Effect of rice husk ash and rice husk powder on expansive soil

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ABSTRACT: Expansive clays undergo swelling when subjected to water. This can cause damage, especially to light weight structures, water conveyance canals, lined reservoirs, highways, and airport runways unless appropriate measures are taken. In this study, Rice husk ash(RHA) and Rice husk powder(RHP) were used to overcome or to mitigate the expansion of an artificially prepared expansive soil sample. RHA and RHP were added to artificial soil in different proportions of 2.5, 5,7.5 and 10%, 5, 10, and 20% by weight respectively. The effects of these stabilizers on, Atterberg limits, swelling percentage of soil samples were determined. RHA and RHP were shown to successfully decrease the total amount of swell while increasing the rate of swell.

1 INTRODUCTION

Expansive soils cause great changes in volume when subjected to moisture variation. (i.e. shrink if their moisture content decreases and swells if their moisture content increases.). The source of moisture may come from rain, flooding, leaking water from broken sewer lines or from reduction in surface evapotranspiration when an area is covered by a building or pavement (Wayne 1984; Komine and Ogata 1996). These types of soil occur in many part of the world, but they are especially abundant in arid and semi-arid zones, where environments are convenient for the formation of clayey minerals((Huang and Wu, 2007; Sabtan, 2005, Al-Rawas and Goosen, 2006).The clay mineral that has a high potential to expansiveness belong to smectite group such as montmorillonite or some types of illite(Alraws and Goosen,2006). These clays are distinguished by having a very small particle size, a large specific surface area and a high Cation Exchange Capacity (CEC) (Fityus and Buzzi, 2009; Nalbantoglu, 2004; Nalbantoglu and Gucbilmez, 2001).The swelling soil may use enough pressure to crack sideways, driveways, basement floors, pipelines and even foundations; causing extensive damage to structures if not adequately treated (Al-Rawas et al. 2002). The annual cost of damage done to non-military engineering structures constructed on expansive soils is estimated at $220 million in the United Kingdom and many billions of dollars worldwide (Gourly et al. 1993).

As a result of the increase in the amount of solid waste all over the globe, engineers and researchers carry out many investigations to find use for such wastes. To ameliorate the problems posed by expansive soils, many innovative techniques have been developed. Belled piers (Chen,1988), granular pile-anchors (Phanikumar,1997; Phanikumarer et al., 2004) and chemical stabilization with lime and fly ash (Chen,1988; Hunter, 1988; Cokca, 2001; Phanikumar and Sharma, 2004) have been suggested for mitigating heave problems. Cokca, et al. (2008) studied the possibility of using granulated blast furnace slag (GBFS) and GBFS-cement in stabilization of expansive clays. Book (2009) studied the use fly ash & RHA in soil stabilization. Attom and Al-sharif (1997) studied the use burned olive waste in soil stabilization. Tension cracking and volume change due to swell/shrink in compacted clays decreased when reinforced with polypropylene fibers (Al Wahab and El-Kedrah, 1995; Nataraj and McManis, 1997).

The improvement of soil at a site is indispensible due to rising cost of the land, and there is huge demand for high-rise buildings. There is a need to concentrate on improving properties of soils using cost-effective practices like treating with industrial wastes those having cementations value(Sabbara et al.,2011).

In this study, industrial wastes like rice husk powder (RHP) and rice husk ash (RHA) were used to reduce swelling of a soil. No research had been done on RHP; Therefore the results will be of immense benefit.

The soil used in this study are prepared by mixing 70% red clay (G_s=2.61) and 30% bentonite (G_s=2.40), based on the high FSI of the soil, it can be classified as having "high" degree of expansion.

Geotechnical properties studied in this research includes Index properties like liquid limit, plastic limit, and differential free swell index of soil with and without additive non swell materials.

The objective of this research is to evaluate the effect of using industrial waste on soil expansion and Atterberg limits.

2 EXPERIMENTAL STUDIES

The aim of this experimental study to determine the effects of RHA and RHP on Atterberg limits and swelling potential of clay.

