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Addition of Crusher Dust for Stabilization of Expansive Soil

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Abstract: *Flexible pavements are the most commonly used form of pavement and have four component layers namely Sub-grade, Sub-base and base and surface courses which are made up of materials like natural soils, sand, morrum etc., are proved to be costly in terms of construction as well as maintenance. Performance of Flexible Pavement depends on the functions of the component layers especially Sub-grade. Sub-grade is compacted layer of soil, provides the lateral support to the pavement. Construction over soft Sub-grade affects the performance of pavement and results in shorter life of pavement. The typical approach of stabilization of soft Sub-grade is to remove the soft soil, and replace it with soil of high strength. The high cost of replacement of poor soil has caused highway agencies to assess alternative methods to construct the highway over soft Sub-grade. One approach is to improve the properties of soil by using crusher dust with expansive soils. Soil stabilization is one of the most suitable alternatives which are widely used in pavement construction. Soil stabilization technique used to improve the engineering properties of soil such as strength and stability. Crusher dust is one of the admixtures utilized for effective ground improvement technique over weak Sub-grade soil deposits. In this study crusher Dust has been selected as a Stabilizer. Laboratory tests were conducted on soil with various percentage of crusher Dust. Atterberg limit and compaction test were carried out on expansive soil-crusher dust mixtures and compared with properties of field soil. California bearing ratio (CBR) test was performed to determine the strength properties of the expansive Soil–crusher dust mixtures. Higher CBR values of expansive soil-crusher dust mix extent their potential for use as a Sub-grade for flexible pavement.*

1. Introduction: Sub-grade is generally made up of locally available natural soils. The strength and performance of a pavement is dependent on the load-bearing capacity of the sub-grade soil. In case of poor soil in construction site, the poor soil can be removed or replaced with the soil of high strength. Design of pavement is depend upon the strength of the sub-grade soil, which affects the thickness of pavement ultimately increase the cost of construction. Improvement in load bearing capacity of soil will improve the load-bearing capacity of pavement and thus, pavement strength and its performance.

Aggregate crusher units produce large quantities of crusher dust, a waste product, produced during crushing of Gravel and rock. Disposal of these large quantities of quarry dust produces serious problem in environment and health hazard. There is requirement to utilize these waste materials. Quarry dust can be used in very large quantity, reducing the total cost of construction in addition to providing a solution to an environmental problem.

2. Characteristics of crusher dust

Every day, quarries move large amounts of stones and aggregate In the process of removing these materials from the earth and moving them, quarries create a large amount of dust that is made from very small stone particles, known as crusher dust. Crusher dust is also created when metals such as iron ore are separated from iron ore and the resulting slag is crushed into fine particles. Crusher dust looks much like sand but is made up of angular particles with a rough surface.

Some of the characteristics are:

- Consistent chemistry
- Excellent load bearing capacity
- Non-plastic
- Resistant to heat and fire
- Alkaline in presence of moisture
- Effective utilization of an industrial by-product conserving natural resources

3. Aim

The present study is aimed to stabilize the expansive soil and utilize it as a pavement sub grade material by taking a mix proportion of expansive and crusher dust.

3.1 Objectives & Scope

- To find out the properties of the field soil.
- Utilization of locally available soil to improvise the pavement characteristics.

- To give a comparative study between field soil and expansive-crusher dust composition.

Fig.1 Crusher Dust

Crusher dust/Quarry dust exhibits high shear strength which is highly beneficial for its use as a geotechnical material. It has a good permeability and variation in water content does not seriously affect its desirable properties. Crusher dust proved to be a promising substitute for sand and can be used to improve the engineering properties of soils. The dry density increased with the addition of Crusher dust with attendant decrease in the optimum moisture content. Crusher dusts use less water than other alternatives and have excellent load bearing capabilities and durability. Crusher dust is fire and heat resistant; non-plastic.
As the stability of flexible pavements depends upon the particle friction and cohesion, cohesive frictional soils are the best suitable for the construction of flexible pavements.

