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Stabilization of Peat soil using locally available admixture

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***Abstract*—Peat soil has geotechnical properties such as high water content, high organic matter content, low shear strength, low bearing capacity and high compressibility which makes it as a difficult soil for construction of structures in its natural state. In Manipur, India around 4,24,000 hectares of land area is covered by peat soil, so, improvement mechanism is needed for construction of structures upon it. Industries are very less in Manipur, so commonly used stabilising industry by products like fly ash, lime etc are not economically available. Therefore, locally available admixtures such as stone dust (S D) and kiln dust (K D) have been selected for stabilization of peat soil. Admixtures are mixed with peat soil in different seven (7) percentages: 0%, 2%, 5%, 8%, 10%, 12%, and 15%, respectively. Again the peat soil is also mixed with both stone dust (S D) and kiln dust (K D) in the ratio of (soil: stone dust: kiln dust); 94:3:3, 92:4:4, 90:5:5, 88:6:6 and 86:7:7. Proctor compaction test, Unconfined compressive strength test, triaxial shear strength test and California bearing ratio tests are conducted on stabilised soil to determine admixture impact on peat soil properties. Laboratory test results shows that Maximum dry density (MDD) and unconfined compressive strength of stabilised soil are maximum at 10% of admixtures. Maximum value of shear strength are observed at 8%, for soils with KD and SD+KD, & at 5% for soils with SD. CBR values increases in all cases & bearing capacity is maximum at 8%. Results of this study show that, if properly optimized, the use of these locally available admixtures may be a viable alternative for the stabilization of peat soil.**

***Keywords* — Peat Soil, Stabilization, Admixture, Stone Dust, Kiln Dust.**

I. Introduction

About 1billion or about 4.5% of total land areas of the world is covered by Peat soil. [1]. According to horticulture and soil conservation department of Manipur about 4,24,000 hectares of land area of Manipur, India is covered by peat soil. This soil is not suitable for the construction of embankment, highway, building or any other load bearing engineering structures in its natural state as it has the properties of high organic content, high water content, acidity, and low shear strength and bearing capacity, low specific gravity and it is extremely compressible. Peat exhibits unique geotechnical properties in comparison with those of inorganic soils such as sand, silt or clay. As the peat soil is highly compressible, so it undergoes excessive settlement when buildings are constructed above it. It causes instability problems such as slip failure, local sinking, and considerable primary and long-term settlement even a moderate load is subjected on it.

With the increasing demand of land for the development of a country, it is very difficult to avoid construction over the soft peat soil as it cannot be used commonly for the cultivation of crop because of its acidity. Therefore, it becomes necessary to improve the properties of peat soil for any construction of civil structures on it. Various construction techniques have been carried out by several researchers, such as excavation-displacement or replacement method, stage loading and surface reinforcement method, pile supported embankment method, light weight fill raft method, deep in-situ chemical stabilization method and thermal precompression method. These methods involve high cost. Stabilization of peat soil by adding industry by products such as lime, fly ash etc. as admixture is also in practice.

Several researchers have studied the stabilization of peat soil by cement, lime, fly ash and combination of cement with fly ash, cement with bentonite, calcium chloride, lime, lime with cement, lime with fly ash[4-11]; stabilization on soft soil using chemical [12-13], lime[14], lime with fiber [17], lime with Sludge [18], lime with mine trilling [19], Granulated blast-furnace slag with lime and cement [20],Granulated blast-furnace slag and fly ash [16], using plastic waste [15] oil-shale solid waste[22].

In Lamphelpat,(24.825067˚N 93.908987˚E) Manipur, India industries are very less, so commonly used stabilising industry by products like fly ash, lime etc are not economically available. Therefore, in this research paper, an approach is being made to use locally available admixtures such as stone dust (SD) and kiln dust (KD), as an alternative stabilizing materials to stabilize peat soil. Stone dust and kiln dust are by product from the crushing stone factories and brick industries respectively.

II. Test Material and Methodology

A. *Peat soil sample*

In this study, peat soil samples are collected from Lamphelpat, Manipur, India where National Institute of Technology, Manipur is proposed to be constructed. From the

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site investigation, it has been observed that the site is water logged and it has climatic condition such as moderate temperature, moderate to high humidity and high rainfall etc. which lead to the formation of peat soil. It is observed from visual observation that the soil is black to dark brown in color and spongy in nature.

