Utilization of Crusher Dust Stabilized Gravels as Sub-Base Materials

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ABSTRACT:

Presence of excess fines in gravel soils make them as water retaining materials and develop plasticity characteristics which lead to excess shear deformation causing several failures. To arrest these characteristics Crusher Dust has been selected as a Stabilizer. To study the behaviour of Crusher dust with gravels soils as a sub-base material, various percentages of Crusher Dust was added to gravel soils and studied plasticity, compaction and strength characteristics to meet MORTH specification as a sub-base material. From the test results it is identified that plasticity characteristics were decreased and CBR values were increased with addition of Crusher Dust. Form the test results it is also identified that 10-15% of Crusher Dust is required for these gravel soil to make them low-plastic and 10-25% is required to make them non-plastic and high values of CBR can also obtain at these percentages the material to suit as sub-base materials based on MORTH specifications.

Key words: Gravel, CBR, Crusher Dust, Plasticity, Fines.

1.0 Introduction:

Gravelly soils frequently used as Sub-Base layers in road networking and as a fill material in Embankments and low-lying areas in several projects. By the nature of the composition of these soils particles varying in the range from 56 mm to 2 μm. Presence of wider range of particles make the Gravel soils Dense/Compacted and achieved higher strength under shearing. Sometimes the presence of plastic fines like clay particles and plastic silts take excess moisture and make these gravel soils high plastic and large deformations under shearing. The excess plastic deformations make these soils to lose their strengths under saturated condition. To arrest these plastic deformations by reducing the excess intake of moisture by these fines (Slits and Clays) stabilization techniques can be proposed. In this an attempt is made to stabilize the plastic fines by reducing the plasticity and expansion characteristics by addition of industrial waste products. Crusher dust is one such and selected as a stabilizer. Various percentages of Crusher dust was added to Gravel soils of various degrees for plasticity, strength characteristics.

Crusher dust can be advantageously used as road construction material in reinforced earth retaining walls, reinforced soil beds and reinforced flexible pavements as a fill material due to its stability, free draining nature and good frictional characteristics. Moorthy N.V.R. et al (2002) have studied the interaction of usage of rock flour with Geotextiles and reported the potential areas of application. Soosan et.al (2001) identified that crusher dust exhibits high shear strength and is beneficial for its use as a geotechnical material. Sridharan et.al. (2005) studied the effect of quarry Dust in highway construction that CBR and angle of shearing resistance

values are steadily increased with increase the percentage of Quarry Dust. Praveen Kumar et.al(2006) conducted CBR and tri-axial tests on fly ash, coarse sand, stone dust and river bed materials for their use in the sub base materials of the flexible pavements. Shanker and Ali (1992) have studied engineering properties of rock flour and reported that the rock flour can be used as alternative material in place of sand in concrete based on grain size data. Rao, et al (1996) have reported that sand can be replaced fully with rock flour. Wood S.A et.al reported that the quality of crushed stone dust depends on the type of parent materials.

Some of the researchers on utilization of Gravel and morrum in Geotechnical applications are Ramana Murthy. V. et.al, (2003,2004), Hausmann (1990), Prakash et.al, (1993), Gourley C. S et.al, Nunan T. A et.al, (1990), Thom N. H et.al, (1988), jain P.K et.al, (2010) studied the stabilization of morrum and their strength characteristics in terms of CBR as a Road Construction material. In this an attempt is made to study the interaction of Crusher dust with Gravel soils with respect to plasticity and Strength Characteristics.

2.0 Materials:

2.1 Gravel Soils:

Four Gravel soil samples were collected from various sources of North coastal districts of Andhra Pradesh i.e., Anakapalli, Vishakhapatnam, and Vizianagaram. The collected Gravel soil samples from the sources can be designated Anakapalli as (AG), Visakhapatnam as (VG_1 & VG_2) and Vizianagaram as VZG. These samples were subjected to various Geotechnical Characterization such as Gradation, Compaction and Strength as per IS: 2720 and the results are listed below in the tables and figures.

2.1.1 Geotechnical Characteristics of Gravel soils:

Gradation Characteristics:

Sieve Sizes (mm)	AG	VG1	VG2	VZG
	Finer (%)			
75	100	100	100	100
53	96	92	94	94
26.5	65	62	66	68
9.5	54	48	52	54
4.75	48	41	45	46
2.36	42	36	39	40
0.425	32	27	26	28
0.075	23	19	15	18
0.002	8	6	6	6

Table: 1

Consistency Characteristics:

Consistency Limits	AG	VG1	VG2	VZG
Liquid Limit (W_L) %	26	24	23	30
Plastic Limit (W_p) %	19	18	18	19
Plasticity Index (I_p) %	7	6	5	11
IS Classification	GC	GM-GC	GM-GC	GC

Table: 2

Compaction Characteristics:

Compaction Characteristics	AG	VG1	VG2	VZG
OMC (%)	8.5	8	7.8	9
MDD (g/cc)	2.08	2.10	2.12	2.04

Table: 3

Strength Characteristics:

