IMPROVEMENT IN ENGINEERING PROPERTIES OF EXPANSIVE SOIL USING RICE HUSK

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Abstract— **This research paper clarify about the In India, one-fifth part (1/5th) of the land area is covered by 'black cotton soil' which is also known as 'expansive soil'. These soils are in abundance in arid and/or semi-arid regions. 'Black soils' are create problems in construction activities, now & then. They cause severe damage to the structure because of its alternate swell-shrink behavior. This happens due to alternate drying and wetting of black soil. The soil must be stabilized and strength be increased in appropriate proportion, to avoid these circumstances. Use of chemicals or wastes as a stabilizing agent, mechanical methods etc, are some among many such methods that help to modify and / or improve the characteristics of the existing soil. If we use any of the above mentioned methods, then the properties of the soil can be improved effectively and beneficially. Waste generation in India is a serious problem. We can find waste in India in every nook and corner. It includes domestic wastes, waste from industries, wastes from agricultural/farm produce etc. We can use this waste as a stabilizing agent, we can improve the strength of the soil and consequently, reduce the cost of construction. It also helps in disposing the wastes efficiently. And this in turn, makes the environment eco-friendly. We have done this research as a study with sole aim of finding the effects of 'Rice Husk Ash' (R.H.A.) on the soil. It is an agricultural waste. Study is done on the index & engineering characteristics of the 'expansive soil' , added in suitable proportions.. The soil properties such as index properties, free swelling index(FSI), 'unconfined compressive strength' (U.C.S.) are determined by replacing R.H.A. partially in black cotton soil'. This investigation is done on a clayey soil, taken from Jhansi (Uttar Pradesh), in order to study the improvement in its geotechnical properties by adding different percentages of RHA (10, 20 and 30%) and hydrated lime (3, 6 and 9%) by weight. According to Laboratory results, O.M.C increases and M.D.D decreases with the increase in %age of RHA & added Lime. In this study, with the increase in % age of lime added for stabilization of soil; RHA mixes and the soil gains strength.**

Keywords: cotton soil, domestic wastes, agricultural waste, compressive strength.

1. INTRODUCTION

In India, 'Black cotton soils' covers almost one fifth(1/5th)to one sixth(1/6th) part of total area that is covered by land. The 'Black cotton soils' covers an area, mostly consisting of the Deccanplateau region.Map shows that-Andhra Pradesh, Tamil Nadu(T.N.), Western Madhya Pradesh(M.P.), Gujarat Karnataka and few parts of Uttar Pradesh(U.P), Bihar and Jharkhand are covered by this soil. 'Black cotton soil' which is a typical 'expansive soil' has got shrink swell behaviour , i.e., it swells in the presence of water and shrinks when it becomes dry. Consequently its strength parameters are uncertain. This behavior is due to the presence of montmorillionite, a mineral which has got a typical structure in which gibbsite sheet of 10 A^0 is followed by silica sheet of the same thickness. Again it is followed by a gibbsite sheet and in between 2 such units water is entrapped, which is the root cause of problem.

In this review paper section I contains the introduction, section II describe the objectives of study, section III Black Cotton Soil / Expansive soil, section IV contains the literature review details, section V contains the details about material & method, section VI describe the experimental work, section VII describe the result details, section VIII provide conclusion of this research paper.

2. Objectives of Study

Our objective is to see the improvement in engineering characteristics of 'Black cotton soil / expansive soil' by adding certain additives in definite percentage and see the improvement. The main parameter which has to be observed is 'free swell index' which is a preliminary indicator for swell shrink behavior of soil under consideration. In our case, we have chosen 'Rice Husk' as an additive.

- Studying effects of 'Rice husk ash' (R.H.A.), an additive, on expansive soil, in terms of F.S.I and strength parameters.
- A comparative study of strength was done with the 4 different proportions of 'Rice husk ash'(10%, 15%, 20% and 25%).
- A comparative study of strength was done with the fix %age of 'rice husk ash' (optimum percentage).

