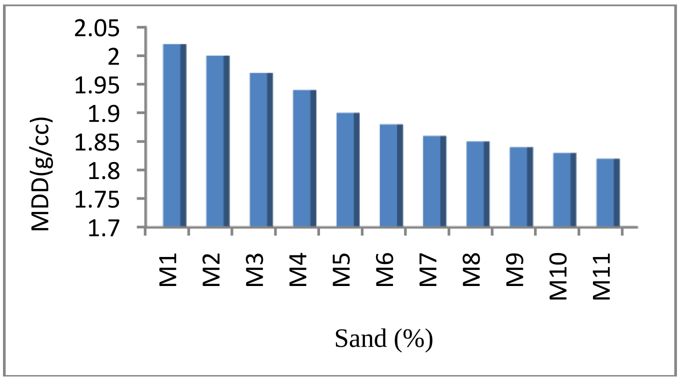

Fig 6

Fig 5&6 :Variation of OMC and MDDW.R.TCrusher Dust and Sand Mixes

From the experimental data it is observed that as the percentage of sand is increasing, optimum moisture content and maximum dry density values are decreasing. A steady decrease was observed upto 30% and a rapid decrease was observed in between 30% - 50% followed by a steady decrease upto 80% and later a slow decrease was observed. Similarly the same trend took place in case of maximum dry density values. At high percentages of crusher dust, the slow decrease in OMC and MDD was due to dominance of the behaviour of crusher dust due to availability of wide range of particles. Rapid decrease is due to overriding of sand particles with respect to crusher dust particles whereas at high percentages of sand, complete dominance of sand behaviour requires less water to mobilize particles to attain dense conditions.

3.2Angle of shearing resistance:

Various percentages of crusher dust and sand mixeswere compacted at their maximum dry densities in the shear box apparatus and tested at a strain rate of 1.25 mm/min as per IS 2720-part 13(1986). The results are shown in table-5 and fig 7.

Table 5: Angle of Shearing Resistance (ϕ)

MIXES	Crushed Dust(%)+Sand(%)	Ø(deg)
M_1	100+0	36
M_2	90+10	36.5
M_3	80+20	37
M_4	70+30	38
M_5	60+40	38
M_6	50+50	37.5
M_7	40+60	37
M_8	30+70	36.5
M_9	20+80	36
M_{10}	10+90	35
M_{11}	0+100	35

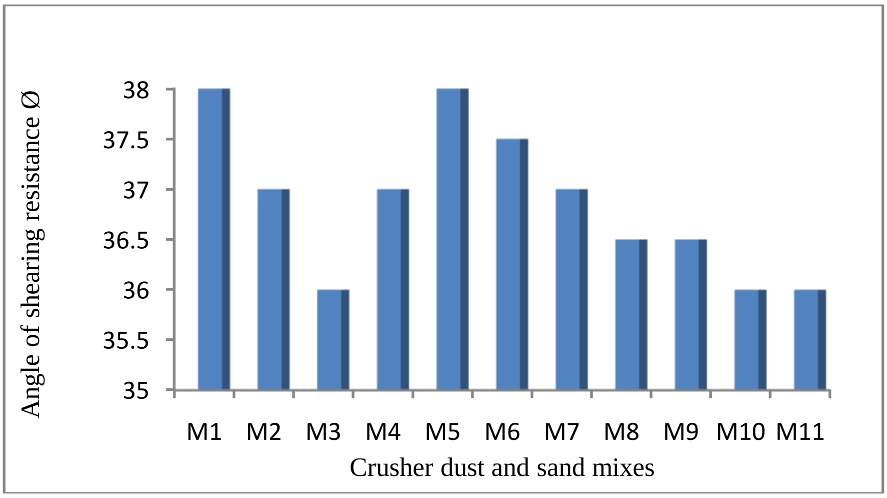

Fig 7: Variation of angle of shearing resistance

From the experimental data it is observed that as the percentage of sand is increasing, the angle of shearing resistance values are increasing upto 40% and then decreasing. A steady increase was observed upto 20% and a rapid increase was observed in between 20% - 40% followed by a steady decrease upto 80% dosage of sand. Maximum values were attained at a dosage of 30% - 40%. Increase in angle of shearing resistance values are due to development of frictional resistance by filling up of formed voids of crusher dust and sand mixes by the lower sizes of sand and crusher dust particles. Hence a combination of crusher dust and sand particles mobilizes more frictional resistance than individual crusher dust and sand particles. Maximum value attained at a dosage of 30-40% sand is 38^0.