Strength Characteristics	AG	VG1	VG2	VZG
CBR (%)	28	32	36	26

Table: 4

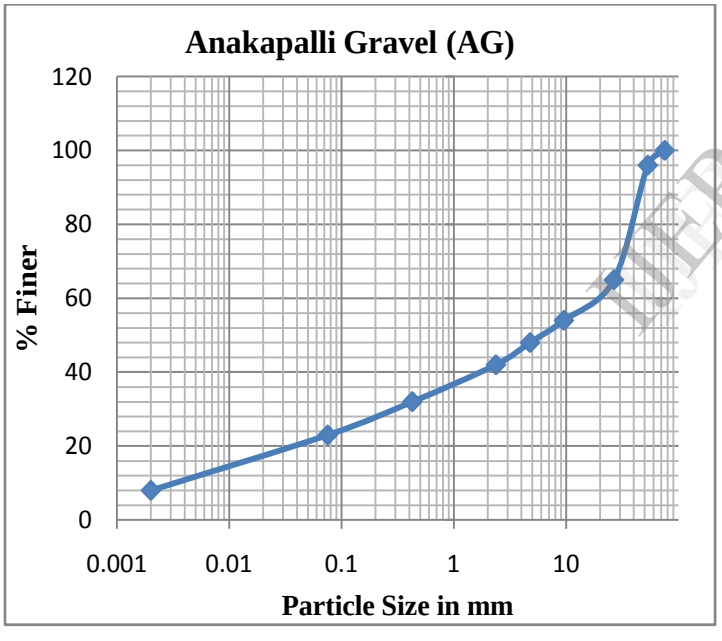

Fig: 1

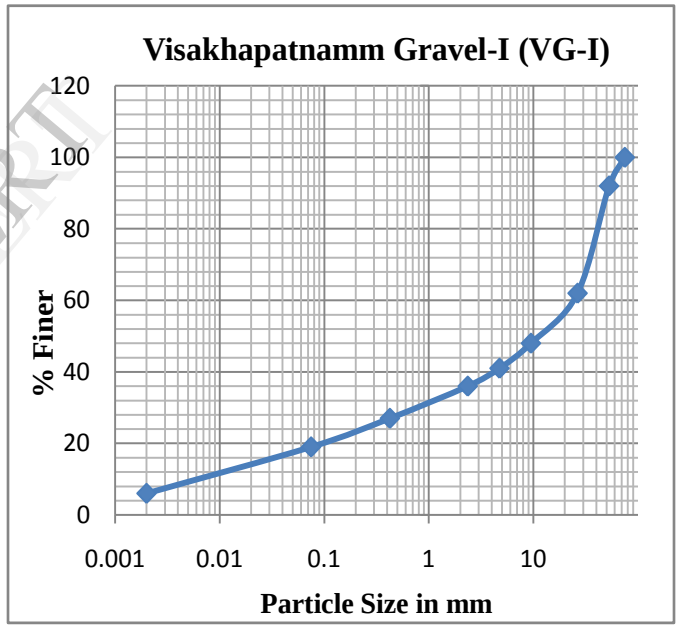

Fig: 2

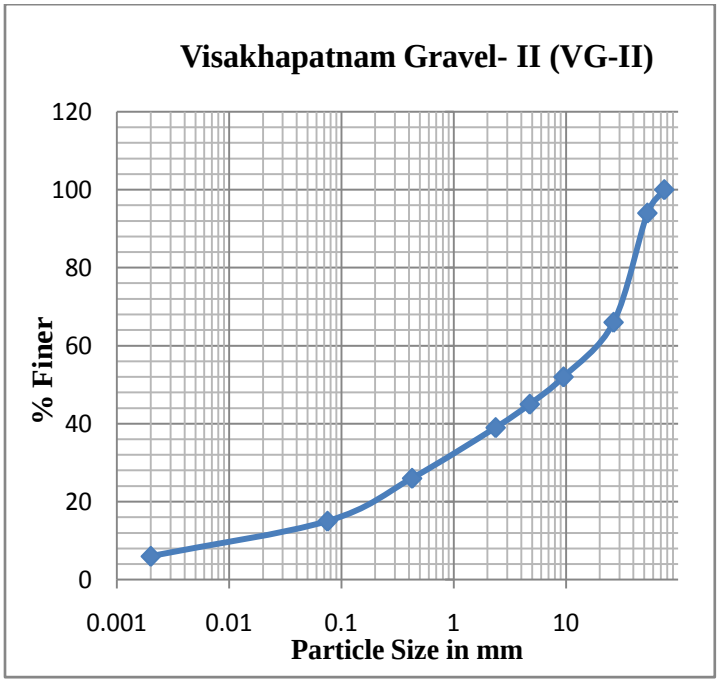

Fig: 3

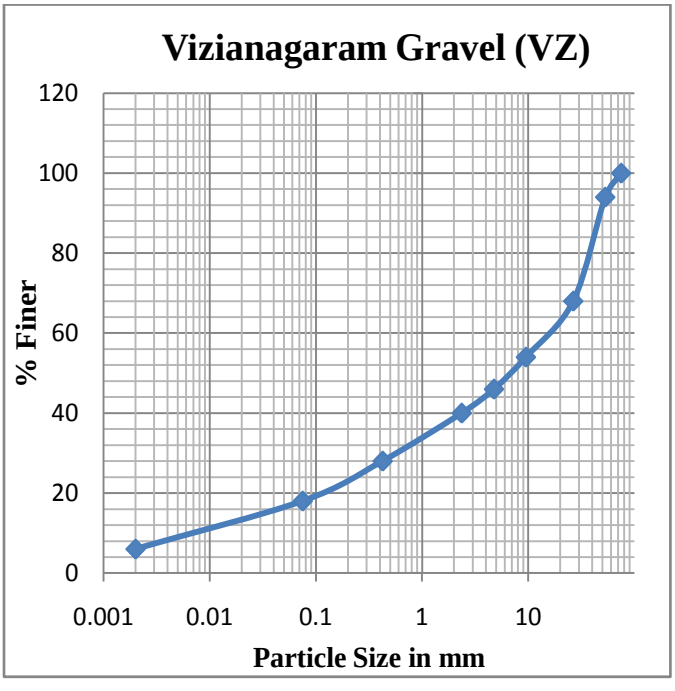

Fig: 4

Gravel soils collected from Anakapalli (AG), Visakhapatnam I and II (VG_1 & VG_2), and Vizianagaram have the following identifications based on their Geotechnical Characteristics. From the gradation test analysis all the four gravel soils consisted gravel particles (>4.75 mm) as major constituent and fines (<0.075 mm) are varying 18-23%, out of which silt particles are 9-15 and Clay particles are 6-8%, the Gradation particles of these soils with MORTH gradation for Sub-base materials. In most of these are accepting Grade 1 of close gradation except the percentage of fines. From the consistency data Vizianagaram Gravels exhibited medium Plastic characteristics (I_p<7-15) where as Vishakhapatnam and Anakapalli exhibited low plastic characteristics (I_p<7). From the four gravel soils Vishakhapatnam satisfies these specifications and Anakapalli is at border case where as Vizianagaram is away from the required Plasticity Index. From the compaction test data it is identified that Vishakhapatnam, Anakapalli Gravel soils attained high Maximum Dry Density with less Optimum Moisture Content, where as Vizianagaram soil attained low Maximum Dry Density with high Optimum Moisture content. Attainment of high densities are due to occupation of more solids with less water due to presence of less amount