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Impact of Stone Mine Waste on Sub Grade Characteristics of Expansive Soil

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ABSTRACT

Today, India is running on the way of development, thus the rapid growth of industrialization is increasing which creates scarcity of land for disposal of their industrial wastes. Hence, the urgent demand for utilization of such types of waste is coming out. From the civil engineering point of view, the kota stone dust, marble dust, rice husk, fly ash, blast furnace slag, foundry sand, glass waste, tiles waste, ceramics waste etc are the commonly waste which are used as a construction materials with replacement of conventional materials successfully and also having effective characteristics required by a good soil stabilization admixture. The current research shows the effective utilization of kota stone dust in the improvement of sub grade characteristics of black cotton soil. A number of tests were conducted in laboratory which shows that the kota stone slurry dust is a good alternative for the improvement of sub grade characteristics of black cotton soil. The Standard compaction test were conducted in laboratory for obtaining the maximum dry density (MDD) and optimum water content (OMC) corresponding to 3% to 24% of kota stone slurry dust mixed with black cotton soil in the variation of 3% each. After the determination of OMC and MDD of different proportion, the laboratory California bearing ratio (CBR) tests were conducted with the above proportion of kota stone slurry dust and it was concluded that soaked CBR value of black cotton soil blended with 18% kota stone dust increased from 2.12 to 8.37 i.e. 295%.

Keywords:-*Black cotton soil, CBR Test, cost analysis, kota stone slurry dust*

INTRODUCTION

As per the current scenario of India, the production of waste materials researches its maximum limit as compared to their utilization. In the field of civil engineering the various waste materials are currently used as a substitution of the convention materials such as fly ash mostly used in the replacement of cement etc. these waste materials also having the good geotechnical characteristics and easily used in the soil modification programs. Soil improvements or stabilization technique is basically used for improving and enhancing the geotechnical properties of soil. The stabilized soil is having the beneficial properties, which basically depends upon the applications area where soil is used. Generally stabilized soil reduces the pavement thickness, eliminate the handling and hauling quantity of excavation material, higher the resistance value, reduce the swelling characteristics and plasticity of clayey soil. The black cotton soil, which also known as expansive soil, is found in major parts of Rajasthan, Madhya Pradesh and Andhra Pradesh of India and it covers $0.70X10^6$ km² approximately 21-25% land area of India. It is types of a problematic soil contain the famous clay mineral Montmorillonite approximate 30-60% hence as per the chemistry of these clay mineral whenever it comes in the contact of water they causes swelling and when water content removes, they shrink the soil mass with appearance of lot of cracks on the surface of black cotton soil. The estimated data shows that the structures founded on the black cotton soil experiences the structural damage of about $1000 Millions in USA, £150 UK, and many billion pounds in worldwide annually [1].

In recent years the waste management in the field of civil engineering gets a successful leads the many researches completed the work on these filed and applied them into many serious and problematic conditions regions such as in the area of black cotton soil etc. For the purpose of soil modification, the various industrial waste materials such as marble dust, fly ash, rice husk ash, phosphor-gypsum, cement kiln dust, copper slag, bagasse ash ceramic dust, waste steel chips, brick dust and lime were frequently used.

There are many natural stone wonders the earth offers us which we must pamper as unique treasures. India offers a variety of natural stone viz; Granite, Sandstone, Slates, Kota stones, Quartzite, Kota stone in multi colors, shapes and size. Unique to the region of Kota, the exclusive range of Kota stone is easily available in the natural surroundings. Made up of limestone, Kota stones are usually preferred for interior decoration of an apartment. The suddenly growth of industries of Kota stone, generates a hazardous slurry dust at a large extent which creates a problems to the humans surrounding them as well as acts as a industrials pollutant so affect the ecological system of the environment. It is a type of a solid waste which is generated from cutting and polishing of stone.

