Experimental Study on the Effect of Neem Leaves Ash and Coir Fibre on Bentonite Clay

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Abstract - *Black cotton soil is regarded as an inappropriate soil for constructional purposes. The core reason for its negative out turn is due to the enormous presence of highly troublesome mineral named "montmorillonite". Bentonite clay also has huge content of the same montmorillonite mineral, which induces the expansion and contraction of soil mass according to the water content, making it unstable. Hence, the exploration on stabilization of such unsteady clay is really essential to harness its potential for civil engineering purposes. It can be a coupled benefit, if we utilize, a natural abundantly available material or a waste material for the rectification of instability of soil. So, in this project, we investigate the combined utilization of neem leaves ash and coir fibre for the stabilization of montmorillonite rich bentonite clay. Coir fibre is a proved stabilizer for improvement of bearing capacity of soil whereas neem leaves ash might alleviate the swell characteristics by exhibiting pozzolanic properties. So, we inspect the scope of combination of these two materials on bentonite clay on the hope of exploring a much better combined stabilizer for practical use at a cheaper rate.*

Key Words: **Bentonite clay, Coir fibre, Neem leaves ash, Stabilization.**

1.INTRODUCTION

Montmorillonite rich bentonite clay is an expansive soil which when identified in sub grade, increases the difficulty and cost of construction because this soil possesses a high expansive nature. They undergo massive volume change as the water content increases or decreases. This continuous change in volume causes structures built over this soil to move unevenly, leading to differential settlement. Montmorillonite is the mineral which imparts high plasticity and swelling to an expansive clay-type soil. Soil stabilization is one of the methods used for improving the soil properties. Soil stabilization is a general term for any physical, chemical, mechanical, biological or combined method of changing a natural soil to meet an engineering purpose. Improvements includes increasing the bearing capabilities, tensile strength and overall performance. This paper is an effort towards the direction of exploring the possible usage of neem leaves ash and coir fibres to obtain beneficial effect on the engineering properties of swelling soil. Therefore, the aim of the study is to harness the potential of two cost effective materials, namely, neem leaves ash and coir fibres to stabilize montmorillonite rich bentonite clay.

2. MATERIALS

2.1 Bentonite Clay

Bentonite is a clay generated frequently from the alteration of volcanic ash, consisting predominantly of smectite minerals, usually montmorillonite (80-90% by weight). For different purposes, different properties of extracted bentonite are emphasized and appropriate test methods have been developed. Mineralogical and chemical composition affects the properties of bentonite. On the other hand, the measured physical characteristics are frequently used to interpret the mineralogical composition of bentonite. Table I shows the physical and engineering properties of the bentonite sample obtained for the study.

2.2 Coir Fibre

Coir fibre is a natural fibre extracted from the husk of coconut. It has high tensile strength and it is a huge reservoir of hemicellulose, cellulose and lignin. It is also lighter than other natural fibres. The material is also environmentally friendly. The inclusion of these fibres has a significant influence on the engineering behavior of soil-coir mixtures.

2.3 Neem Leaves Ash

Neem is a medicinal plant. Neem is an easily available material which has good chemical properties. It has high calcium content which induces binding property to its ash and enable to act as a pozzolanic material. Neem leaves were collected and dried for few days. Later they were burned to get ashes and then ashes were sieved through 75 micron IS Sieve to obtain fine ash for preparing new soil mix.

Table -1: Index Properties of Bentonite clay

Properties	Values
Specific gravity	2.71
Liquid limit (%)	201
Plastic limit (%)	32.39
Plasticity index (%)	168.61
Optimum moisture content (%)	27

Maximum dry density (g/cm^3)	1.33

3. METHODOLOGY

The initial phase was to refer literatures published on stabilization of expansive soils using various materials, methods etc. The analysis helped to identify the key issues addressed when expansive soil meets construction works. It also aided identifying wide range of methods available and accessible at an inexpensive manner. After a thorough review on various literatures and our requirements, stabilizing materials were fixed as coir fibre and neem leaves ash on bentonite clay.