- Studying the suitability of stabilized soil for flexible pavement(s).
- To study and compare other properties of soil sample with the stabilized soil.

3. Black Cotton Soil / Expansive soil

- 'Black cotton / expansive soil deposits' cover mainly 20% of India's land surface. They are residual soils of basaltic origins and are foundmostly in the Deccan Plateau, parts of Bundelkhand, Kerala, Telangana and few parts of Goa.
- Our concern as an 'Engineer' is not the agricultural properties of 'Black cotton soil' which might be good for cultivation of cotton but those properties which are very problematic for engineering purposes because of its swell - shrink behavior.
- Our purpose is to study the improvement in characteristics of 'Black cotton soil'using certain additives which in our case are R.H.A.

4. RELATED WORK

4.1 General Characteristics

Such clayey soil, when presented to water, demonstrates critical increment in volume. 'Dark cotton soil' is framed through far reaching physical – compound adjustment. Illinite, Kaolinite, Montmorillonite are progressively inclined to changes in their volume. The monmorellonite substance is the dominating mud mineral substance in 'dark cotton soil'. Patches of this dirt can be seen in practically all countries (in world's guide of soil). Indian dark cotton muds are ordinary instances of soil covering a zone around 20 % of all out land zone.

4.2 Nature and Behavior of Clayey Soils

Soil that shows elective swell - recoil conduct (because of dampness variances) is known as 'far reaching soil'. This conduct is because of the nearness of the mud minerals, having extending cross section structure.

Among them, montmorillonite is dynamic and assimilates water commonly in immense volumes. The dirt is hard as long as it is dry, yet loses its quality on wetting for example completely. The splits show up on the outside of the dirt when it dries. In most pessimistic scenarios, the break width is right around 150 m.m. also, heads out down to 3 meter beneath the ground level(G.L.).

The montrimollonite mineral is shaped by a soluble situation, absence of draining and the nearness of magnesium(Mg) particles. Semi-bone-dry locales with generally low precipitation are positive conditions for the arrangement of this mineral. The parent mineral for montrimollonite comprises of magnesium minerals, calciu feldspars and so on.

Other dirt minerals of some significance are-kaolinite and illite. Conditions that support development of Kaolinite are - drawn out draining under acidic condition and high temperatures with lasting rocks containing ferric iron(Fe).

Illinite mineral is framed under conditions like those which lead to the arrangement of montrimollonite and furthermore; the nearness of potassium(K) in the parent mineral is imperative.

'Indian dark cotton soils' are framed by enduring of basaltic rocks and traps of Deccan level. Be that as it may, their event on limestone gneiss, slates, shale, sandstone, and limestone is additionally perceived. This dirt is found generally in the surface, with thickness of layers differing from 0.5 meter to in excess of 10 meter. Nearness of 'titanium' in little amounts records to the particular dark shade of this dirt. Cotton develops in this dirt, in like manner.

4.3 Characteristics creating problem in Expansive soil

During stormy season, soil swells as it ingests immense measure of water. In summers, the dirt dampness gets drained, and offers ascend to the shrinkage splits on the outside of soil . The elective swell – contract conduct results in the arrangement of hurl, and subsequently this dirt settles severely.

The above swell - contract property causes hurls in soil coming about splits in structure which is bolstered on such soils.

1)
4.4 High Compressibility

'Dark Cotton soils' are very compressible and plastic, when they are soaked. High greatness of merged settlement is found in footings laying on such soil(s).

2)
4.5 Swelling

Differential development is found in the structures that are worked in summers, contrasted with those in blustery season; in light of the fact that the 'characteristic water content' is low in dry season. We see breaking in structures that are bolstered by soils that show high swelling on being presented to water. Such structures lift up in the wake of breaking.

The structure can be made appropriate by limiting the swelling weight that is being created by such soil.

4.6 Damage to Pavement

Differential development in structures over such soils is seen where the streets go through sweeping sub-levels or shrinkage.

