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Variables Controlling for Atterberg Limits of Kota Stone Slurry Dust Stabilized Expansive Soil

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ABSTRACT
The production rate of industrialization increases the demand for waste disposal. The method of disposing waste in soil is one of the conventional methods which require a large area of land, but now due to the lack of availability of land, this waste is used as a soil stabilizer in the technique of soil stabilization. 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. In this paper, the reduction of this problematic nature of soil by blending of stone quarry waste material such as kota stone slurry has been attempted. A number of Consistency Limits (Liquid Limit, Plastic Limit and Plasticity Index) tests are carried out on Expansive soil (Black Cotton Soil) stabilized with various kota stone slurry (KSS) contents. The results show that Consistency limits (C_L) fitting curves were followed liner pattern with the increase in KSS and a linear line function has been fitted to assess the optimum relationship between C_L and KSS percentage. It is observed that for the relationship among C_L and KSS, the optimum fit could be obtained after applying the slope equal to -0.4 to the KSS content (L) parameter. Finally, a unique relationship between C_L and KSS is also established, i.e., $C_L = 86.53-18.64x-0.4k$, where k and x represents KSS contents and various consistency limits.

Keywords:-*Expansive soil, quarry dust, consistency limits, morphological characteristics, parameter controlling*

INTRODUCTION

The Black cotton soil or expansive soil contains montmorillonite as a clay mineral, which is responsible for alternative swelling and shrinkage behavior of soil. Basically, montmorillonite contains water bonds between soil particles. Due to these water bonds, the volume of soil increases when in contact with water. This alternation in soil creates structural damage on structure based on them. The volume change properties of expansive soil due to change in the seasonal moisture in soil was reported by Hausmann [25]. About $1000 Millions in USA and £150 UK, and many billion pounds worldwide annually structural damage is caused to structures founded on expansive soil as reported by Gourley et al [23]. A study on swell pressure and methods for reducing swell in the soil has been reported by Ramana Murthy [28]. The stabilization of expansive soil includes the alteration in the fine grain size of particles of expansive soil by using coarser particles of waste materials so that blended composite having the both cohesion and friction soil strength parameter, which enhances the bearing capacity of soil and improves the

problematic nature when it mixed, compacted and placed in control manner.
The enhancement in swelling traits of expansive soil the use of coarse-grained soil is pronounced with the aid of Sherif M. ElKholy [21]. In India, the expansive soil accessible in main components of Madhya Pradesh, Rajasthan and Andhra Pradesh which shelters about 20-25% land vicinity of the country. The use of industrial waste as a soil stabilizer is a low-cost and high-quality way for accomplishing the enhancement in geotechnical backgrounds of expansive soil as advocated by Soni et al [32].

In the location of Kota, the extraordinary vary of Kota stone is effortlessly on hand in the natural surroundings. Made up of limestone, Kota stones are generally desired for indoors ornament of an apartment. The unexpected boom of industries of Kota stone generates hazardous slurry dirt to a giant extent which creates a trouble for the human beings surrounding them as nicely as acts as an industrials pollutant so have an effect on the ecological gadget of the environment. It is a kind of strong waste that is generated from reducing and sharpening of stone. Several researchers have been completed in the route of utilizing of quarry dirt waste into the soil stabilization technique. Swami, 2002; Baser [11], Palaniappan and Stalin, 2009 had printed an attempt on of quarry dirt on geotechnical characteristics of expansive soil and has mentioned that they different successfully. The goal of this find out about is to decide the advantageous utilization of Kota stone slurry on Compaction, Atterberg limits, triaxial, consolidation parameters, unconfined compression strength, Soaked CBR, and Swelling strain characteristics of expansive soil stabilized with the most excellent share of Rice husk ash. Also many researchers such as [1,16,19,22,27,33,36] etc. suggested the high-quality utilization of the quarry dirt in expansive soil stabilization which technically improves the geotechnical behaviors of soil.

In this paper, study the influence of quarry dust (kota stone slurry) on consistency limits of expansive soil and along with parameter controlling kota stone slurry contents.

EXPERIMENTAL PROGRAM

As per experimental guidelines mentioned in ASTM and Indian standards, entire laboratory test is conducted on Expansive soil or Black cotton soil (BCS).The soil was collected locally and it was classified as clay with intermediate plasticity (CI).

Kota Stone Quarry Dust (KSS)

The Kota Stone Quarry Dust was collected from local kota stone industry. The chemical composition of Kota Stone Quarry Dust is represented in in Table 1.