The several researchers has been done in the direction of utilizing of quarry dust waste into the soil stabilization technique. Swami, ; Baser, Palaniappan et. al. [2,3] had revealed that the influence of quarry dust on geotechnical properties of black cotton soil and has reported that they varied successfully. The objective of this study is to determine the effective utilization of kota stone slurry dust on Compaction, Atterberg limits, tri axial, consolidation parameters, unconfined compression strength, Soaked CBR and Swelling pressure characteristics of black cotton soil stabilized with optimum percentage of Rice husk ash. Also many researchers such as Kavas T., Demirel, Agrawal et. al., Chandra et. al., Sabat et. al., Viswakarma et. al., Gandhi, Gupta et. al. [411] etc. reported the effective utilization of the quarry dust in black cotton soil stabilization which technically improves the geotechnical properties such as compaction characteristics, swelling characteristics, hydraulic conductivity, unconfined compressive strength characteristics and index properties of soil such as plastic limit, liquid limit and shrinkage limit.
In this paper, study the influence of waste material (kota stone slurry dust) on sub-grade characteristics of black cotton soil.

EXPERIMENTAL PROGRAM
The entire laboratory test is conducted with accordance of ASTM and Indian standards.

Black Cotton Soil (BCS)
Black cotton soil was collected from Jhalawar (24° 59′ 73″ N, 76° 16′ 10″ E), Rajasthan, India. As per ASTM D2487-11 [12], the black cotton soil used in this study was clay with intermediate plasticity (CI).

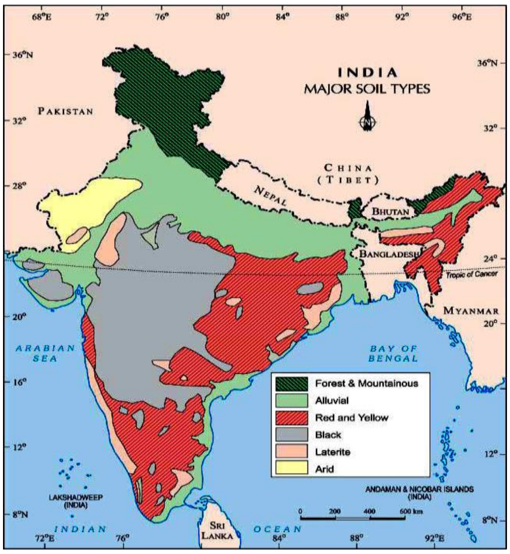

Fig.1:*-Map shows the soil formation in India*

Kota Stone Slurry Dust (KSSD):
KSSD used in this study was collected from local kota stone grinding and polishing industry. The chemical composition of KSSD used in this study is given in Table 1.

Table 1:*-Chemical composition of KSSD*

Constituent	**Percentage**
SiO_2	23.0
Al_2O_3	3.00
Fe_2O_3	0.11
CaO	41.0
MgO	1.50
SO_3	0.15
Na_2O	1.20
K_2O	0.14
Loss of ignition	29.90

The physical properties of black cotton soil and KSSD are presented in Table 2.

Table 2:*-Physical properties of Black soil and KSSD*

Property	**Black Cotton Soil**	**KSSD**
Specific Gravity	2.68	2.59
Maximum Dry Density (MDD), g/cc	1.846	1.843
Optimum Moisture Content (OMC), (%)	13.63	12.77
Soil Classification	CI	-
Differential Free Swell Index (%)	38.65	-
Liquid Limit (%)	42.0	25.7
Plastic Limit (%)	16.75	Non Plastic
Plasticity Index (%)	25.81	-
Shrinkage Limit (%)	10.46	35.51
Uniformity Coefficient, Cu	1.00	1.01
Coefficient of Curvature, Cc	1.02	1.00
Soaked CBR (%)	2.12	-

RESULTS AND DISCUSSIONS

The hydrometer analysis tests were conducted as per ASTM D422-63 [13]. The particle size distributions of black cotton soil and KSSD tested as per ASTM D6913-04 [14] are given in Figure 2.