To ensure the uniformity of the collected soil sample it was dried, pulverized and sieved through 4.75 mm IS sieve before used in the present investigation.

Figure 1: Collection of sample from site.

B. *Stone dust (SD)*

Stone dusts are collected from nearby stone crusher factory. The stone used in this factory are mainly lime stone and sand stone. It has cementing property and can also be used as filler material.

C. *Kiln dust (KD)*

Kiln dust is the by product of clay bricks, collected from the nearby brick farm. Its major constituents are mainly silica quartz and alumino-silicate. It has pozzolonic properties and can also be used as filler material.

Figure 2: Admixtures.

D. *Research Methodology*

Different tests are conducted to determine the optimum percentages of admixtures that can be mixed with peat soil to obtain optimum strength. The admixtures, ie, stone dust and kiln dust are mixed separately with peat soil (by weight of the soil) in seven (7) different percentages: 0%, 2%, 5%, 8%, 10%, 12%, and 15% respectively. Again soil is mixture with stone dust and kiln together in five (5) different ratios i.e. soil: stone dust: kiln dust as 94:3:3, 92:4:4, 90:5:5, 88:6:6 and 86:7:7 respectively. Preparations of stabilized soil samples for test are done as per standard code. Strength test are also done as per relevant IS codes. After completion of strength test for all samples, impacts of different admixture on properties of peat soil are determined in term of strength increase.

E. *Preparation of stabilized soil sample*

Peat soil sample are collected from the field and then transported to the Geotechnical Engineering laboratory of National Institute of Technology, Silchar, Assam to carry out necessary investigation. Peat soil are dried first, under direct sun light and then so selected for the testing such that 50% of soil retain on 4.75 micron sieve and 50% passes through 4.75 micron sieve. Water is added to the soil approximately at optimum moisture content and mixes thoroughly to a uniform condition by hand taking care of minimum loss of moisture. Then, the required quantity of stabilizer is added to the soil and mixed uniformly. Sample are prepared as per IS: 4332 (Part 1)-1967.

III. Experimental investigation

A. *Physical properties of peat soil*

A series of tests are conducted in order to determine the physical properties of the natural or original peat soil and admixtures. Different tests to find the properties of the peat soil like natural moisture content, specific gravity (G), fiber content, liquid limit, plastic limit, particle size distribution, pH value etc are conducted for as per relevant IS codes. Chemical tests are done to find the chemical properties of the peat soil as total soluble solid and total soluble sulphate.

B. *Engineering Properties of peat soil*

Standard Proctor compaction test, triaxial shear strength test, unconfined compressive strength test and CBR test are performed to determine the engineering properties of the peat soil as per relevant IS codes.

Summary of the different properties of peat soil are shown in Table 1. And physical properties of admixture are shown in Table 2. From the laboratory tests, it has been observed that peat soil is fibric in nature having high ash content with highly acidic as per code. [ASTM D 4427 – 92].

IV. Test Results and discussion for stabilized soil

A. *Compaction Characteristics*

Standard Proctor compaction test are carried out for the stabilized soil samples, to find the maximum dry density (MDD) and optimum moisture content (OMC). Graphs are plotted between OMC Vs percentage of admixture as shown in "Fig. 3", and MMD Vs percentage of admixture as shown in "Fig. 4". From the test results it is found that the OMC of the stabilized soil samples decreases with the increase of admixture to a minimum value (at 10% of admixtures),

beyond that, the OMC of the stabilized soil starts increasing again. The maximum dry density (MDD) increases with increase of admixture and become maximum at 10% then it starts decreasing. Similar trends occur for all the type of admixtures. The maximum MDD is found to be 9.52 kN/m^3 at OMC of 47% for stone dust, for kiln dust maximum MDD is 9.39 kN/m^3 at OMC of 45.23%. For combination of stone dust and kiln dust the maximum MDD and corresponding OMC are 9.27 kN/m^3 and 49.65% respectively.

