INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
(Volume 5, Issue 4)
Available online at: www.ijariit.com

Effective stabilisation of pavement subgrade using crusher dust

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ABSTRACT

Roads are an important form of infrastructure in any country. Good and safe roads are important for the economic and social growth of the country. National highways are strategically planned with the objective of smooth and fast movement of goods, services, and people to different locations in the country. With this mandate the Government of India set up National Highways Authority of India (NHAI) by an act of Parliament 'NHAI Act 1988'. National highways connect small towns and districts to capitals of the state and the country and also to places of economic importance. National highways like NH6 provide a good connection with neighboring states, and NH43 and NH200 provide the main north-south connection between Raipur, Bilaspur, and Jagdalpur. About 19 National highways pass through the state of Chhattisgarh, however, apart from these not all roads are all-weather roads and are not safe especially in monsoons. The function of any road depends on its pavement and pavement function depends on its component layer especially the sub-base layer. So, it is very important for any designer to study the natural conditions of the site before the construction of any road network. The sub-base layer is mostly made up of natural soil like gravel soil, which deforms excessively. So to increase the life span of the pavement it is important to reduce their plastic characteristics. Stabilization is one of the techniques for its improvement. Here, we are using crusher dust as a stabilizer. Plasticity characteristics were reduced and CBR values were improved by using crusher dust as a stabilizer. The addition of 20% of crusher dust makes the gravel soils meet the specification of MORTH as a sub-base material is identified from the test results.

Keywords— *Density, Water Content, Pavement, Subgrade, Stabilisation, Crusher Dust*

1. INTRODUCTION

Gravelly soils frequently used as Sub-Base layers in road networking and as fill material in Embankments and low-lying areas of the several projects. By the nature of the composition of the soil particles varying in the range from 56 mm to 2 µm. Presence of these under a range of particles make the Gravel soils Dense/Compacted are 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 subjected to high plastic 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. Crusher dust has been selected as a stabilizer. Various percentage of Crusher dust was added to Gravel soils of various degrees of plasticity characteristics.

Crusher dust is often well employed in strengthened earth retentive walls, strengthened soil beds and strengthened versatile pavements as a fill material thanks to its stability, free exhausting nature and good frictional characteristics with synthetic reinforcement. Moorthy N.V.R.etal (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. In this, an attempt is made to study the effect of Crusher dust and Crushed Stone Mixes in studying there, plasticity Compaction Characteristics and strength characteristics.

2. OBJECTIVE OF THE STUDY

The main objective of the present study is stabilization of Gravel soils with Crusher dust material and their mixes can be used as sub-base material in road construction.

(a) To know the geotechnical Characterization of Gravel soils from Chhattishgarh
(b) To know the plasticity characteristics of Gravel-Crusher dust mixes at the various percentage of Crusher dust.
(c) To know the Compaction and strength characteristics of Gravel-Crusher dust mixes at the various percentage of Crusher dust.
(d) Suitability of the stabilized Gravel soils as Sub-base material in accordance with MORTH specifications.

3. METHODOLOGY

Experimental procedures adopted in this investigation and the methodology adopted during the course of the study are briefly presented.

3.1 Material Used

The materials used in this investigation are:

- Gravel
- Crusher dust

The following tests were conducted on the soil. The index and engineering properties of soil were determined.

- Grain size analysis confirming (IS: 2720-part 4, 1985)
- Consistency limits or Atterberg's Limits (IS: 2720-part 5, 1985)
- Compaction test confirming (IS: 2720- Part 8: 1983)
- California bearing ratio test confirming (IS: 2720- Part 16: 1987)

4. RESULTS AND DISCUSSION

4.1 Soil sampling

Four Gravel samples were collected from various source districts of Chhattisgarh that is, Ambikapur (ABKP), Durg (Durg), Khairagarh (KRGH) and Raipur (R). These samples were subjected for Geotechnical Characterization such as Gradation, Compaction and Strength as per IS: 2720 and the results are listed below-mentioned tables and figures

4.1.1 Geotechnical Characteristics of Four Gravels

Table 1: Gradation Characteristics

Sieve Sizes	ABKP	DURG	KRGH	R
75	100	100	100	100
53	94	96	94	100
26.5	60	66	69	76
9.5	56	44	53	65
4.75	43	40	44	53
2.36	47	32	42	52
0.425	37	28	28	37
0.075	25	20	19	30
0.002	10	5	5	12

Table 2: Consistency Characteristics: Index Properties

Consistency Limits	ABKP	DURG	KRGH	R
Liquid Limit (W_L) %	28	25	31	37
Plastic Limit (W_p) %	21	19	19	20
Plasticity Index (I_P) %	7	6	12	17
IS Classification	GC	GM-GC	GC	GC

Table 3: Compaction Characteristics

Compaction Characteristics	ABKP	DURG	KRGH	R
OMC (%)	8.5	8	9	11
MDD (g/cc)	2.09	2.10	2.02	2

Table 4: Strength Characteristics

Strength Characteristics	ABKP	DURG	KRGH	R
CBR (in %)	29	33	24	22

4.1.2 Crusher dust: Crusher dust was obtained from local stone crushing plants near village *Jorain* in Raipur district of Chhattisgarh. The sample is subjected to various geotechnical characterizations. The results are shown in the table below.