An artificial, potentially expansive soil (mixture), was prepared by mixing 70% red clay (Gs=2.61) and 30% bentonite(Gs=2.005), by dry mass. Prior to mixing, the red clays were dried and passed through a No. 40 (0.425 mm) sieve (ASTM D 422-90 1990). After weighting the constituents, Na-Bentonite and red clay were mixed using a trowel. A preliminary swell test on (mixture M) resulted in 13% 1-d vertical swell, according (Seed et al, 1962 classification) indicating a highly expansive soil. To mitigate the swelling potential, RHA, was first added in amounts ranging from 2.5,5,7.5 and 10% in dry mass to mixture (M). In this study, RHP was manufactured by grounding machine . RHP was added in amounts ranging from 5, 10, 15 and 20% in dry mass to sample(M). Stabilized specimens were prepared by mixing a pre-calculated amount of RHA or RHP and (mixture M) at a moisture content of 25% The sample M—RHA or sample M—RHP blends were compacted directly into consolidation ring at 25% moisture content and sealed in bags to prevent loss of moisture. Samples were left for 24 hours.

Used mixture (M) has 30% bentonite and high swell percent and PI. The properties of the mixture are presented in Table1. Chemical composition of rice husk ash used in this investigation is given in Table 2. Constituents of rice husk powder used for the study are listed in Table 3.

In this experimental study, the ‘‘Free Swell Method’’ (ASTM D4546 (ASTM 2008)].) was used to determine the amount of swell. A single preparation water content was used for all specimens to simulate routine field compaction specifications. Each specimen was prepared by mixing 60 g dry mass and 15 ml water was added to the sample to obtain 25% water content. The total weight of each sample was 70g in the consolidation ring of the oedometer apparatus (height = 20 mm and diameter = 50 mm) [Noorany and Stanley 1994; ASTM D4546 (ASTM 2008)]. Each specimen was fitted with dry top and bottom porous stones, and loaded with a predetermined surcharge stress of σ =1 psi or 6.9 kpa. After the oedometer sample was mounted on the loading device, the dial gauge measuring the vertical deflection was set to zero. After compression ceased, each specimen was inundated with water, and swell was monitored for 4 days (96 hours).

Free swell percent was calculated from Eq. 1:

Free Swell (%) = 100 ΔH/H (1)

where ΔH is the change in the initial height of the specimen after it is inundated, and H is the original height of the specimen just before the inundation.

Table1. Properties of mixture(M)

properties	Value
Liquid Limit	148%
Plastic limit	22.37
Free swell index	13%
Degree of expansivity	High
Maximum dry density(MDD)	1.395 g/cm³
Optimum moisture content(OMC)	25%

Table2.Chemical composition of rice husk ash

Consistent	percentage
Silica (SiO2)	91.1
Alumina (Al2O3)	0.4
Calcium oxide (CaO)	0.4
Ferric oxide (Fe2O3)	0.4
Sodium (Na2O)	0.1
Sulphur (Na2O)	0.1
Magnesium oxide (MgO)	0.5
Potassium oxide (KaO)	2.2
Loss on ignition	4.8

Table3. Chemical constituents of therice-husk powder (Han-Seung Yang et al,2004).