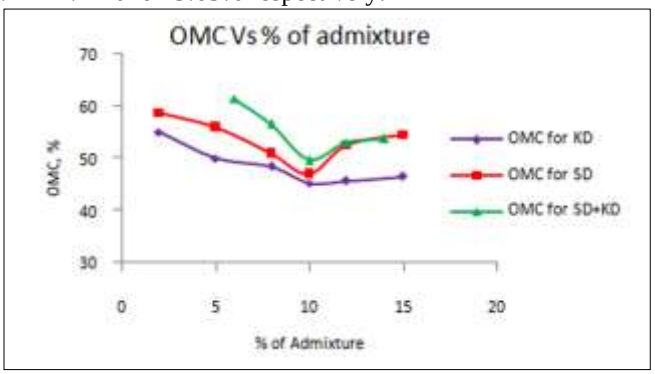

Figure 3: OMC Vs Percentage of admixture.

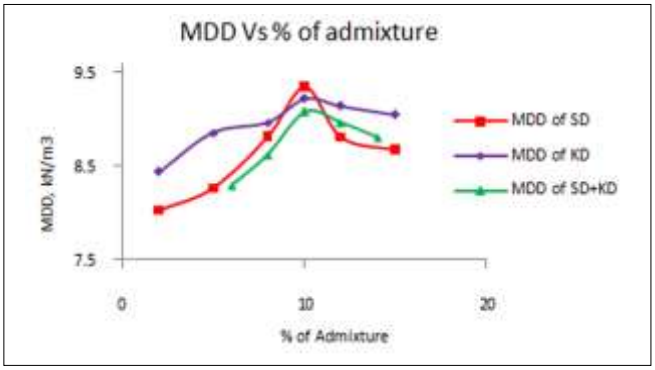

Figure 4: MDD Vs Percentage of admixture.

B. *California bearing ratio test results*

CBR test are used to evaluate the subgrade strength of stabilized soil. The unsoaked CBR tests are conducted on stabilized soil samples compacted at OMC in accordance with IS: 2720 (Part 16) – 1987. The variation of unsoaked CBR value with addition of admixtures is shown in "Fig. 5". The unsoaked CBR value increases with the increase in admixture percentages in all cases. Soil with stone dust attains maximum CBR value (5.84%). The maximum CBR value of the soil stabilized with kiln dust and combination of stone dust and kiln dust are 3.36% and 3.98% respectively.

C. *Unconfined compressive strength*

The UCS tests are conducted on stabilized peat soil samples and the results are shown in "Fig. 6". It has been observed that UCS of stabilized peat soil increases significantly for all admixtures and attains optimum value at 10 %.The maximum values for KD, SD, SD+KD & remoulded peat soil are 137 kN/m^2, 107kN/m^2, 135kN/m^2 & 58kN/m^2 respectively.

TABLE 1: SUMMARY OF THE PROPERTIES OF PEAT SOIL.

Properties	Values
Moisture content (ω)	408.40%
Organic content (OC)	75.04%
Ash content	24.96%
Fibre content	78.4%
Specific gravity (G)	1.34
pH of the soil	4.43
Liquid limit (LL)	160 %
Plastic limit (PL)	140.67%
Plasticity index (PI)	19.33
Gradation of soil	Well graded
Optimum moisture content (OMC)	102%
Maximum dry density (MDD)	5.9 kN/m^3
Bulk density	8.83 kN/m^3
Compressive strength (undisturbed)	18.0 kN/m^2
Cohesion, C (undisturbed)	8.0 kN/m^2
Angle of internal friction, Φ	1°
CBR value(remoulded)	1.98%
Soluble solid	0%
Sulphate	5.31%

TABLE 2: PHYSICAL PROPERTIES OF ADMIXTURE

Admixture	Moisture content	Specific gravity	Gradation
Stone dust	2.63	2.48	Well graded
Kiln dust	4.62	2.46	Well graded

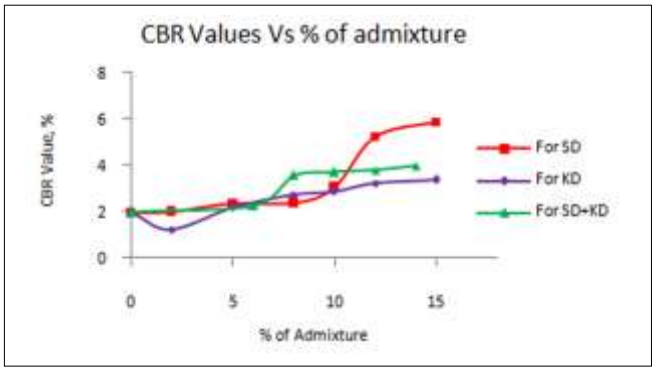

Figure 5: CBR values of stabilized soil using different admixtures.