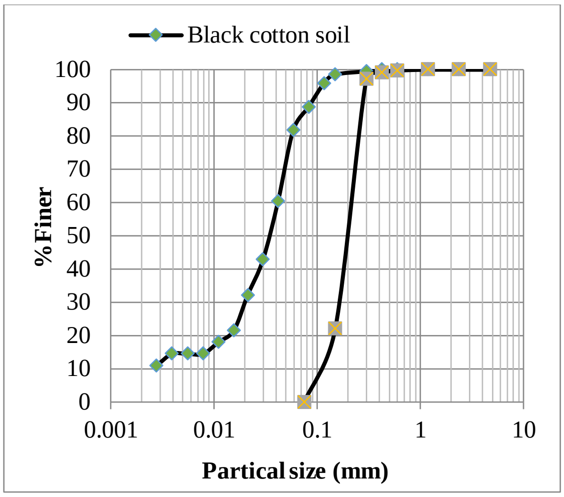

Fig.2:-*Particle size distribution of black cotton soil and KSSD*

Compaction Tests:
The standard compaction tests were performed in laboratory in accordance with ASTM D698-07E1 [15]. The water content-dry density curves of black cotton soil mixed with KSSD varying from 3% to 24% are shown in Figure 3. It is observed that maximum dry density (MDD) of the black cotton soil-KSSD composite increases with the increase in KSSD content up to 18% and decreases with further increase in KSSD whereas the optimum water content (OMC) decreases. This occurs due to the reason that the void spaces between the black cotton soil particles are occupied by the KSSD particles. The variations in MDD and OMC with KSSD are shown in Figure 4.

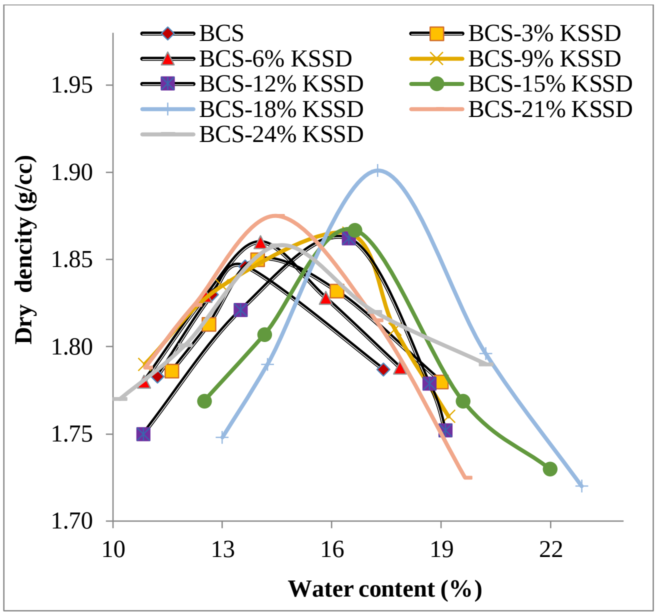

Fig.3:-*Compaction characteristics of black cotton soil (BCS)-KSSD*

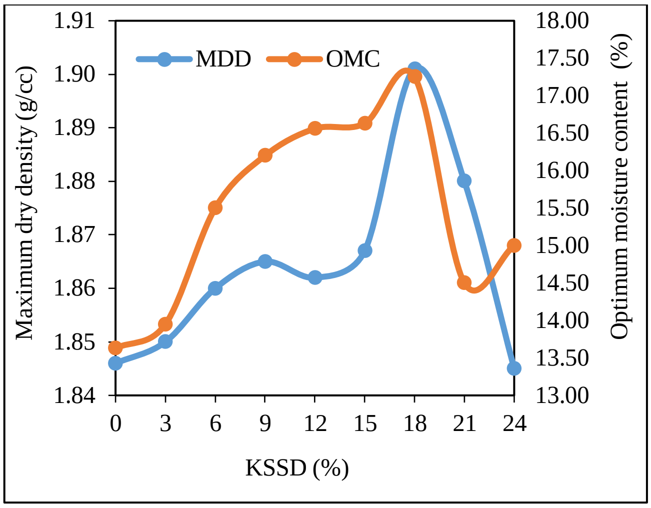

***Fig.4:**-Variation in MDD and OMC*

California Bearing Ratio Test:
The California bearing ratio tests were performed in laboratory in accordance with ASTM D1883-05 [16]. The improvement in CBR value may be attributed to better compaction and packing of the mix particles with addition of micro silica fume. The California bearing ratio provides a basis of designing the sub-grades of flexible pavements. Usually, a value of CBR more than 5.0 is considered to be satisfactory for the design of flexible pavements with traffic intensity of 1 to 10 million standard axles (Msa). Thus, the black cotton soil blended with KSSD can be effectively used in the construction of sub-grades of roads with low traffic volume. The Figure 5 shows that that the max CBR value achieves at 18% KSSD blended with black cotton soil. The value of soaked CBR of black cotton soil increases from 2.12% to 8.37%. The improvement in CBR value may be attributed to better compaction and packing of the mix particles with addition of KSSD.