***Table 1:**-Chemical composition of KSS*

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 expansive soil and KSS are presented in Table 2.

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

Property	Expansive soil	KSS
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

As per ASTM D422-63, the hydrometer analysis of compositions was completed in laboratory. The grain size distributions curve of materials is represented in Figure 1, whereas the Figure 2, represents the test setup.

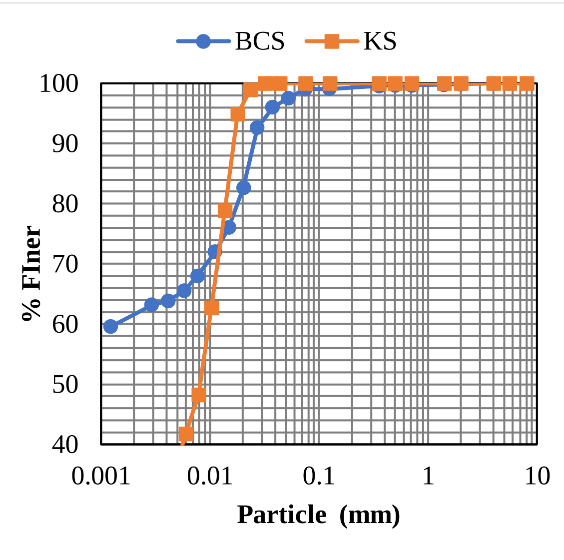


***Fig.1:-**Particle size distribution of expansive soil and KSS**Fig.2:-**Hydrometer Arrangement*

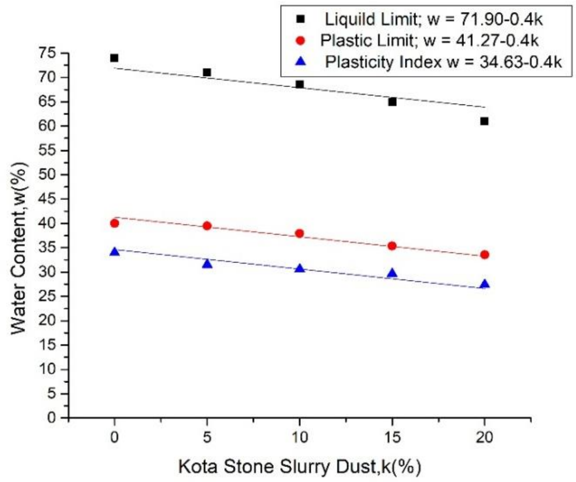
Primary, The soil was mixed with kota stone slurry in various commotions such as 5-20% and afterward the characteristics of stabilized soil were examined by conducting respective tests in the laboratory.

Index Properties Tests

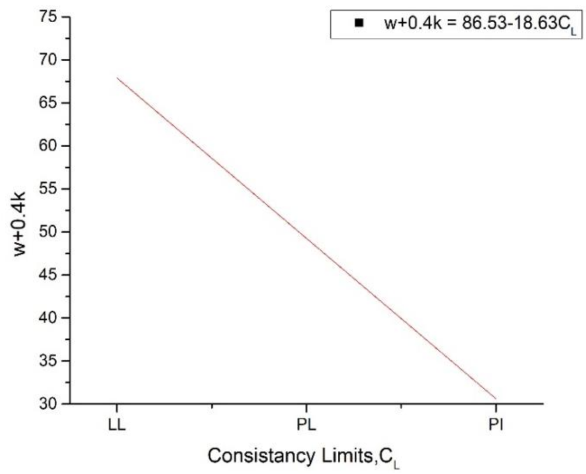
The index properties i.e. consistency limits, specific gravity and particle size distribution tests were conducted as per relevant ASTM standard as shown in Table 2.

Consistency Limits

As per ASTM D4318-10 standard the consistency limits test was conducted in Laboratory which shows that, liquid limit and plastic limit decreases, whereas the shrinkage limit increases on every addition of waste material in the expansive soil. The variation in the Consistency limits i.e. liquid limit, plastic limit, and plasticity index of all composites are shown by Figure3(a).