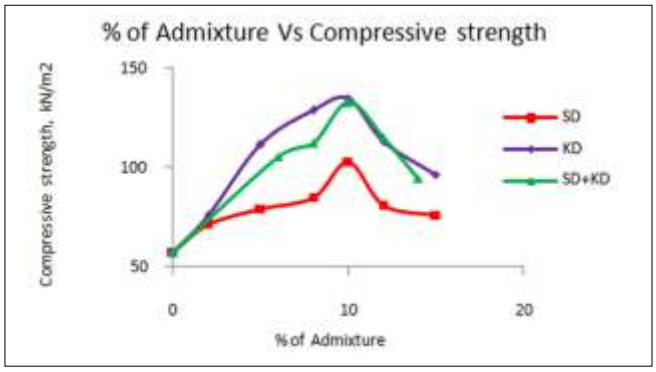

Figure 6: Unconfined compressive strength of stabilized soil using different admixtures.

D. Triaxial Test Results

Triaxial tests are performed to determine the shear strength parameters of the stabilized soil and the test results are shown in "Fig. 7" and "Fig. 8", in term of cohesion Vs percentage of admixture and angle of friction Vs percentage of admixture respectively. It has been observed that cohesion of the stabilized soil attains maximum value at 5% for stone dust (103kN/m^2) and 8% for kiln dust (124.6kN/m^2) & stone dust+ kiln dust (80.95kN/m^2). For remoulded soil it is 49kN/m^2. The value of angle of internal friction increases with the increase in percentage of the admixtures for all admixtures.

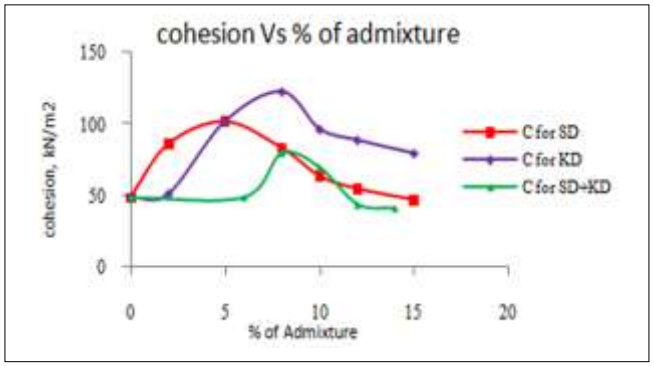

Figure 7: Cohesion of stabilized soil using different admixtures.

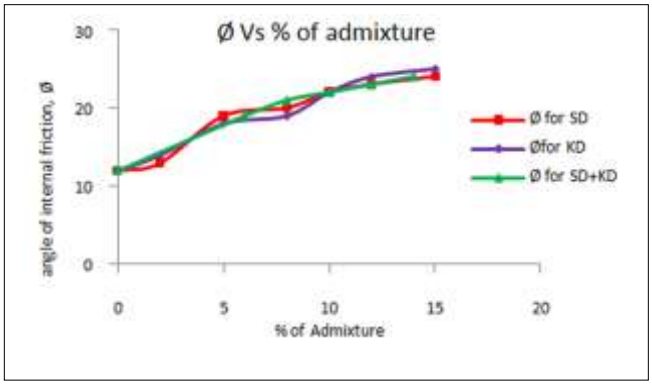

Figure 8: Angle of internal friction of stabilized soil using different admixtures.

V. Calculation of shear strength and bearing capacity

A. *Shear strength calculation*

Shear strength of the soil is the maximum resistance offered by soil to resist deformation by continuous shear displacement of soil particles or masses upon the action of a shear stress just before the failure. Shear strength is the principal engineering properties of the soil which controls the stability of the soil mass under load. Shear strength at a depth of 2 m of the stabilized soil mass is calculated from the shear strength parameters i.e. c & ϕ, which are found from the laboratory unconsolidated undrained triaxial test by using Mohr-Coulomb equation.

$$\tau = c + \sigma \tan \phi \qquad (1)$$

Where,

τ = shear strength
σ = normal stress on the plane of rapture, σ = γ x d
γ = unit weight of the soil
d = depth at which failure occurs
c = cohesion of the soil
ϕ = angle of internal friction

The shear strength values of stabilized soil mass are shown in "Fig. 9". The maximum values for KD, SD and SD+KD are 126kN/m^2 (at 8%), 105kN/m^2 (at 5%) and 84kN/m^2 (at 8%) respectively. For remoulded & undisturbed soil values are 50kN/m^2 & 8kN/m^2 respectively.