4.7 Damage to Canals

The issues emerging because of swelling of far reaching soil(s) stretches out its hands to lined and unlined waterways too. At the point when side inclines of channel banks are made utilizing such soil, they dissolve and become delicate. The channel beds block the working of the trench.

4.8 Shrinkage

Structures ought not be worked at the peak of stormy season, on the grounds that the characteristic 'water content' around then is high. This prompts splits in structure because of shrinkage in the dry season that pursues. Also, such structure demonstrates overwhelming settlement.

Figure 1. Cracks Developed in clayey soil (after drying)

4.9 Damage to the Conduits

Conductors, for example, funnels for waste and water supply lines are exposed to both vertical and horizontal developments. Breaking of such supply lines has been accounted for in few cases, particularly where generally pipes of little breadth have been utilized; under extreme dampness conditions.

4.10 Damage to Buildings

Structures speak to the most evident instance of harm brought about by the swelling and shrinkage of establishment soil.

Structures that lay on spread balance are harmed on the off chance that they are light in weight. This happens because of breaking of the dirt. Furthermore structures laying on heap establishment are totally sheared and removed.

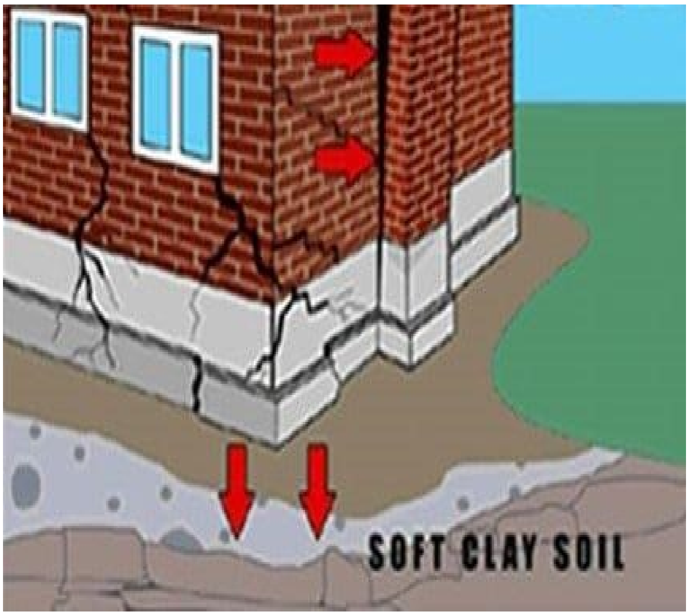

Figure: 2 Damage to house supported on shallow piers

- The wharfs are still when the blustery season starts. They are bolstered by rubbing of the soi at first. When it rains vigorously, splits license the passage of water profound into the dirt.
- After approx ten huge tempests, the dirt swells, lifting the docks and thus the house gets removed.
- The ground-water table falls impressively in summer and the dirt contracts and dries totally. The 'skin grating' is decreased, as the splits begin to show up around the dock. Subsequently, due to drying of the dirt, powerful worry of soil floods and makes issue.
- Attachment is broken by stressing and the dock skins, when the structure load(s) surpasses the rest of the 'skin grating' or the 'compelling worry's of the dirt increments to a record-breaking high.

4.11 Solution to Several Problems

The rules for the deliberate and legitimate segment of treatment and additionally mix of medications that limit the volumetric change viably and at the same time the related harm to the structures ought to be thought of simply after the far reaching soil(s) has/have been described.

The accompanying healing measures are utilized with various level of accomplishment.

4.12 Removing the Expansive Soil Entirely

In this technique, far reaching soil is expelled to an impressive profundity and then channel is inlayed with sand or potentially any dirt that does not swells. This technique gives a granular fill around the foundation(s), that aides in capturing a few developments that may demonstrate to be hazardous, in the event that water achieves the establishment.

5 MATERIALS & METHODS

5.1 Material Used

- Clay soils.
- Rice Husk Ash(RHA).

The clayey soil usedin our study is brought from 'Jhansi district' in 'Uttar Pradesh' (U.P.). The soil sample is collected from different points and experiments are done / performed on soil properties in laboratory.