The expansive soils are lagging in its friction and the crusher dust in its cohesion. Binding of these two soils gives the combination of cohesive frictional soils which is best suitable for the stability of flexible pavements.

4. Materials Used

Expansive Soil:
Expansive soil has been used as base material in the study. Expansive soil is collected from shallow depth from the nearby Rajajinagar Colony in Hanamkonda Town.

Crusher Dust: Crusher dust, basically a waste material, is collected from Gudepad Crusher Quarry (Parkal Road)

5. Experiments conducted

The following tests were conducted in evaluating the properties of expansive soil and crusher dust.

- Differential free swell test to evaluate the swelling index of the soil sample.
- Liquid limit test, plastic limit test to evaluate the liquid limit, plasticity index of the soil sample.
- Sieve analysis for grain size distribution and determination of type of soil.
- Specific gravity test of expansive soil and crusher dust.
- Direct shear test and unconfined compression test to find shear strength parameters of expansive soil and crusher dust.
- Standard proctor test to evaluate the optimum moisture content and dry densities of various mix proportions.
- California bearing ratio test for evaluating the suitability of the expansive soil and crusher dust mix to be used in sub-grade course of a pavement embankment.

Table 1. Properties of crusher dust

Property	Range
Is classification	SP
Specific gravity	2.55
Compaction characteristics:	
Optimum moisture content (OMC) (%)	5.88
Maximum dry density (MDD) (g/cc)	2.24
Shear parameters:	
Angle of shearing resistance (deg)	48°40'
California bearing ratio (CBR) (%) (Soaked)	20
Permeability (cm/s)	$4.92*10^{-3}$

	Property	Range
1.	Liquid limit (%)	**41.044**
2.	Plastic limit (%)	**26.93**
3.	Specific Gravity	**2.75**
4.	Differential free swell (DFS) of expansive sample	**14.28%**
5.	The unconfined	**1.2kg/sq.cm**