Table 5: Geotechnical Characteristics of Crusher dust

Property	Values
Grain size distribution:	
Gravel (%)	06
Sand (%)	88
Fines (%)	06
Silt(%)	05
Clay(%)	0
Consistency:	
Liquid Limit (%)	NP
Plastic Limit (%)	NP
I.S Classification	SP
Specific gravity	2.64
Compaction characteristics:	
Optimum moisture content (OMC) (%)	14
Maximum dry density (MDD) (g/cc)	1.8
Shear parameters:	
Angle of shearing resistance(deg)	36
California bearing ratio (CBR) (%) (Soaked condition)	8.0

Table 6: Gradation data for Crusher dust

Crusher Dust	
Sieve Sizes (mm)	**% Finer**
4.75	95
2.36	48
1.18	30
0.6	21
0.425	15
0.3	13
0.1	7
0.075	5

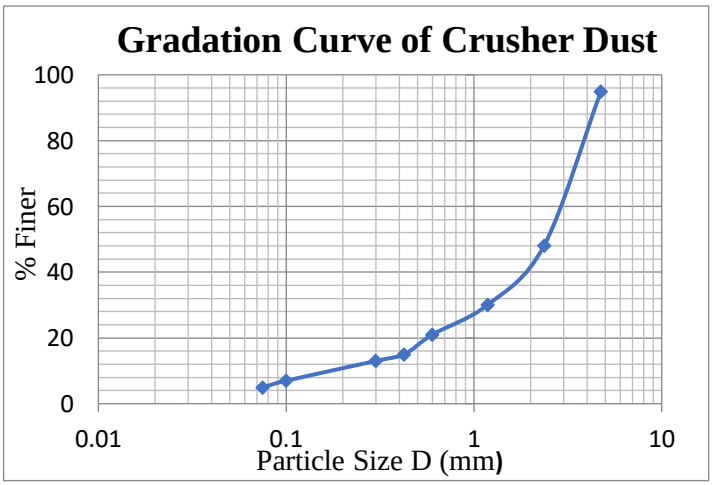

Fig. 1: Gradation curve of crusher dust

Table 7: Compaction Characteristics of Crusher dust

Water content (%)	Dry density(g/cc)
2	1.65
4	1.54
6	1.6
8	1.7
10	1.75
12	1.79
14	1.8
16	1.77
18	1.72
19	1.6

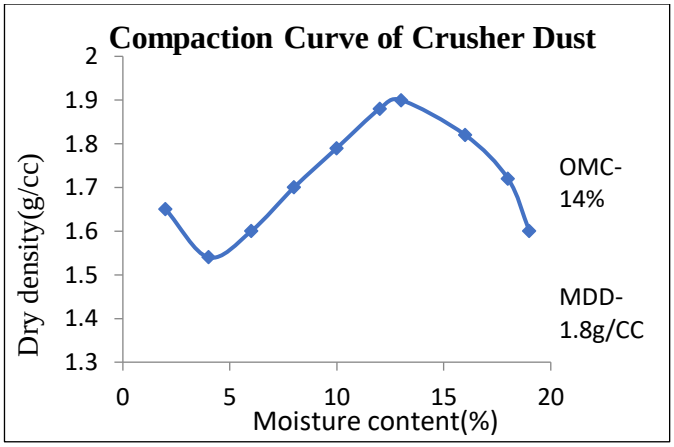

Fig. 2: Compaction curve of Crusher dust

From the physical characteristics, it is observed that crusher dust is a grey colour 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 very low compressive (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.

4.2 Performance of Gravel Crusher dust Mixes

To study the performance of gravel crusher dust mixes various percentages of Crusher dust by the Dry weight of soil masses were added. Various percentages of crusher dusts such as 5, 10, 15, 20, 25, 30, 35, 40, 45 and 50 were added to gravel and were subjected to various Geotechnical Characterizations such as Plasticity characteristics like Liquid Limit and Plastic limit and Compaction Characteristics like Optimum Moisture Content, Maximum Dry Density and Strength (CBR) etc., and the results are shown below.