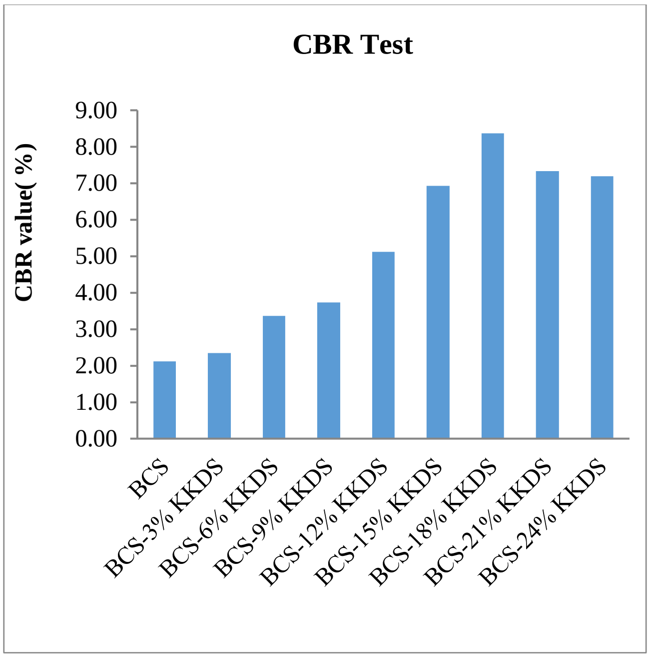

***Fig.5:**-Variation of soaked CBR value with percentage of KSSD*

DESIGN AND COST ANALYSIS OF FLEXIBLE PAVEMENT

According to IRC: 37-2001 [17] (Guide lines for the design of Flexible Pavements), a flexible pavement has to be designed for cumulative traffic of 1, 5 and 10 msa (million standard axles) for CBR values of both stabilized and unstabilized soils. Generally, the soaked CBR value greater than 5.50% is preferred for sub-grade of flexible pavements having lighter traffic intensity. The soaked CBR value of unstabilized soil is 2.12% and the soaked CBR value of stabilized soil mix is 8.37% which have been considered for the design purpose.

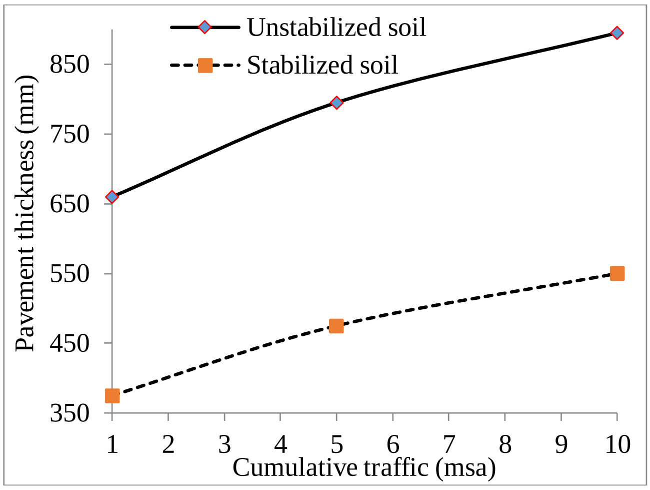

Fig.6:-*Variations in pavement thickness corresponding with cumulative traffic (msa)*

From the Figure 6, it is clear that the pavement thickness with respect to cumulative traffic (msa), reduces significantly, hence the cost in rupees per m^2 for pavement design, calculated by local standard schedule of rates (SOR), also reduces with stabilization of black cotton soil in the influence of waste materials, shown by Figure 7 which shows that the cost of flexible pavement construction per square meter varies from 1073 to 2117 Rupees using un-stabilized sub-grade and from 672 to 1436 Rupees using stabilized sub-grade for cumulative traffic of 1-10 msa.