of fines. For explaining strength characteristics CBR value have chosen. From the test results it is identified that high CBR values obtained for Visakhapatnam, Anakapalli Gravel and Vizianagaram gravel is at border case (CBR>25) to suit as sub-base material with respect to MORTHS specifications for Grade 1 to 3. (Table 400)

To meet the MORTHS specifications of these gravel soils as a close graded sub-base material it is necessary to modify the fines with respect to Plasticity i.e, I_P<6 and Liquid Limit i.e, (W_L) <25%). In this connection Crusher dust has been selected from the nearby Crushing stone plants in Anakapalli to study the interaction between Crusher Dust particles and Fines of gravel soils. The results of the Crusher Dust with respect to its Compaction, Strength are listed in table 5 and figure 6 and 7.

2.2 Crusher Dust:

Crusher Dust was obtained from local stone crushing plants near Anakapalli, Visakhapatnam district, Andhra Pradesh. The sample was subjected to various geotechnical characterizations. The results are shown in table 5 and fig 6&7.

Property	Values
Grain size distribution:	
Gravel (%)	05
Sand (%)	90
Fines (%)	05
a. Silt(%)	05
b. Clay(%)	0
Consistency:	
Liquid Limit (%)	NP
Plastic Limit (%)	NP
I.S Classification	SP
Specific gravity	2.64
Compaction characteristics:	
Optimum moisture content (OMC) (%)	13
Maximum dry density (MDD) (g/cc)	1.9
Shear parameters:	
Angle of shearing resistance(deg)	36
California bearing ratio (CBR) (%) (Soaked condition)	8.0
Coefficient of Uniformity (C_u)	15
Coefficient of Curvature (C_c)	2.01