Later, the required materials for the study were collected. Bentonite clay was collected from Tel Trade Company. Index and engineering properties of the soil were identified. Neem leaves were obtained from the along sides of streets, as a domestic waste material and discarded coir after use was utilized to obtain the fibre. Physical properties were studied on the adopted materials.

Obtained neem leaves were then sun dried and later burned to form ash. Neem leaves ash is reported to have pozzolanic properties, it not only aids in enhancing the engineering properties for the short term but also helps in achieving improved features of the soil in the long run.

Initially the bentonite clay was mixed with neem leaves ash which was sieved through 75 μ IS sieve. Various amounts of neem leaves ash (2%, 4%, 6%, 8%, and 10%) by weight of soil were added to bentonite. The coir fibres were then cut into the desired lengths of 10mm, 20mm and 30mm, and then air dried before mixing. The various proportions of coir fibre added were 0.1%, 0.3%, 0.5%, 0.7% and 1%.

3.1 Preparation of Specimen

The process of soil preparation was initiated by determining its natural moisture content. For this purpose, a small amount of bentonite was placed inside the oven for 24 hours and the natural moisture was found to be almost nil. Later on, neem leaves were sun dried for days before combustion and then burned to ashes. Obtained ash was then sieved through IS 75micron sieve to obtain fine ash. The uniformity, colour and texture of the obtained ash is analysed and then stored properly.

The coir fibre was obtained by entangling single fibres from the coir. By completing the process of preparation of the required raw materials, the process of mixing both neem leaves ash and coir fibre were carried out in dry condition to obtain uniform mixing. Soil–neem leaves ash-coir fibre dry mixture is then added with water amounting to the optimum water content of the bentonite to prepare the specimen. The specimen was prepared with different percentage of neem leaves ash and coir fibre in the same manner.

4. EXPERIMENTAL TESTS

4.1 Unconfined Compressive Strength

The unconfined compression test is so far the most popular method of soil shear testing because it is one of the fastest and cheapest methods of measuring shear strength. This investigation required the preparation of three types of specimens. The test was initially conducted on undisturbed bentonite clay sample saturated to its optimum moisture content. For the next stage, the coir fibers were cut into small pieces (30 to 50 mm in length), and are randomly mixed into the soil until it was homogeneous and the new specimens were prepared and tested. The coir fiber content variations used were 0%, 0.2%, 0.5%, 0.8% and 1.0% under the conditions of optimum moisture content (OMC) and maximum dry density (MDD) of bentonite sample. Then next specimens were prepared by adding neem leaves ash to the bentonite sample at 0%, 2%, 4%, 6% and 8% ash content.

Final test specimens were prepared by adding various percentage of coir fibre with the estimated optimum content of neem leaves ash to the bentonite sample, inorder to check the strength of new soil mix comprising of neem leaves ash, coir fibre.

4.2 Consistency Limits

The consistency of fine-grained soil is the physical state in which it exists. It is used to denote the degree of firmness of soil. The water content at which soil changes from one state to another is known as consistency limits.

The liquid limit was found out by Casagrande's liquid limit device. Here 0%, 2%, 4%, 6% and 8% neem leaves ash content were added to the bentonite clay and mixed with various amount of water and applied to the Casagrande's apparatus. Flow curve was plot with number of blows on x axis and water content on y axis. The water content corresponding to 25 blows is its liquid limit.

Plastic limit is the water content below which the soil stops behaving as a plastic material. It begins to crumble when rolled into a thread of soil of 3mm diameter. At this water content, the soil loses its plasticity and passes to semi-solid state. Here 0%, 2%, 6% and 8% neem leaves ash contents were added to the bentonite clay.

4.3 Free Swell Index

Free swell or differential free swell, also termed as free swell index, is the increase in volume of soil without any external constraint when subjected to submergence in water. Eight measuring jars of 100 ml capacity were taken for the test, four of which were filled with water and remaining four with kerosene. Each jar was filled with 100g of bentonite sample admixed with neem leaves ash at 0%, 2%, 4%, 6% and 8%. The experimental setup for the test is illustrated in Fig.1.