(a)



(b)

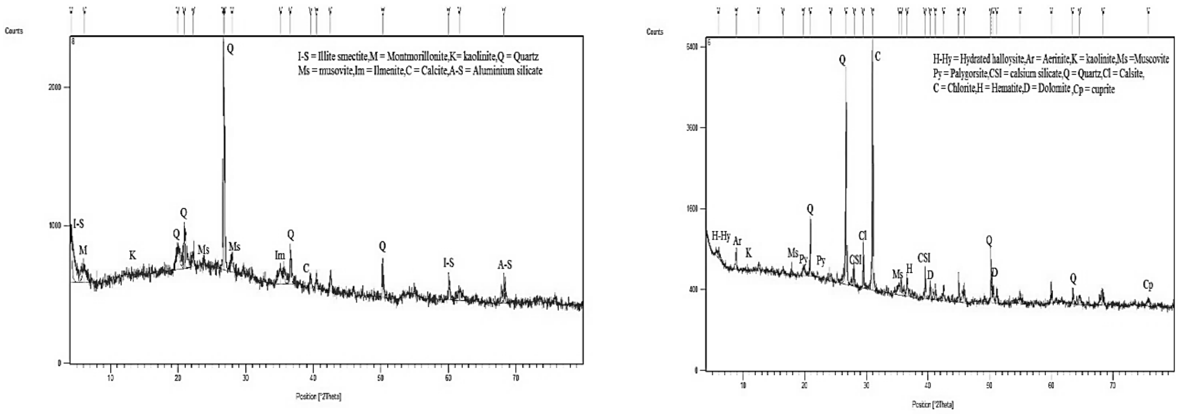
Fig.3:*(a)Variations in Consistency limits for all mixes blended with expansive soil; (b) Relationship between water content (w), KSS content (k), and various consistency limits (x)*
With the help of statistical analysis tool, the linear regression analysis was done in which a linear curve was fitted on the experimental data sets of consistency limits such as Liquid Limit (L_L), Plastic Limit (P_L) and Plasticity index (P_I).

The Figure 3 Represents the fitted curve along with Adjusted R-Square Values. The results derived from mentioned regression are represents by Eq. 1-3.

For Liquid Limit (Water Content), $w = 71.90-0.4k$; ($R^2 = 0.98$) (1)
For Plastic Limit (Water Content), $w = 41.27-0.4k$;($R^2 = 0.92$) (2)
For Plasticity Index (Water Content), $w = 34.63-0.4k$;($R^2 = 0.96$) (3)
It is observed that for the relationship among water content for various consistency limits (w) and Kota Stone Slurry (k) contents, the optimum fit could be obtained after applying the slope equal to -0.4 to the KSS content. The Finally, a unique relationship between water content for various consistency limits, KSS content (k) and Consistency limits (x), is also established, i.e.,
$w = 86.53-18.64x-0.4k$;($R^2 = 0.93$) (4)

where x represents various consistency limits. The value of x for Liquid Limit (L_L), Plastic Limit (P_L) and Plasticity index (P_I) are 1, 2 and 3 respectively.

Morphological Study
The morphological study (X-Ray Diffraction) of expansive and the optimum exapnsive soil and KSW blend were conducted. The Figure4(a,b) shows the XRD graphs of expansive soil and optimum blend (BCS-15% KSS) respectively.



(a) (b)

Fig.4:*-XRD images of (a) Expansive Soil, (b) Optimum blend of soil and KSS waste*

The Figure 4, illustrate the morphological characteristics (XRD images) of expansive soil and the final optimum blend, shows that the expansive soil having the Montmorillonite as a clay mineral which passage a swelling nature in soil. Whereas after the treatment of soil with KSS, optimum blend has not contained these mineral and having calcium minerals in large quantity so that by they form a calcium silicate hydrated structure and passage greater strength and lack in its swelling behavior.

CONCLUSION

As aforesaid, due to alternate swelling and shrinkage behavior of soil causes structure failure and financial loss worldwide. Whereas Kota stone quarry is waste substances produced by way of the slicing of stone with additionally having appropriate geotechnical characteristics too. Thus, the addition of quarry dirt into soil, decorate the formed composite combine. It lets in its uses in many development areas main to protected disposal of waste. Based on the above study, the conclusions can be drawn:

1. The blend of soil and KSS dust was creates a composite interlocked well graded material.
2. The Atterberg limits such as liquid and plastic limit of stabilized soil were improving with presence of KSS dust in stabilized composite. (The variation in index properties is shown in Figure 3).
3. A unique relationship between water content, KSS content and various consistency limits is established.
4. Results presented by Eq. (4) can help the engineer/user to choose the optimum amount of KSS for appropriate consistency limits.

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