Table: 5

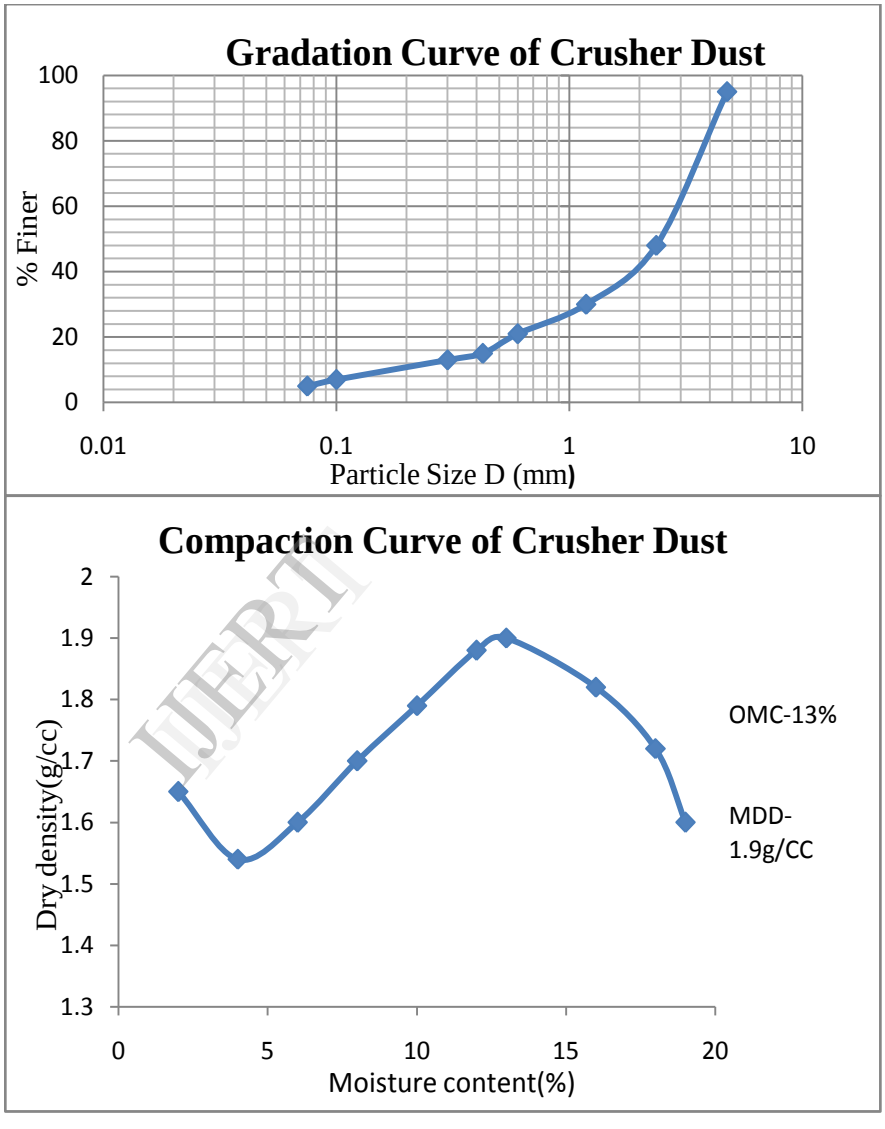

Fig: 6 & 7

From the physical characteristics it is observed that crusher dust is a grey color fine aggregate consisting of medium to fine sand size particles and of angular shape with rough surface texture. From the consistency data it is non-plastic and incompressible in nature. From the compaction curve it can be seen that crusher dust attains higher densities with wider variation in moisture content and also increase in workability at higher moisture contents.

3.0 Results and Discussions:

3.1 Stabilization of Gravel Soils: To study the interaction between coarse and fine particles of gravel soil with crusher dust particles have been studied by addition of crusher dust to gravel soil samples of Anakapalli, Visakhapatnam and Vizianagaram.

3.1.1. Plasticity Characteristics:

Plasticity Characteristics and their deformation can be betterly explained with Index Properties like Liquid Limit (W_L), Plastic Limit (W_P), and Plasticity Index (I_P). To know the results of gravel Crusher Dust mixes the material passing through 425 µm of Crusher dust Gravel mixes have taken at various percentages of crusher dust and subjected for consistency limits such as Liquid Limit, Plastic Limit and Plasticity Index etc, as per IS:2720 and the results are shown in table 6 to 10 and fig 8 to 11.

Plasticity Characteristics of AG:

Crusher Dust(%)	liquid limit (%) (W_L)	Plastic Limit (%) (P_L)	Plasticity Index (I_P)
0	26	19	7
5	24	18	6
10	21	17	4
15	NP	NP	NP
20	NP	NP	NP
25	NP	NP	NP
30	NP	NP	NP
35	NP	NP	NP
40	NP	NP	NP
45	NP	NP	NP
50	NP	NP	NP

Table: 6

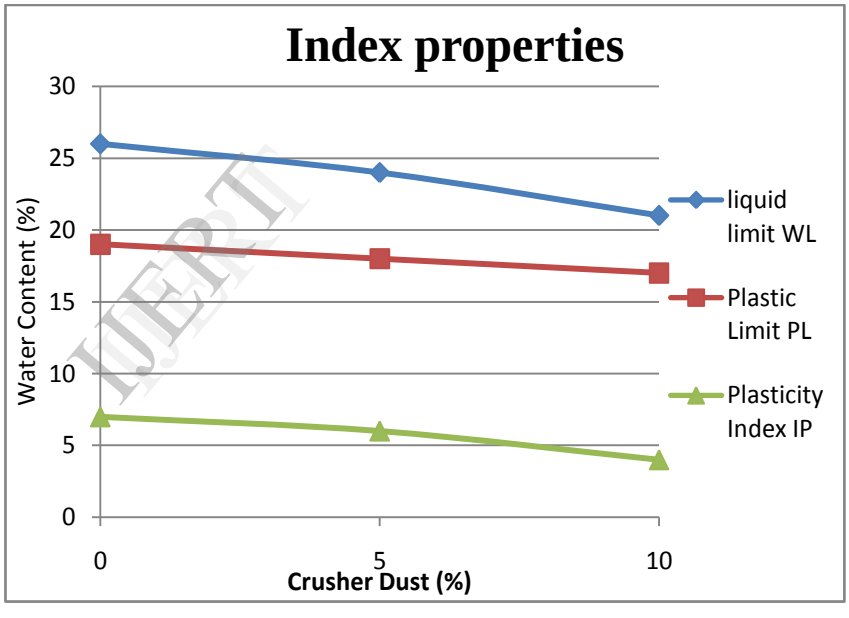

Fig: 8

Plasticity Characteristics of VZG:

Crusher Dust (%)	Liquid Limit (W_L)	Plastic Limit (P_L)	Plasticity Index (I_P)
0	30	19	11
5	27	18	9
10	24	17.5	6.5
15	22	17	5
20	20	NP	NP
25	NP	NP	NP
30	NP	NP	NP
35	NP	NP	NP
40	NP	NP	NP
45	NP	NP	NP
50	NP	NP	NP

Table: 7

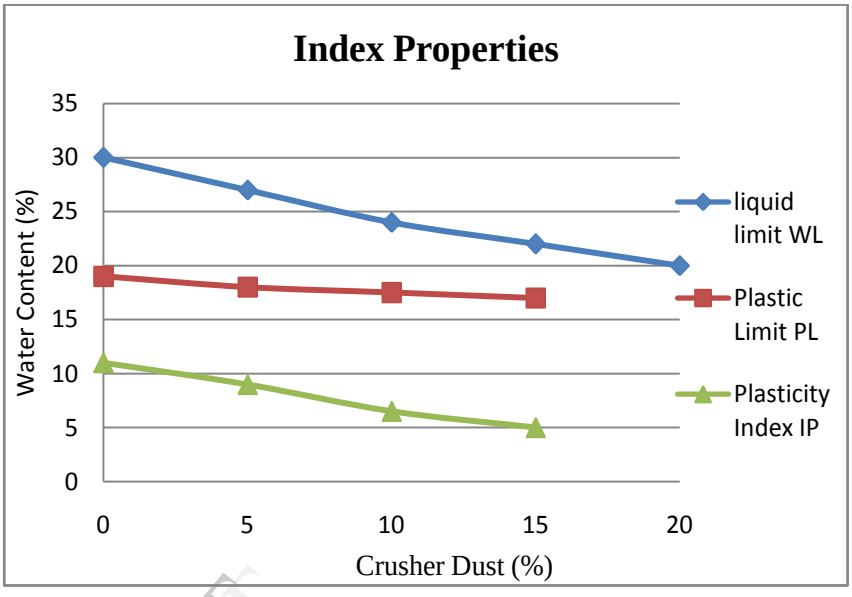

Fig: 9

Plasticity Characteristics of Visakhapatnam Gravels VG-I:

Crusher Dust (%)	liquid limit (W_L) (%)	Plastic Limit (W_P) (%)	Plasticity Index (I_P)
0	24	18	6
5	21	17	4
10	NP	NP	NP
15	NP	NP	NP

Table: 8

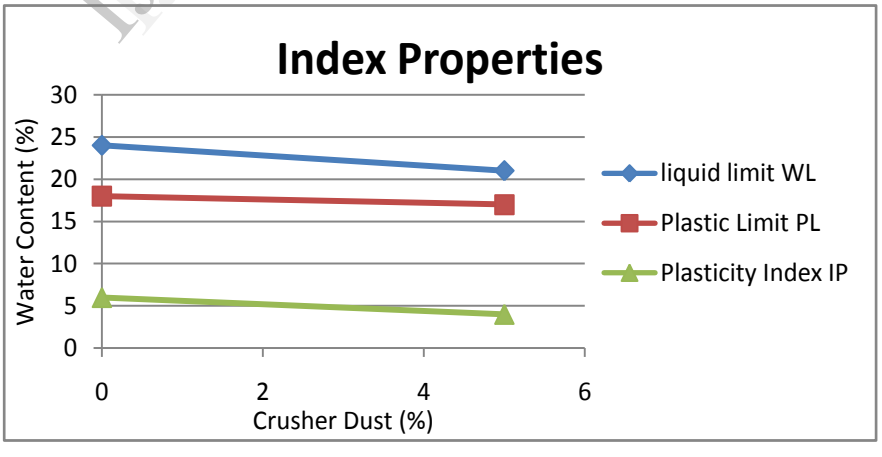

Fig: 10

Plasticity Characteristics of Visakhapatnam Gravels VG-II:

Crusher Dust(%)	liquid limit (W_L)%	Plastic Limit (W_p)%	Plasticity Index (I_p)%
0	23	18	5
5	21	17	4
10	NP	NP	NP
15	NP	NP	NP