Free Swell Index = $[V_d - V_k] / [V_k] * 100$ %

Where,

V_d = volume of soil specimen read from the graduated cylinder containing distilled water.

V_k = volume of soil specimen read from the graduated cylinder containing kerosene.

Fig -1: Free swell index experimental setup

5. RESULT AND DISCUSSION

5.1 Consistency Limits

The liquid limit of bentonite was determined for a normal soil and the ash-mixed soil using the Casagrande apparatus. The variation of the liquid limit concerning neem leaves ash content in soil is clearly illustrated in Fig.2. The liquid limit of the bentonite decreased significantly with the increase in neem leaves ash content. It was observed that there is a reduction in liquid limit value from 201% to165% as the ash content increases from 0 to 8%. This reduction in liquid limit could be due to the reduced thickness of the diffused double layer of water due to the cation exchange between H+ /K+ ions and Ca2+/ Mg2+ ions furnished by the neem leaves ash. Due to the decrease in the thickness of the diffused double layer of water, the soil mass starts flowing like a liquid at very less water content due to the reduced magnitude of forces associated with the adsorbed layers like hydrogen bond and Van der Waal forces.

Fig.3 depicts the variation of the plastic limit at varying percentage of neem leaves ash added in the soil. It was reduced from 32.39% to 22.5% after the mixing of ash. This reduction in the plastic limit of the soil can be explained in terms of the reduction in the diffused double layer thickness of water. As the thickness of adsorbed film reduced, the ability of the soil mass to deform plastically without cracking decreased. A significant decrease in the plasticity index was observed after the addition of neem leaves ash. Fig.4 shows the variation of the plasticity index at varying percentage of neem leaves ash.