compressive strength	
6. OMC	**10.02%**
Dry density	**2.14 g/cc**

Table 2 Properties of Expansive

6. Stabilization of soil using crusher dust

6.1 Addition of 10% crusher dust for stabilization

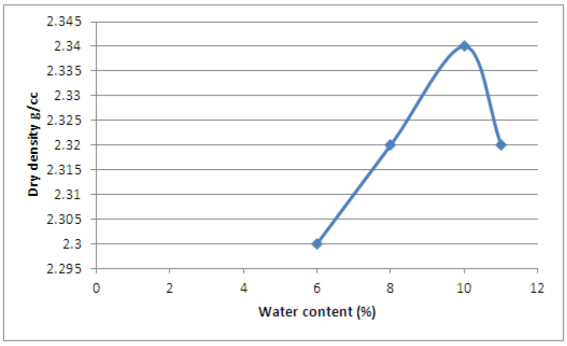

Fig. 2 Compaction Curve for 10% Crusher Dust
OMC = 10.0%
MDD = 2.34 g/cc

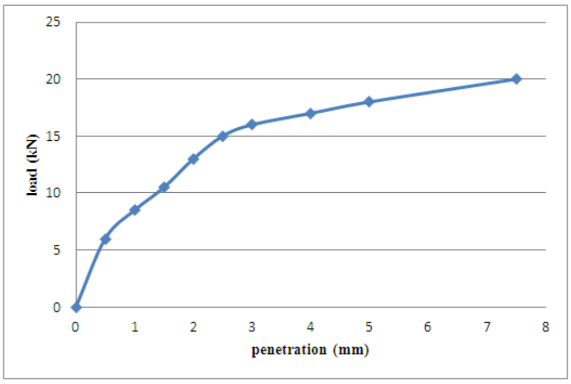

Fig. 3 CBR Test Curve for 10% Crusher Dust
CBR Soaked (%) = 2.56

6.2 Addition of 20% crusher dust for stabilization

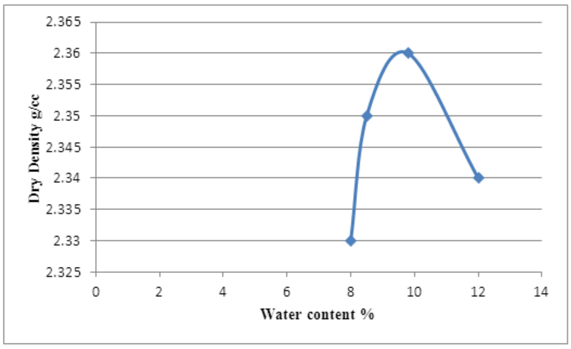

Fig. 4 Compaction Curve for 20% Crusher Dust
OMC = 9.9%
MDD = 2.36 g/cc

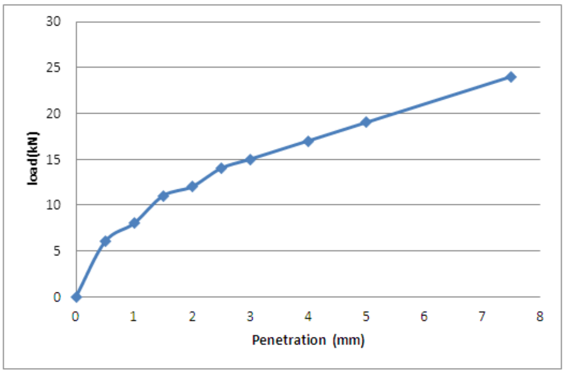

Fig. 5 CBR Test Curve for 20% Crusher Dust
CBR Soaked (%) = 2.75

6.3 Addition of 30% crusher dust for stabilization

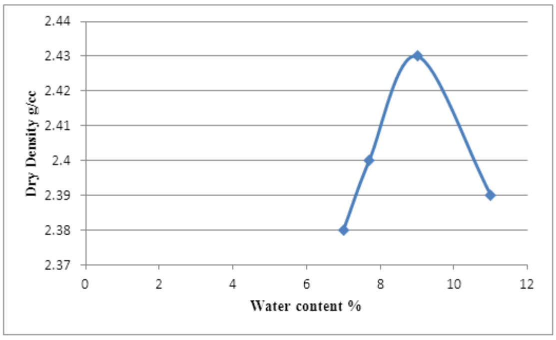

Fig. 6 Compaction Curve for 30% Crusher Dust
OMC = 9.87 %
MDD = 2.43 g/cc

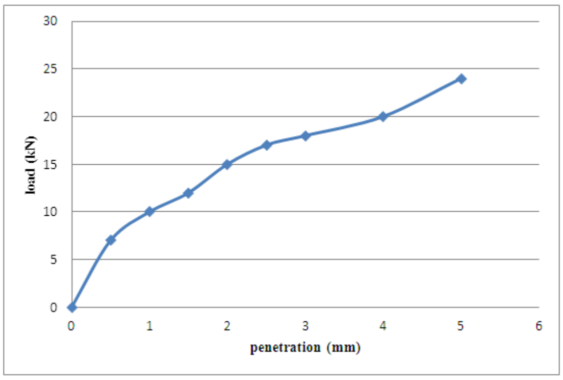

Fig. 7 CBR Test Curve for 30% Crusher Dust
CBR Soaked (%) = 3.94

6.4 Addition of 40% crusher dust for stabilization

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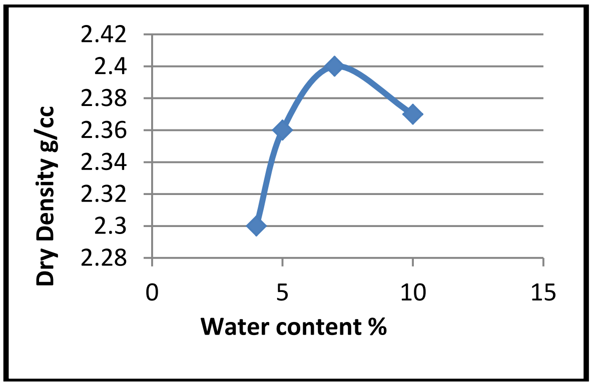