Table: 9

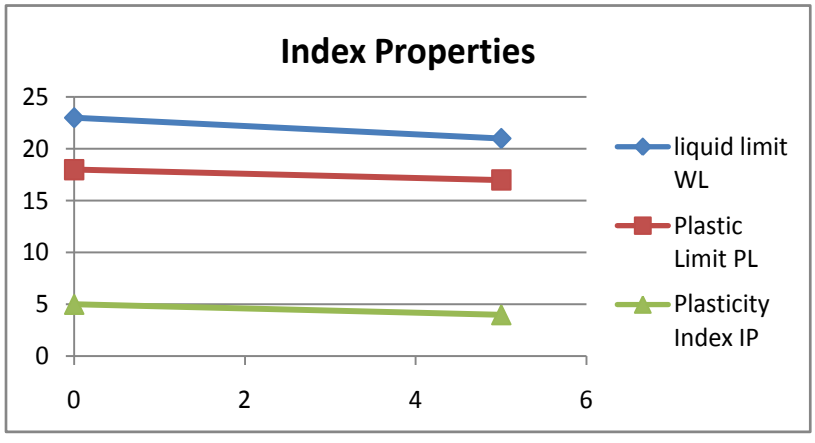

Fig: 11

From the test data it is observed that addition of crusher dust decreases Liquid Limit, Plastic Limit and Plasticity Index values. Vizianagaram gravel soil requires 20-25% of crusher dust to make it a non-plastic and 15% is sufficient to meet the requirements (I_p<6) as per MORTH Specifications (Table 400), Anakapalli soil requires 15% dosages for non-plastic and a minimum 10% is requires to meet specifications of MORTH (Table 400) where as Visakhapatnam gravel requires 10% of crusher dust to meet as a non-plastic material. The plasticity characteristics of the gravel soils purely depend on the percentage of fines (< 425 µm). In the given soils composition, the percentage of fines are less and the main contributor for development of plasticity characteristics is clay content which is also less. This composition makes the soil to attain a low compressibility i.e, Liquid Limit <25% and low Plasticity (I_P<6) Characteristics. Due to nature of these gravel soil a less amount of Crusher dust dosage (10-15%) made crusher dust soil mixes low Plastic and beyond 15% dosage of Crusher dust made the Crusher dust soil Mixes as Non-plastic.

3.2 Compaction Characteristics:

Various percentages of Crusher dust was added to Gravel soils at their dry weights and IS heavy compaction test was performed as per IS: 2720 and the results are listed below table 10 to 13 and Fig 12 to 19.

Compaction Characteristics of AG:

Crusher Dust (%)	OMC (%)	MDD (g/cc)
0	8.5	2.08
5	8.2	2.1
10	8	2.12
15	8.2	2.11
20	8.4	2.1
25	8.7	2.08
30	8.9	2.07
35	9	2.06
40	9.1	2.05
45	9.3	2.04
50	9.5	2.04

Table: 10

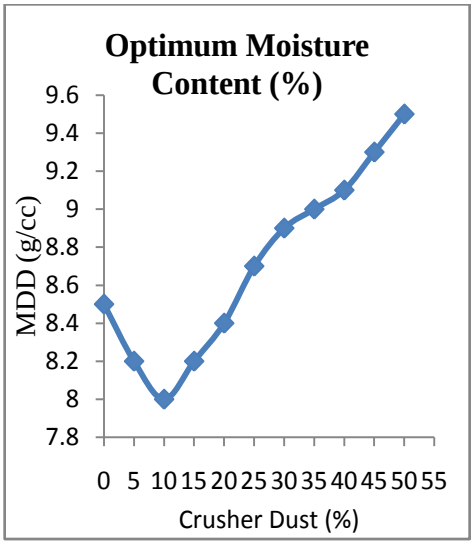

Fig: 12

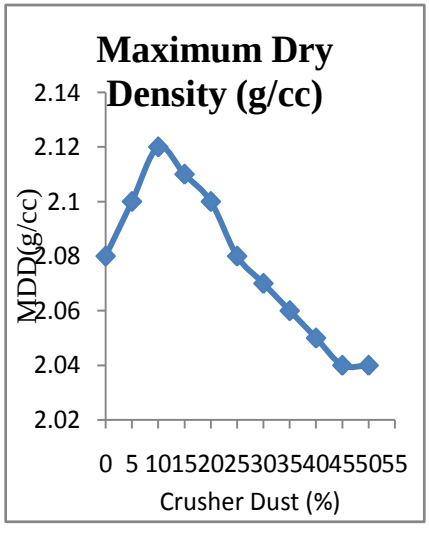

Fig: 13

Compaction Characteristics VZG:

Crusher Dust (%)	OMC (%)	MDD (g/cc)
0	9	2.08
5	8.8	2.1
10	8.5	2.12
15	8	2.14
20	7.5	2.15
25	7.2	2.15
30	7	2.13
35	6.5	2.12
40	6.8	2.1
45	7.2	2.1
50	7.5	2.09