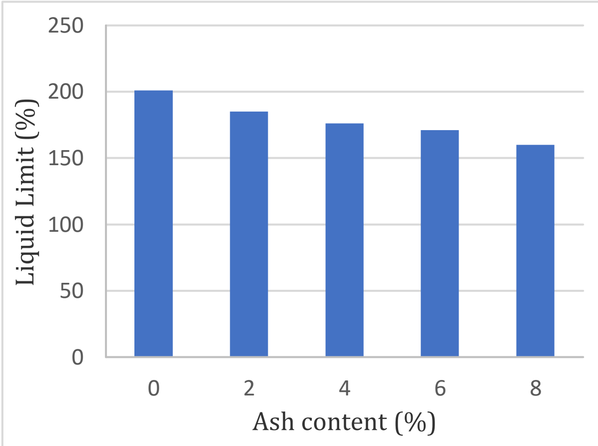

Chart -1: Variation of liquid limit

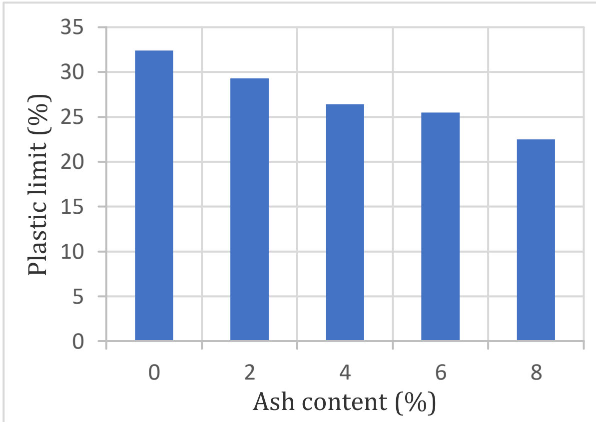

Chart -2: Variation of plastic limit

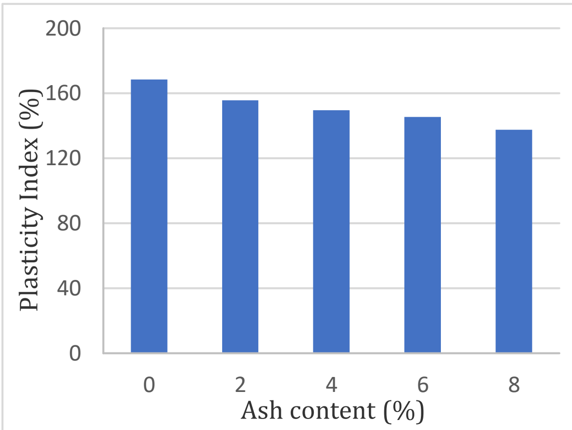

Chart -3: Variation of plasticity index

5.2 Free Swell Index

The free swell index of bentonite was compared with the free swell index of bentonite after adding the ash. From Fig. 5, it is evident that the free swell index of neem leaves ash-treated bentonite has reduced significantly. The free swell index reduced from 400% to 125% as the amount of ash increased from 0 to 8%. The bond that exists within the montmorillonite mineral of the bentonite clay is fragile in nature. Due to this weak bond in montmorillonite, bentonite is highly expansive. When neem leaves ash is added to the bentonite, it resulted in the accumulation of calcium and magnesium ions. These ions replace the H+ ions by cation exchange or base exchange process and form a relatively stable soil mass structure. This stabilized soil mass undergoes very little swelling as compared to the original soil. This result was really a promising one.

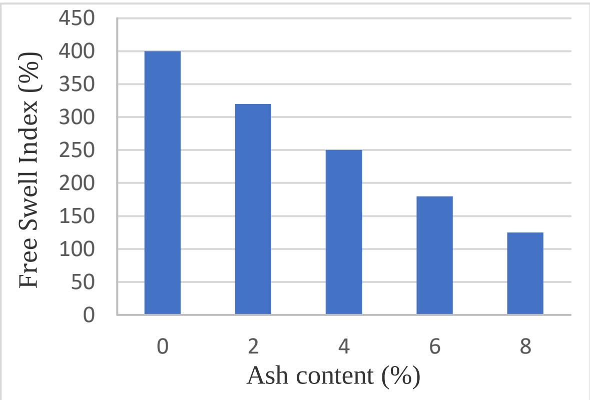

Chart -4: Variation of free swell index

5.3 Unconfined Compressive Strength

The unconfined compressive strength of pure bentonite clay, bentonite- ash mix and bentonite- ash-coir fibre mix were conducted and compared. The maximum values of U.C.S value obtained were, for bentonite-coir fibre mix-2.52kg/cm^2, bentonite-ash-mix-0.92kg/cm^2 and for bentonite- ash-coir fibre mix-3.01kg/cm^2. Fig.6 shows the failed specimen (bentonite -coir mix) after UCS test. Fig.7 shows the variation of U.C.S value of bentonite -coir mix. Fig. 8 shows the variation of U.C.S value of bentonite admixed with neem leaves ash at different percentages. Fig.9 shows the variation of U.C.S value of bentonite- ash-coir fibre mix. Bentonite-ash- coir fibre mix is prepared by adding different percentages of coir fibre with the optimum percentage of neem leaves ash obtained from Fig.8. In order to obtain maximum accuracy for the combination of bentonite-coir-ash mix, U.C.S value is obtained at 0.85%, 0.9% and 0.95% of coir fibre in addition to other percentages. Comparing Fig.7, Fig.8 and Fig.9, maximum value of UCS was obtained as 3.01kg/cm^2 which is from bentonite- ash-coir fibre mix @ 0.85% of coir fibre with optimum neem leaves ash (8%) added.

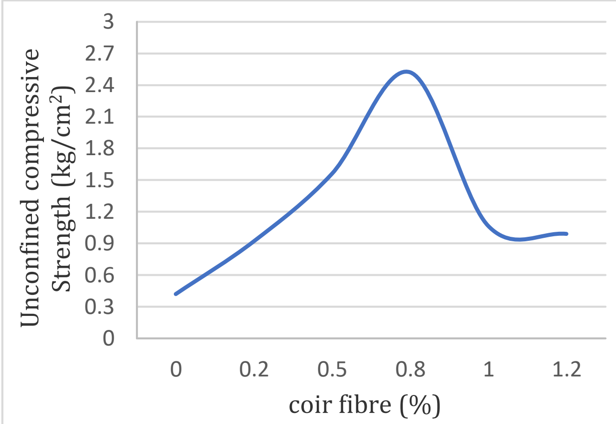

Chart -5: Variation of U.C.S at different percentage of coir fibre.