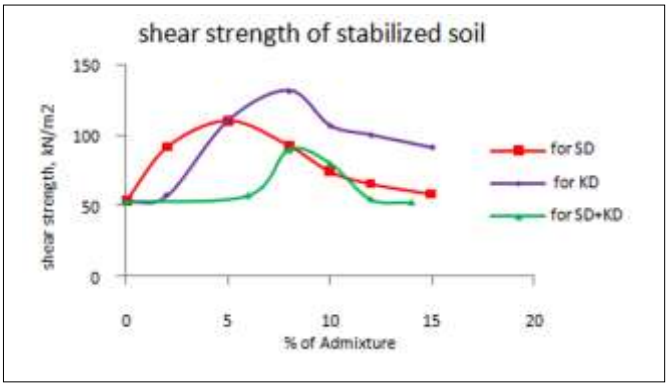

Figure 9: Shear strength of stabilized peat soil for different percentages of admixture

B. *Ultimate Bearing capacity of soil*

Ultimate bearing capacity is the theoretical maximum pressure which can be supported by soil without failure. A square footing of size 2m X 2m at depth of 2m is assumed and bearing capacity of stabilized soil mass is calculated by IS code method(IS:6403-1981). Ultimate Bearing capacities of stabilised soil for different types of admixtures are shown in "Fig. 10". The maximum values for KD, SD and combination of SD and KD are 1452kN/m^2 (at 8%), 1161kN/m^2 (at 5%) and 1010kN/m^2 (at8%) respectively. For remoulded & undisturbed peat soil values are 417kN/m^2 & 44kN/m^2 respectively.

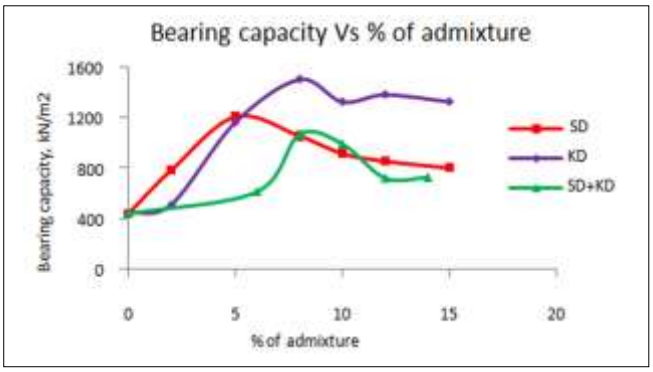

Figure 10: Bearing Capacity of soil for different percentage of admixture

VI. Conclusions

The present paper investigates the effect of different types of stabilizer on peat soil samples from Lamphelpat, Imphal, India. From the laboratory tests results, the following conclusions can be drawn:

i.) The results of standard proctor compaction test conducted on stabilized soil specimen indicates that the value of maximum dry density (MDD) is maximum at 10% for all type of admixtures and highest is for Stone Dust (percentage increase with remoulded compacted peat soil is 61%).

ii.) The unconfined compressive strength of stabilized peat soil is maximum at 10% for all type of admixtures and highest is for Kiln Dust (percentage increase with remoulded compacted peat soil is 136%).

iii.) CBR value of the stabilized peat soil increases for all type of admixtures and highest is for Stone Dust (percentage increase with remoulded compacted peat soil is 195%).

iv.) The shear strength of peat soil at a particular depth increases with the increase of the percentage of admixture. The optimum value attains at 5% for SD and 8% for KD and SD+KD. Highest value is for Kiln Dust (percentage increase with remoulded compacted peat soil is 152 %).

v.) Bearing capacity of the stabilized soil increase with increase of the admixture. Optimum value attains at 5% for SD and 8% KD & SD+KD. Highest is for Kiln Dust (percentage increase with remoulded compacted peat soil 248 %).

It can be concluded that addition of stone dust and kiln dust can improves the engineering properties of peat soil of Lamphelpat and the selection of best type admixture and its optimum percentage will depends on the purpose and the natural of the engineering project involved.

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