5.2 Tests Performed on Soil and Rice Husk Ash(RHA)

5.2.1 Specific Gravity (IS 2720 Part 4, 1985)

Specific gravity is defined as the ratio of mass of the soil per unit volume to the ratio of same amount of water per unit volume. It gives a measure of the mass of the soil with the standard value of mass of water amd is always measured at the given temperature. Pycnometers are used to measure S.G.

5.2.1.1Test Procedure

- Weight of the empty, dry and clean pycnometer,(W_P) is found and noted down.
- Place 125gm of dry soil sample (passed through sieve no 10) in the pycnometer.
- Pycnometer's weight, that has dry soil, W_{PS} ; is found and noted.
- Adding distilled water to fill about half(1/2) to three fourth(3/4) of the pycnometer. The sample is kept and soaked for about ten minutes.
- The air that is entrapped is removed by applying partial vacuum for the next ten minutes.
- Now the vacuum is stopped and the 'vacuum line' is carefully removed from the pycnometer' .
- Distilled water is filled to the mark in 'pycnometer' . Exterior parts are thoroughly cleaned with a dry and clean cloth . The weight of the pycnometer and the contents(W_B) is determined
- Pycnometer is emptied, cleaned and then filled with 'distilled water' to the required mark .
- Exterior parts are thoroughly cleaned with a dry and clean cloth . The weight of the 'pycnometer' plus the distilled water(W_A) is determined .
- Pycnometer is finally emptied and cleaned.

3) 5.2.2 Liquid Limit (IS 2720 Part 5, 1970)

Soil contains some shear strength even in liquid state. L.L. is the threshold value of water content at which soil shows some shear strength. It is measured by Cassangrande Apparatus in which cassangrande tool is used to cut the soil sample placed in a cup, which has got a device to give ceratin no of blows.

The CG cutting tool is 2 mm at the bottom end and 20 mm at the top.A cut is made in the soil sample filled in the cup with certain amount of water and 25 blows are given to the cam. It is the water content at which 11 m.m. of the cut is made after 25 blows.

Standard procedure for finding out the water content is adopted.
The cohesive soil passes from 'plastic state' to 'liquid state' at this limiting moisture content, called 'Liquid Limit' .

5.2.2.1 Purpose and Objective

L.L. gives slight idea of the previous stresses in the soil. It gives the indication of softness and hardness of the soil. If the natural water content of the soil is nearing L.L., it means it is soft. And also, it is the minimum water content at which soil tends to flow as liquid.

5.2.2.2 Determination of L.L

4) Apparatus requirement –

- Weighing Machine.
- Cassagrande's L.L. Apparatus with grooving tool.
- Plates to mix the soil.
- Spoon.
- Heating device.

Figure 3 Liquid Limit experiment performed on Cassagrande apparatus

5.2.2.3 PROCEDURE

- 250 gram of soil dried in oven is allowed to pass into an 'evaporating dish' through 0.425 mm sieve. We add water (distilled) to the contents and mix them thoroughly to make a paste which is uniform in nature. The mixed paste must have a consistency that permits the closer of groove for sufficient length. For this, 30 to 35 drops of cup are added.
- Strokes of 'spatula' are applied to spread the contents of a part of mix paste that is placed in the cup of Liquid Limit(L.L.) device.
- It is trimmed to 1 c.m. depth. This trimming is done where it (paste) has 'maximum depth' . Soil that is in excess is returned back to the dish.
- Using a 'grooving tool', a groove is cut along the 'center line' of the mix paste of soil that is kept in a cup. We observe that a groove is formed which is clean, sharp and has following dimensions: 11 m.m. top width, 2 m.m. bottom width, and a depth of 8 m.m.
- Crank' is turned at 2 revolutions / sec. , and the cup is continuously lifted and dropped by this revolution. This process is continued till the 2 halves of the mix of soil paste come closer by 13 m.m. length. Number of blows, (N) taken to reach this condition, is recorded.
- To determine the 'moisture content' of the soil, we take a fixed part of soil mix from the cup.
- This test is repeated minimum five times, with blows ranging between 15 to 35 .