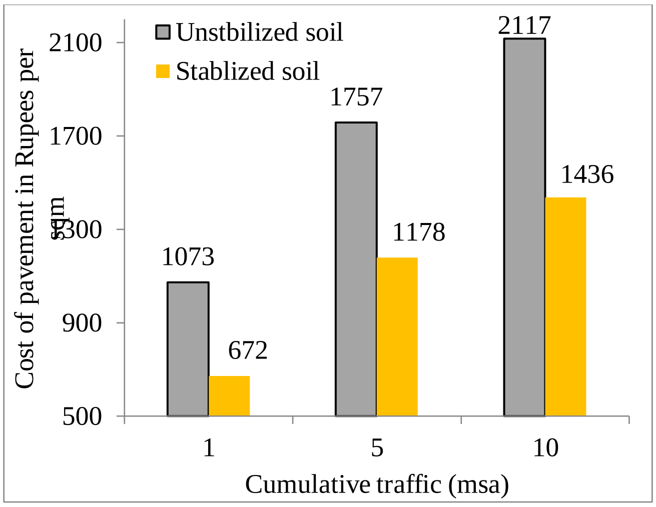

Fig.7:-*Variations in Cost of pavement (Rupees per sqm) corresponding with cumulative traffic (msa)*

The variation of percentage saving in cost of flexible pavement construction per square meter for cumulative traffic of 1 to 10 Msa is shown in Figure 8. It is observed that the saving in cost for the flexible pavement constructed by using stabilized soil sub-grade varies from 37% to 32% for cumulative traffic of 1 msa to 10 msa respectively. Thus, the stabilization of locally available soil utilizing industrial and construction waste materials along with stone quarry dust provides improved compaction and strength characteristics and reduces the cost of construction substantially. The degradation caused to the environment due to use of these waste materials can also be controlled to some extent.

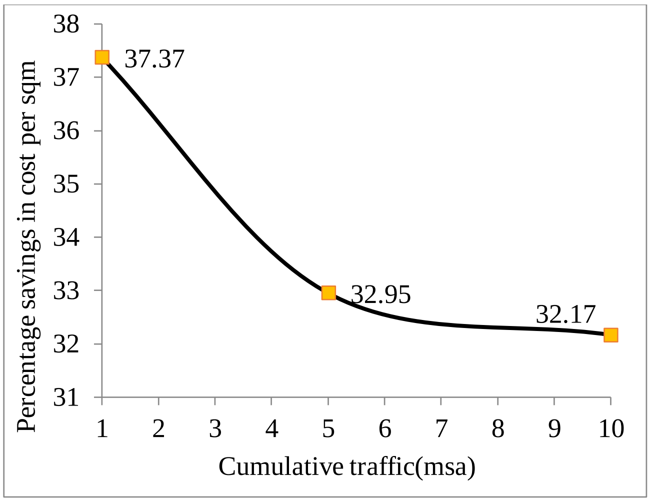

Fig.8:*-Variations in % saving in cost per sqm corresponding with cumulative traffic (Msa)*

CONCLUSION

Based upon the above study the following conclusions can be drawn:

1. Maximum Dry Density (MDD) of the black cotton soil-KSSD composite increases with the increase in KSSD content up to 18% and decreases with further increase in KSSD (Figure 3). This occurs due to the reason that the void spaces between the black cotton soil particles are occupied by the KSSD particles.
2. The soaked California bearing ratio value of black cotton soil improved significantly i.e. from 2.12% to 8.37% approximately 295% with black cotton soil-18% KSSD composite mix (Figure 5).
3. Thus, black cotton soil stabilized with KSSD can be used as a sub-grade material for construction of flexible pavements in rural roads with low traffic volume.
4. The final optimum mix of waste materials blended with black cotton soil is an improved construction material and in the construction of flexible pavement design it imparts considerable cost saving. (Figures 6-8)

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