Fig. 8 Compaction curve for 40% crusher dust
OMC = 7 %
MDD = 2.40 g/cc

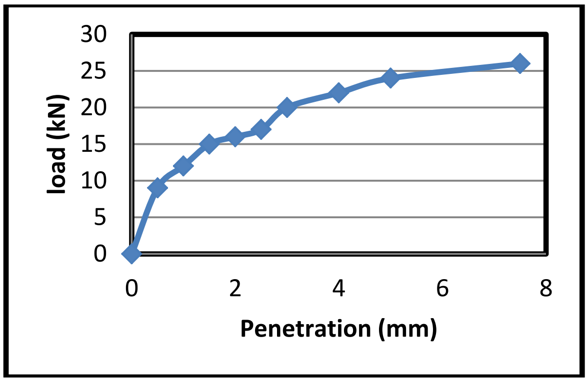

Fig. 9 CBR Test Curve for 40% Crusher Dust
CBR Soaked (%) = 3.35

6.5 FIELD SOIL
6.5.1 Compaction Curve for Field Soil

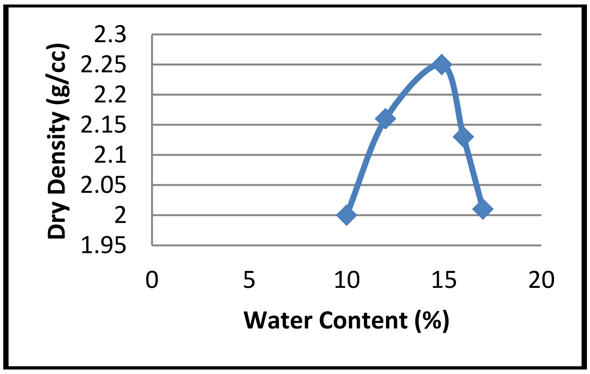

Fig. 10 Compaction Curve for Field Soil
OMC = 14.89%
DRY DENSITY = 2.25g/cc

6.5.2 CBR for Field Soil (Soaked)

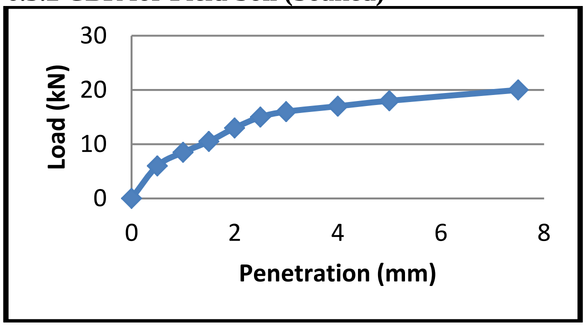

Fig. 11 CBR Test for Field Soil
CBR Soaked (%) = 2.56

Optimum moisture content and maximum dry density and CBR values of expansive soil and crusher dust are tabulated as follows

Table 3. Results of tests conducted on expansive in addition with crusher dust

Mix proportion	Optimum water Content(%)	Maximum dry density g/cc	Soaked CBR (%)
Expansive Soil + 10% Crusher Dust	10	2.34	2.56
Expansive Soil + 20% Crusher Dust	9.8	2.36	2.75
Expansive Soil + 30% Crusher Dust	**9.57**	**2.43**	**3.94**
Expansive Soil + 40% Crusher Dust	4.0	2.5	3.35

7. Conclusion

The experiment conducted to study the effect of quarry dust addition on conventional soil reveals the following.

- The addition of crusher dust to the soil reduces the expansive content and thus increases in the % of coarser particles, reduces OMC of soil to 63% with increase in % of crusher dust.

- MDD of soil is increased by 8.0% by addition of 30 % crusher dust
- It is also identified that addition of 30% crusher dust yield a higher CBR value.
- It is observed that MDD is increased when crusher dust is added when compared with field soil.

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