Consistent	percentage
Holocellulose	60
Lignin	20
Ash	17
Others	3

Figure 1. (a) RHA and (b) RHP

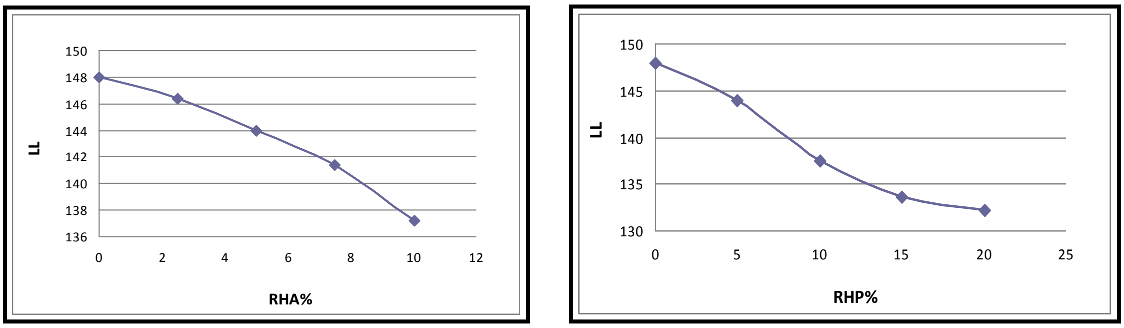
3 DUSCUSSION OF TEST RESULTS

Effects of RHA and RHP addition on the Attemberg limits of expansive soil are discussed here. The relation between liquid limit and RHA content is shown in Figure 2(a). As can be seen in the figure liquid limit decreased from 148 % to 137.2 % with increase in RHA content from 0 % to 10 % respectively. This can be considered to be as a result of the replacement of the soil fines by RHA. RHA has less affinity for water, causing a drop in liquid limit.

Table 4. Eexperimental results with Additives.

Additive	LL(%)	PL(%)	PI(%)	FS(%)
0%	148.0	22.37	125.63	13
2.5%RHA	146.4	22.51	123.89	11.1
5% RHA	144.0	24.24	119.76	10.6
7.5%RHA	141.4	26.49	114.90	10.4
10% RHA	137.2	26.10	111.10	5.65
5% RHP	144.0	24.72	119.28	11.0
10% RHP	137.5	28.50	104.00	9,25
15% RHP	133.6	31.78	101.82	8.55
20% RHP	132.22	32.94	99.28	8.25

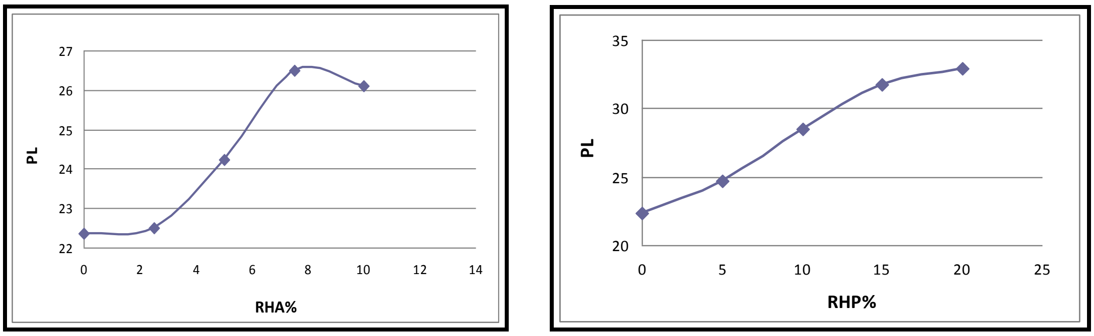
The samples treated with RHP showed a reduction in LL (Figure 2b). Liquid limit decreased from148% to 132.2% with increase in RHP content from 0% to 20% respectively. This reduction may be due to the addition of none plastic RHP to plastic artificial clay.



(a) **(b)**

Figure2. Variation of Liquid Limit with Additives,(a)RHA and (b)RHP.