Table: 11

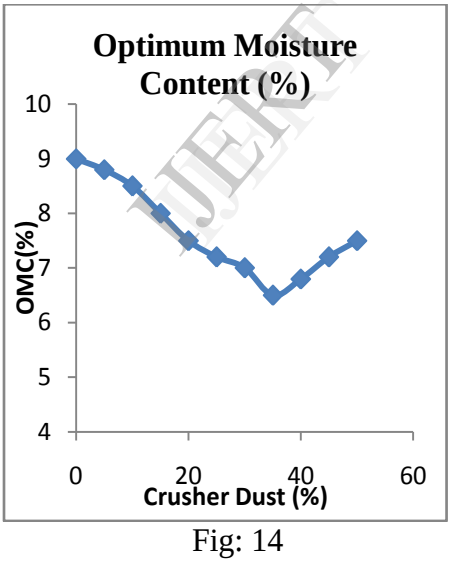

Fig: 14

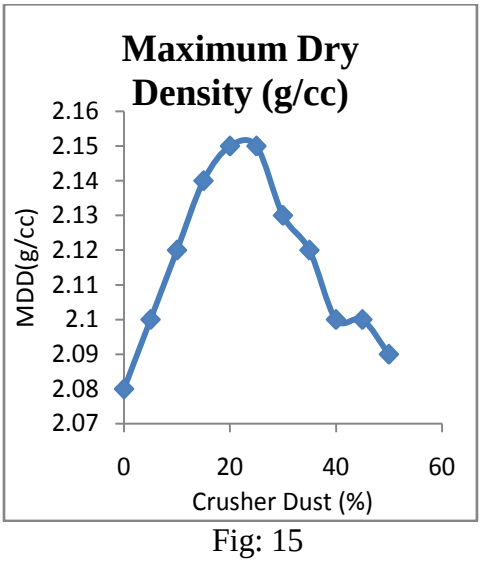

Fig: 15

Compaction Characteristics of VG-I:

Crusher Dust (%)	OMC (%)	MDD (g/cc)
0	8	2.1
5	8.2	2.12
10	8.5	2.14
15	8.8	2.12

Table: 12

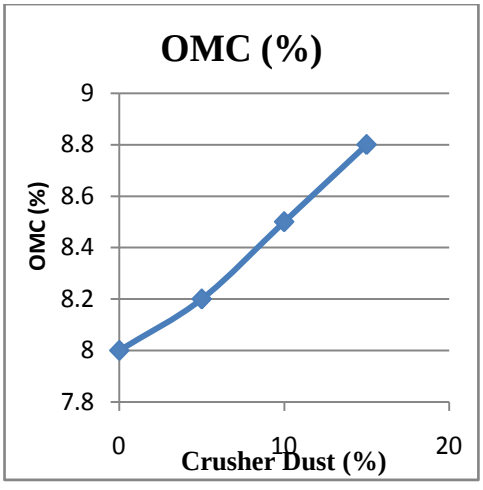

Fig: 16

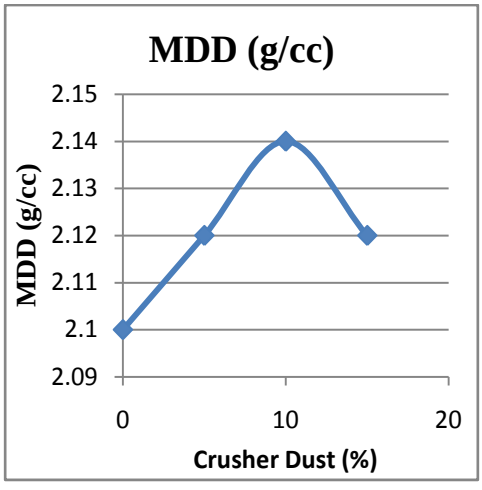

Fig: 17

Compaction Characteristics VG-II:

Crusher Dust (%)	OMC (%)	MDD (g/cc)
0	7.8	2.12
5	8	2.14
10	8.3	2.13
15	8.6	2.12

Table: 13

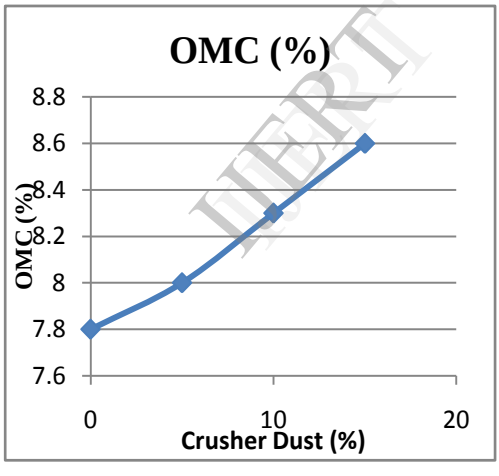

Fig: 18

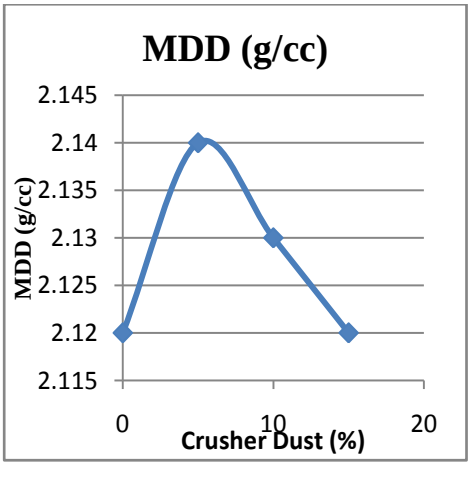

Fig: 19

From the test results it is identified that for Anakapalli Gravels as the percentage of crusher dust is increasing the optimum moisture content values are decreasing upto 10% and increasing beyond this dosage, whereas the maximum dry density values are increasing upto 10% and then decreasing, a continuous decrease in optimum Moisture contents and continuous increase in maximum dry densities were observed for Vizianagaram Gravels and for Visakhapatnam gravels a continuous decrease in Optimum moisture contents and increase in maximum dry densities were observed for higher percentage of Crusher dust Dosages. The decrease in optimum moisture contents are due to replacement of Silt and Clay particles by Crusher Dust particles which reduces the intake of moisture compared to Crusher Dust particles and increase in dry densities are due to occupation of more solids with respect to interaction of Crusher Dust and fines of gravel particles. Hence the optimum dosage of Crusher Dust for these type of Gravel soils is 10-20%. Hence from these test results it is

also identified that Vizianagaram Gravel soils requires high percentage of Crusher Dust where as Anakapalli, and Visakhapatnam Gravel soils required less dosage of Crusher Dust.