3.3 California bearing ratio:

Samples of crusher dust and sand mixes were compacted in the CBR mould at their maximum dry densities and soaked for four days and tested at a strain rate of 1.25mm/min and the results are shown in table 5 and fig 8.

Table 6:variation of CBR with Crusher dust + Sand mixes

MIXES	Crusher dust(%)+sand(%)	CBR(%)
M_1	100+0	10
M_2	90+10	11
M_3	80+20	12
M_4	70+30	13
M_5	60+40	14

M_6	50+50	13.5
M_7	40+60	12
M_8	30+70	11
M_9	20+80	10
M_{10}	10+90	9
M_{11}	0+100	8

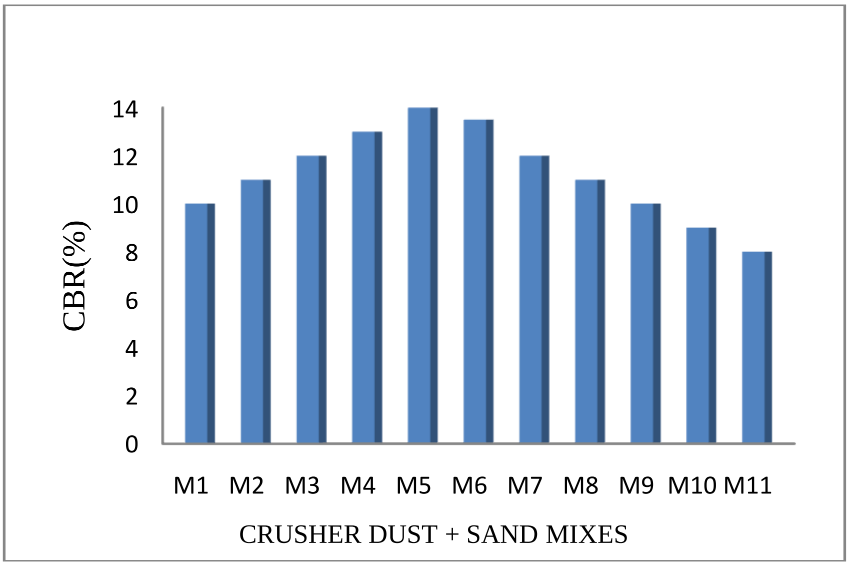

Fig 8: Variation of CBRWith Crusher + Sand mixes

From the experimental data it is observed that as the percentage of sand is increasing,CBR values are increasing (10-14) upto 40%and decreasing (14-8)upto 100% of sand. Maximum values attained (14) at a dosage of 40%and at 30 to 50% of sand, the CBR values are in the range of 13-14. Increase in angle of shearing resistance values are due to development of frictional resistance by filling up of formed voids of crusher dust and sand mixes by the lower sizes of sand and crusher dust particles. Hence a combination of crusher dust and sand particles mobilizes more frictional resistance than individual crusher dust and sand particles against compression. Hence 30-40% dosage of sand to crusher dust attained high CBR values.

4 APPLICATIONS

1. Crusher dust attained high dry density (2.02 g/cc) by maintaining wider variation of moisture contents with high angle of shearing resistance (36^0) and high CBR (10%) can be used as Sub-grade and fill material in road

construction.sand has max dry densitiy (1.82 g/cc) at 6% moisture content with angle of shearing resistance of (35^{0})and CBR of (8%) can also be used as Sub-Grade and fill material for low intensity roads.

2. Combination of crusher dust and sand have given strength values like angle of shearing resistance (ϕ) as 38 degrees and CBR as 14%.
3. 30%- 40% sand can be considered as effective utilization in the crusher dust – sand mixes by maintaining high strength values against shear and compression.

CONCLUSIONS

Test Results says that crusher dust and Sand are two coarse grained,non plastic materials can be chosen as construction material.Combination of Crusher dust and sand coherently give high strength values in terms of Angle of shearing resistance (38^{0})and CBR (14%) can be effectively used in civil construction as Embankment, Sub-grade, fill material, and Reinforced earth material.

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