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Geotechnical properties of expansive soil stabilized with stone dust

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Abstract
Expansive soil have the tendency to swell or shrink depending on its moisture content. Due to such expansive characteristics of soil, the structures constructed over this may develop some cracks in due course of time. This paper presents the effect of stone dust on the expansive soil, the following test were performed on soil-stone dust mix specimen; Atterberg's limit, Standard proctor test, California bearing ratio. The stone dust content varied from 10 to 40%. The CBR test were performed for 3days soaked condition. It is there for essential to stabilize such soils, prior to any construction work carried out on this to improve its engineering properties.

Keywords: expansive soil, stone dust, atterberg's Limit, OMC, MDD, CBR etc.

1. Introduction
Expansive soils are inorganic clays of medium to high compressibility and form a major soil group in India. They are characterized by high shrinkage and swelling properties. This expansive soils occurs mostly in the central and western parts and covers approximately 20% of the total area of India. Because of its high swelling and shrinkage characteristics, the expansive soils (Black cotton soils) has been a challenge to the highway engineers. For improvement the geotechnical properties of expansive soil, stone dust were mixed in this research work. Stone dust is by-product of stone crushing industries and disposal of stone dust is very big problem for developing country like India.

2. Literature Review
1. Dhananjay Kumar Tiwari Carried out the suitability of using waste material i.e. stone dust and polypropylene fibers for improving the civil engineering properties of black cotton soil. Various tests like Standard Proctor Test, CBR, UCS etc. performed on the soil specimens prepared by using stone dust and polypropylene as stabilized material and mixed with black cotton soil at different percentages. Results obtained from these results it may be concluded that the strength of black cotton soil can be substainsly improved by mixing with stone dust and polypropylene fibre as stabilized material.
2. Arun Patidar *et al*. carried out to study the effect of high density polyethylene fibres, stone dust and lime on index and engineering properties of the Black Cotton Soils. The properties of stabilized soil such as compaction characteristics, unconfined compressive strength and California bearing ratio were evaluated and their variations with content of fibres, stone dust and lime are evaluated. The optimum content of each ingredient has been determined.

3. Experimental program
a. Particle Size Distribution: The percentage of particle i.e. clay, silt and sand (fine grained or coarse grained) in the soil was found after conducting laboratory experiments as per IS: 2720 (Part V) – 1985.
b. Atterberg Limit: Liquid limit, plastic limit, plasticity index and shrinkage limit was determined as per IS: 2720 (Part IV) – 1985 in the laboratory.
c. Specific Gravity: Specific gravity of soil is obtained as per IS: 2720 (Part III) – 1980 with the help of pycnometer method.
d. Standard Proctor Test: The standard procedure of standard proctor test is followed as per IS: 2720 (Part VII)-1980 to determine optimum moisture content and maximum dry density of soil.
e. California Bearing Ratio: the standard procedure of CBR test is followed as per IS: 2720 (Part XVI) - 1987 for Flexible Pavement Design.

4. Material used
1) Expansive soil
Expansive soils are generally reddish brown to black in color and occur from 0.5m to 10m deep and have high compressibility. Expansive soil is collected from the Borkheda area of Kota district, Rajasthan.
The properties of expansive soil was tested for their properties according to the relevant IS code provisions. Table 1 shows the geotechnical properties of expansive soil.

Table 1: Properties of expansive soil

S. No.	Property	Value
1	Liquid Limit (L.L.)	41.64
2	Plastic Limit (P.L.)	20.45
3	Plasticity Index (P.I.)	21.19
4	Soil Classification	CI
5	Specific gravity (G)	2.68
6	Max. Dry Density (ϒd)	1.68 kg/cm³
7	O.M.C	18.35%
8	CBR % (3days Soked)	2.13

2) Properties of Stone Dust

Stone dust is a by-product of stone crushing industries. It is widely used on place of sand in concrete on construction sites.Stone dust exhibits high shear strength which is highly beneficial for its use as a civil engineering material. The physical properties of stone dust is mentioned in table 2.

Table 2: Physical parameters of Stone Dust.

Parameters	Properties
Bulk density	1720-1810 kg/m³
Odor	Odorless
Specific gravity	2.78
Colour	Grey
MDD (kg/cm³)	1.89
OMC %	14.5

Table 3: Atterberg's Limit for Expansive Soil with Different Percentage of Stone Dust

Particulars	Liquid limit	Plastic limit	Plasticity index
Expansive Soil	41.64	20.45	21.19
E.S. + 10% stone dust	37.49	17.40	20.09
E.S. + 20% stone dust	33.12	15.82	17.3
E.S. + 30% stone dust	29.81	14.22	15.59
E.S. + 40% Stone dust	26.43	12.36	14.07

5. Experimental results

1) Atterberg's limits

The consistency of a clayey soil is the physical state in which it exists. It is used to denote the degree of firmness of a soil. Consistency of a soil is indicated by such terms as soft, firm or hard. The moisture content at which the soil changes from one state to another are known as consistency limits or Atterberg's limits. These data are observed while tests were performed the LL, PL and Plasticity Index.