5.2.2.4 COMPUTATION / CALCULATION

The relation between 'water content' (w) and 'number of blows' (N) is plotted on a semi log graph . 'W' is taken on the y axis, while 'N' is taken on the x axis. This curve drawn is called 'flow curve' .

The liquid limit(w_L) is represented on the graph by the 'moisture content' obtained from 25 blows. We express it to the nearest whole number.

Liquid limit(W_L) =(At 25 blows, from semi log- graph of water content v/s. N, 'number of blows')

Flow index, $I_f = (W_2 - W_1) / \log(N_1/N_2)$

= slope of the 'flow curve'.

6 EXPERIMENTAL WORK

6.1 Soil Index Properties

The soil used in our experimental study & analysis is brought from 'Jhansi district' (U.P.). The index properties of Black cotton/clayey soils are presented in table 1 –

Table 1 Index Properties of Black Cotton Soil/clayey

S.No.	Description of Property	Value
1.	LL (%)	62.55
2.	PL (%)	37.70
3.	P.I. (%)	26.31
4.	S.G.	2.59
5.	I.S.Classification	CH
6.	OMC	23.69%
7.	M.D.D (t/cu.m)	1.80
8.	U.C.S test	17.79 Kg/cm^2
9.	F.S.I.	86.61
10.	C.B.R. value	1.56

Table 2 M.D.D. at different O.M.C.

S.No.	Optimum Moisture Content (O.M.C.) (%age)	Maximum Dry Density,M.D.D. (t/cubic m.)
1.	14.75	1.619
2.	17.70	1.750
3.	22.87	1.798
4.	25.66	1.690

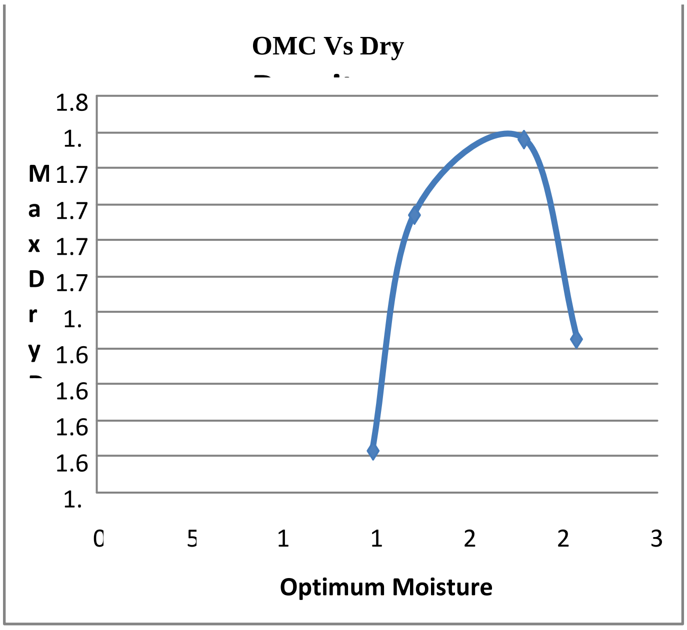

Figure 4 Optimum moisture content(O.M.C.) v/s Max. Dry density(M.D.D.)

7 RESULTS

The most important property of a weak soil deposit is its shear strength, which gives a measure of the load it can take before it fails. Whenever any construction work is being done over the soil, we consider the shear strength parameters, as they play an important role. Compaction characteristics are also determined to study the effect that R.H.A. produces on soil.

7.1 Unconfined Compressive Strength

U.C.S test was carried out on'rice husk ash' modified soils and untreated lime, to achieve variations in shear strength.