3.3 California Bearing Ratio (CBR) for AG:

Various percentages of Crusher dust was added to Gravel soils at their dry weights and California Bearing test was performed on soaked samples for four days soaking period compacted at their maximum dry densities as per IS: 2720 and the results are listed below in table 14 to 17 and Fig 19 to 22.

California Bearing Ratio of AG:

Crusher Dust (%)	CBR (%)
0	28
5	31
10	35
15	38
20	34
25	30
30	28
35	26
40	25
45	23
50	20

Table: 14

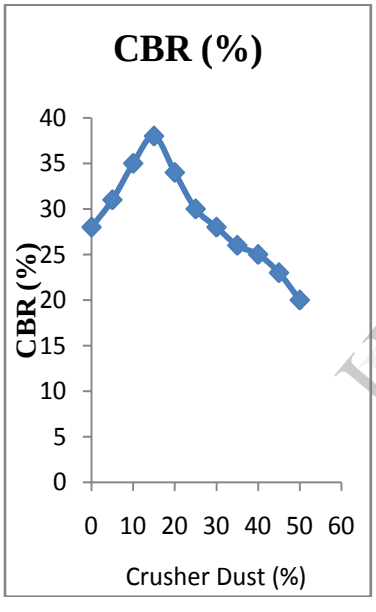

Fig: 20

California Bearing Ratio of VZG:

Crusher Dust (%)	CBR (%)
0	26
5	30
10	34
15	38
20	40
25	42
30	38
35	35
40	32
45	28
50	25

Table: 15

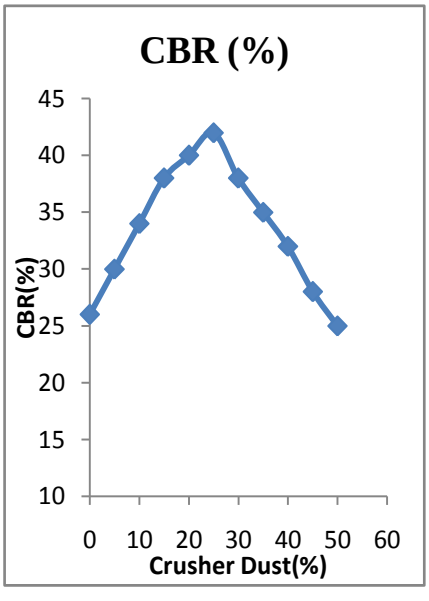

Fig: 21

California Bearing Ratio VG-I:

Crusher Dust (%)	CBR
0	32
5	35
10	38
15	35

Table: 16

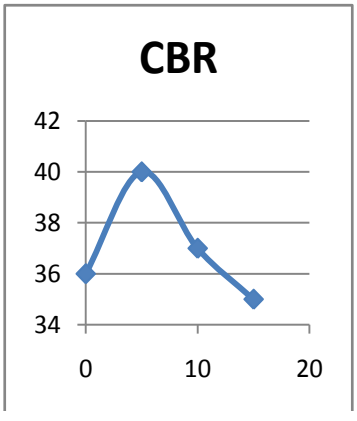

Fig: 22

California Bearing Ratio VG-II:

Crusher Dust (%)	CBR
0	36
5	40
10	37
15	35

Table: 17

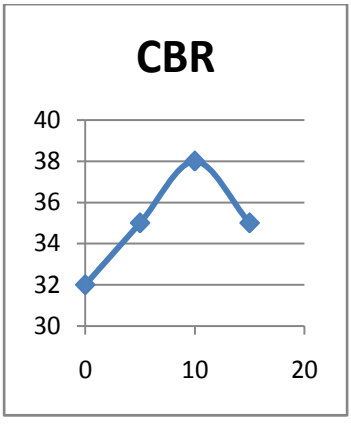

Fig: 23

From the test results it is identified that as the percentage of Crusher dust is increasing CBR values are increasing upto 15% for Anakapalli soils, 25% for Vizianagaram soils and 5-10% for Visakhapatnam Gravel soils. Attainment of maximum values are due to more solids occupied in the given volume due to the effective interaction between the Crusher Dust particles and Fine and coarser particles of Gravel soil, offers more shearing resistance against compression. Based on MORTH specifications for meeting the specification of Sub-base material for Grade-I (Table 400), a dosage of 10-15% for Anakapalli Gravel soils, 20-25% for Vizianagaram Gravels 5-10% for Visakhapatnam Gravels were required.

4.0 Conclusions:

By observing the test results of crusher dust and gravel mixes high plastic gravelly soils require more dosage of Crusher dust and low plastic soils require less dosage to meet the specifications of MORTH grade-I sub-base materials for close grading. It is also identified that 10-25% dosage of Crusher dust yield high CBR values and made them non-plastic.

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