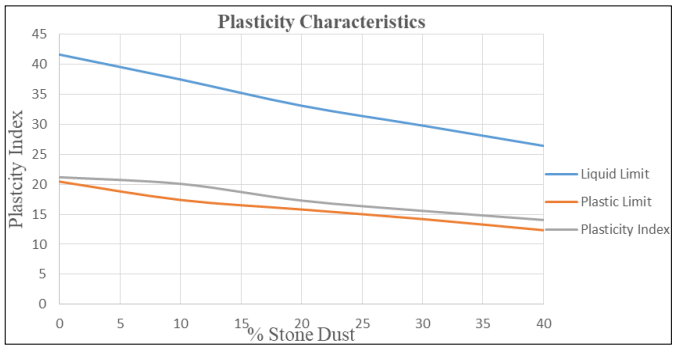

Fig 1: Atterberg's Limit for Expansive Soil with Different Percentage of Stone Dust.

2) Compaction test

The standard proctor test is performed for evaluate maximum dry density and optimum moisture content of soil with various percentage of stone dust and peak value of the curve is taken as OMC and MDD. Based on these results classification is done as per IS 2720 (Part VII). From table 2 it is observed that the maximum dry density of soil 1.68 kg/cm³ with increasing the percentage of stone dust in expansive soil the maximum dry density is increases up to 1.76 kg/cm³, further increment of stone dust the MDD is decreases, optimum moisture content of soil is 18.35% with increasing the percentage of stone dust in expansive soil the Optimum moisture content is decreases up to 16.89% on 30% of stone dust, further increment of stone the value of OMC is increased.

Table 4: Standard Proctor Test for Expansive Soil with Different Percentage of Stone Dust.

Percentage of Stone Dust With Expansive Soil	MDD (kg/cm³)	OMC (%)
Expansive soil	1.69	18.35
E.S. + 10% Stone dust	1.72	17.82
E.S. + 20% Stone dust	1.75	17.40
E.S. + 30% Stone dust	1.76	16.89
E.S. + 40% Stone dust	1.78	16.23

4) California bearing ratio (3Days Soaked)

California bearing ratio is desired, corrected load value shall be taken from the load penetration curve and the California bearing ratio calculated as follows –

$$\text{CBR} = \frac{Pt \text{ x } 100}{Ps}$$

Where,

Pt = Corrected unit (or total) test load corresponding to the chosen penetration from the load penetration curve.

PS = Standard load for the same depth of penetration as for Ps.

Table 5: Standard Load for CBR test.

Penetration (mm)	Standard load (KGF)
2.5	1370
5	2055
7.5	2630
10	3180
12.5	3600

The value of CBR for expansive soil is 2.13%. Adding 20% Stone dust in soil the value of CBR is increased up to 4.56%, further increment of stone dust percentage the value of CBR is decreases as the mentioned in below table.

Table 4: CBR test value for Expansive Soil with Different Percentage of Stone dust.

Mix proportion	CBR %
Expansive soil	2.13
Expansive soil + 10% stone dust	3.42
Expansive soil + 20% stone dust	4.56
Expansive soil + 30% stone dust	3.48
Expansive soil + 40% stone dust	3.23

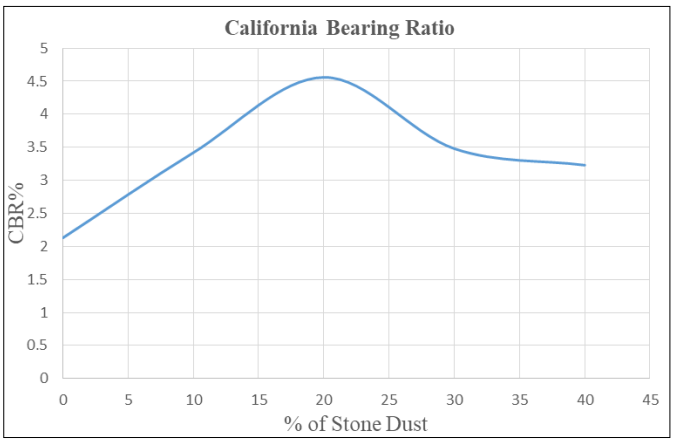

Fig 2: CBR value for Expansive Soil with Different Percentage of Stone Dust.

6. Conclusion

1. The result shows that the maximum dry density was increases and optimum moisture content decreases up to 30% of stone dust, further increment of stone dust percentage the MDD was decreases while OMC increases.
2. By the increment of stone dust in soil up to 20%, the value CBR is increases up to 114.08%.

7. Acknowledgment

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