Table 5.1 Variation of un-
confined compressive strength(U.C.S.) with R.H.A

% RHA	UCS (kg/cm2)
0	0.354
0	0.897
5	0.987
10	0.756
15	0.496
20	0.397

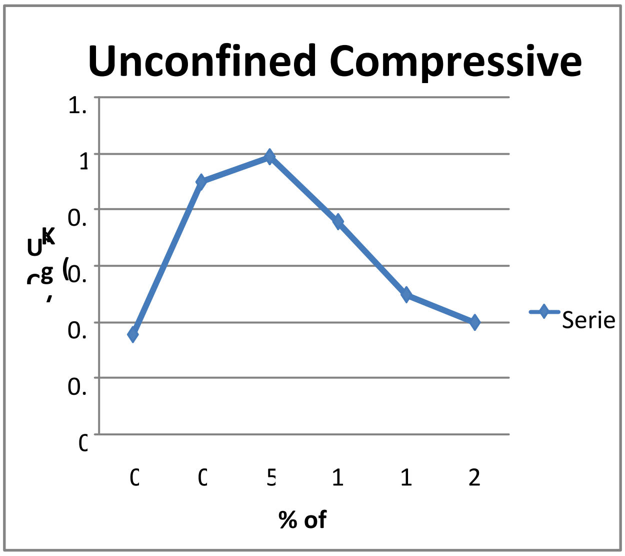

Figure 5: Variation of un
confined compressive strength(U.C.S.) with R.H.A.

The test was carried out after the specimen was made moist and cured for 28 days. Curing is important for the hydration reactions to take place, because it gives full strength to the soil. The results of the test are shown in table 5.1 and figure 5.1.By adding lime, un-confined compressive strength of the soil surges up. We achieved greater strength by replacing a small portion of the soil by 'rice husk ash' (R.H.A.) . As the percentage of Rice Husk Ash(R.H.A.) increases, there is a improvement in strength; which can be very well understood by the fact that R.H.A. is that much effective asa stabilizing agent, as compared to other additives. This in combination with the puzzolanic activity of 'rice husk ash' was found to give good strength. The optimum dosage of 'Rice husk ash' (R.H.A.) was found to be around 5%, above which replacement of 'soil' by 'rice husk ash' significantly reduces the strength.

7.2 Compaction Characteristics

Compaction test was carried out in accordance to 'IS 2720' pro-visions on untreated as well as 'R.H.A. mixes'. Obtained results are shown in table below. It was found that there is a decrease in dry density with increase in the'rice husk ash' content and the O.M.C. increases with the increase in %age of 'rice husk ash' . Specific gravity (G) of 'rice husk ash'is low as compared to that of the soil, due to which we see the decrease in dry density on addition of 'rice husk ash' .The increase in Optimum moisture content(O.M.C.) can be attributed to the fact that-more moisture is required for chemical reactions to occur.

Table 5 Compaction characteristics of the soil specimen

Soil Mix	MDD (g/cm3)	OMC (%)
Untreated soil	1.57	24
Soil	1.56	25
Soil+ 5% RHA	1.52	27
Soil + 10% RHA	1.49	29
Soil + 15% RHA	1.45	30
Soil + 20% RHA	1.30	32

8 CONCLUSION

The main objective to use R.H.A. is to reduce the burden of 'waste material' which can be very effectively done by using it as a 'soil stabilizer' by- partially replacing the soil with RHA. Since R.H.A. is lighter in weight, it can be used very effectively for backfilling along with soil as well as in making the sub-grade of the roads; and if it is added to it, it will have a water proofing property as well. The M.D.D & O.M.C of R.H.A. – soil mix decreased and increased respectively, with increase in R.H.A. content in the soil. The period of curing is yet another factor on which the hydration depends. Hence the strength may increase if the period of curing is increased. It can be another parameter for our investigation. Subsequent upon the stabilization, with RHA, compressive and tensile strength parameters are considerably increased amounting to 4 times increase in strength. The shear strength of the soil increases by the addition of- 'rice husk ash mixture'. The results of the study revealed that- 5 percent replacement of soil by Rice husk ash(R.H.A.) not only makes the stabilization-'economical', but also improves the 'strength of the soil' .

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