Table: 8 Index Properties of Gravel Crusher dust mixes

Crusher dust (%)	Liquid limit (%) (W_L)	Plastic Limit (%) (W_P)	Plasticity Index (I_P)
0	40	20	20
5	38	19.5	18.5
10	36	19	15
15	33	19.5	12.5
20	30	20	10
25	26	21	5
30	23	20	3
35	22	NP	NP
40	NP	NP	NP
45	NP	NP	NP
50	NP	NP	NP

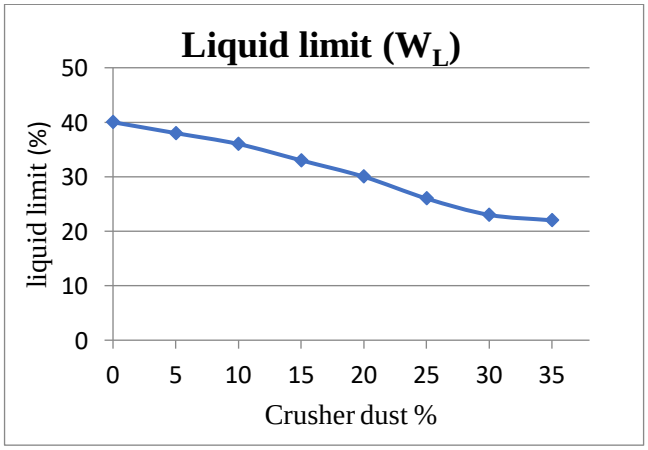

Fig. 3: Liquid limit of Gravel Crusher dust mixes

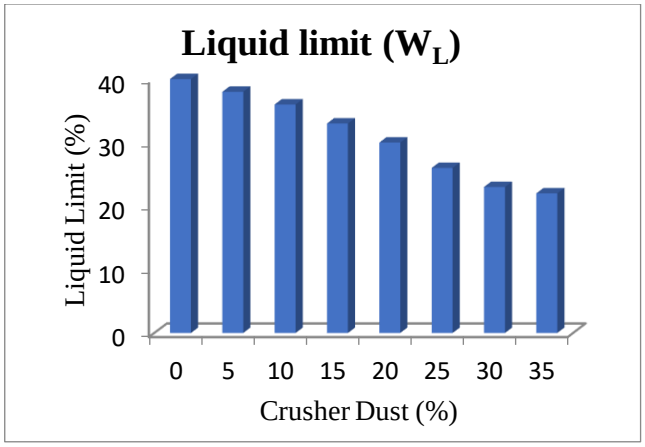

Fig. 4: Liquid limit of Gravel Crusher dust mixes

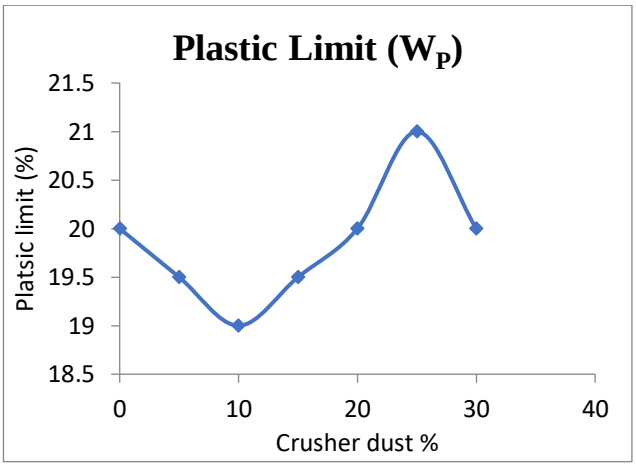

Fig. 5: Plastic limit of Gravel Crusher dust mixes

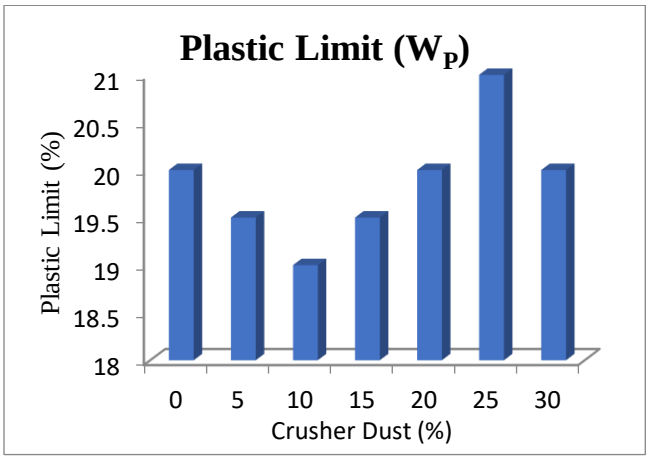

Fig. 6: Plastic limit of Gravel Crusher dust mixes

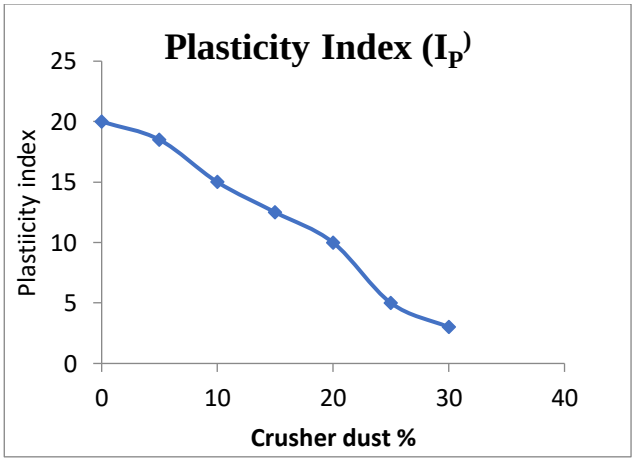

Fig. 7: Plastic Index of Gravel Crusher dust mixes

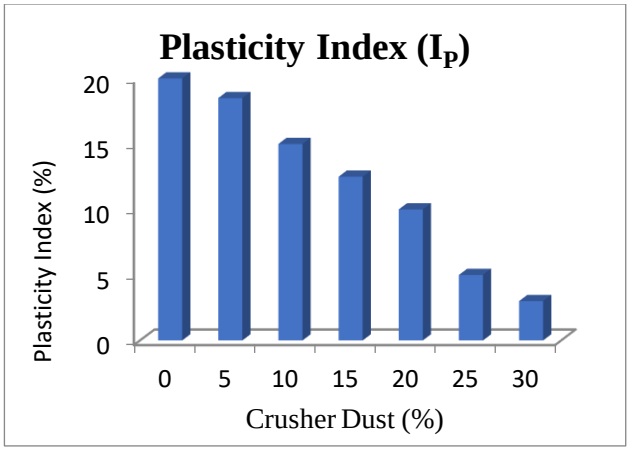

Fig. 8: Plastic Index of Gravel Crusher dust mixes

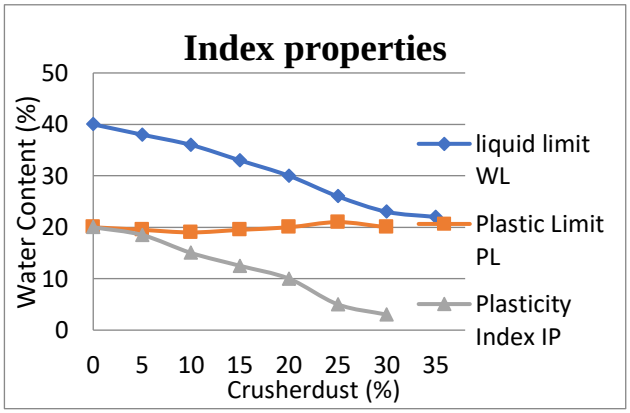

Fig. 9: Index Properties of Gravel Crusher dust mixes

From the test data, it is observed that the addition of crusher dust decreases Liquid Limit, Plastic Limit, and Plasticity Index values. The trend has continued up to 30% of Crusher dust, beyond this, a true non-plastic behaviour was observed. Further increasing the percentage of crusher dust make the Crusher dust and fines of the gravel soil-mixes attained the behaviour of crusher dust. The plasticity characteristics of the gravel soil purely depend on the percentage of particles less than (< 425µm) and specifically less than 75µm. In the given soil composition the percentage of fines is 30%, and the main contribution to the development of plasticity characteristics are due to clay content is also less. This composition by addition of Crusher dust makes the soil to attain a low compressibility that is W_L<25% and low Plasticity that is I_P<6.

5. CONCLUSIONS

Following conclusions can be made from the present study on the performance of crusher dust on gravels soils.

- As the percentage of crusher dust is increasing plasticity characteristics, like liquid limit, plastic limit and plasticity index are reducing.
- As the percentage of Crusher dust is increasing strength characteristics like CBR values are also increasing.
- High plastic soils and intermediate compressible soils like Raipur require a high percentage (30-35%) of crushed dust to meet the specifications of MORTH as a sub-base material.
- Medium to low plastic and low compressible soils like Durg Gravels (DURG) 10%, Ambikapur gravel (AG) and Khairagarh Gravel (KHAIRAGARH) require 15-25% of Crusher dust to attain low to non-plastic condition and to meet the specifications of MORTH as a sub-base material.
- At the higher percentage of Crusher dust, these Gravel soils attained the characteristics of Crusher dust by maintaining high densities and CBR values.

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