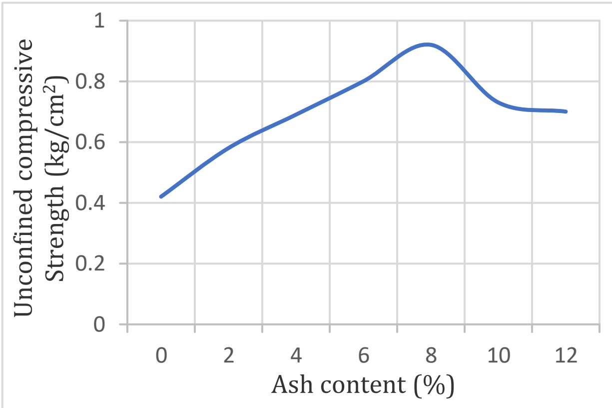

Chart -6: Variation of U.C.S at different percentage of neem leaves ash

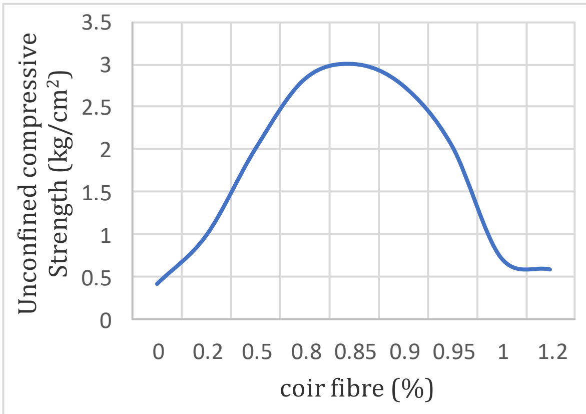

Chart -7: Variation of U.C.S at different percentage of coir fibre admixed with optimum ash content.

6. CONCLUSIONS

- By adding various percentages of neem leaves ash by weight of the soil, the soil consistency limits have changed significantly. The maximum change is noticed with 8% of neem leaves ash.
- At 8% neem leaves ash, the liquid limit, plastic limit and plasticity index were reduced to160%, 22.5% and 137.5% respectively.
- The swelling behavior of bentonite was significantly mitigated by the neem leaves ash. The free swell index of bentonite was reduced from 400% to 125% which is nearly about four times reduction.
- The UCS value of bentonite-coir fibre mix implies that shear strength increases with increase in the coir fibre content upto 0.8%.
- The UCS value of bentonite-neem leaves ash mix implies that the strength of soil increases with neem leaves ash content upto 8%.
- The combination of bentonite-ash-coir fibre led to an innovation. The UCS value obtained is maximum at 0.85% of coir fibre content with 8% of neem leaves ash content.
- It is concluded that proportion of 0.8% coir fibre with 8% of neem leaves ash by weight of soil is considered as optimum content for stabilization of bentonite clay.
- Combination of neem leaves ash and coir fibre don't exhibit any threatening effect towards each other.
- Long term durability tests have to be conducted to evaluate the stabilizer's reliability in their resistance against adverse loading and atmospheric conditions.
- The findings of this study have practical significance as a ground improvement technique especially in engineering projects on black cotton soil, which is the reservoir of montmorillonite mineral.
- Combined use of neem leaves ash with reinforcing coir fibre can help to reduce the burden on deep or raft foundation in weak soils, thus reducing the cost of construction.
- Overall, it can be concluded that utilization of natural coir fibres and neem leaves ash are less expensive when compared to synthetic stabilizers which may also cause environmental concerns.

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