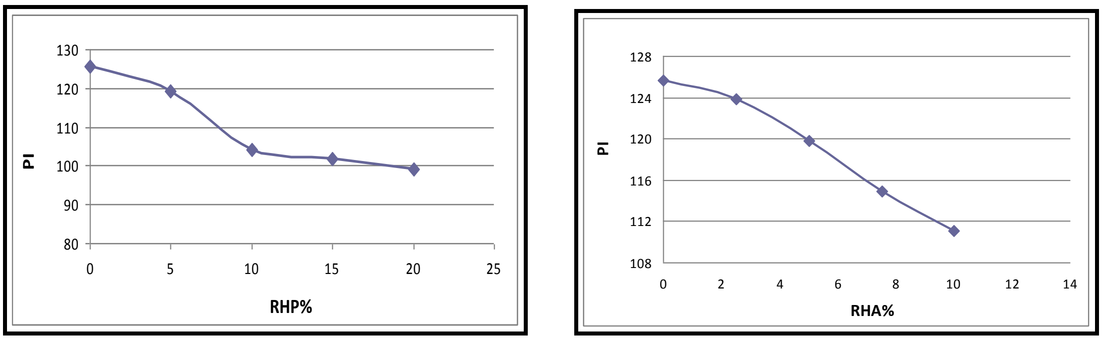
The PL increases from 22.37 % to 26.49 % with increasing %RHA from 0 % to 7.5 % further addition of RHA the PL slightly decreases (Figure.3a). The reasons for the variation of LL with RHA content are also similar to that of the variation of PL with RHA content. Figure 3.b shows the relation between PL and RHP content. The PL increases from 22.37 % to 32.94 %with increasing %RHP from 0 % to 20 %.



(a) **(b)**

Figure3. Variation of Plastic Limit with additives,(a)RHA and (b) RHP.

The samples treated with RHA and RHP showed a similar behavior of a decrease in PI (Figure4.a and b). PI decreased with increasing RHA. This scenario may be attributed to the replacement of the finer soil particles by the RHA with consequent reduction in the clay content and plasticity index.



(a) **(b)**

Figure4. Variation of Plastic Index with additives,(a)RHA and (b) RHP.

Swelling percentage versus time relationship for samples is plotted in Figs. 5 and 6. Swell percentage of specimens were decreased by both and all amounts of additives (RHA and RHP). The swelling percent decreased from 13% to 5.65 with increase in RHA percent. This scenario may be attributed to the replacement of the mixture (M) by the RHA with consequent reduction in swelling percent.

Fig. 6 shows the results of the swelling test for each of RHP%. As can be seen from the figure, the addition of RHP from 0% to 20% reduce the free swelling values from 13% to 5.65%. In this case of RHP stabilized mixture, amount of swelling is reduced through replacement of swelling soil sample by non-swelling material RHP.

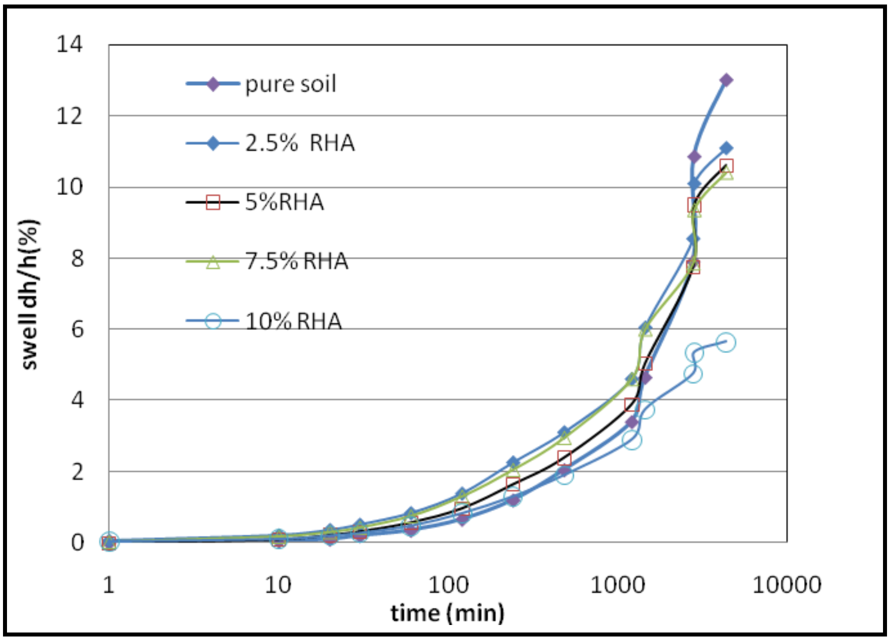


Figure.5 Effect of RHA on Swelling percentage

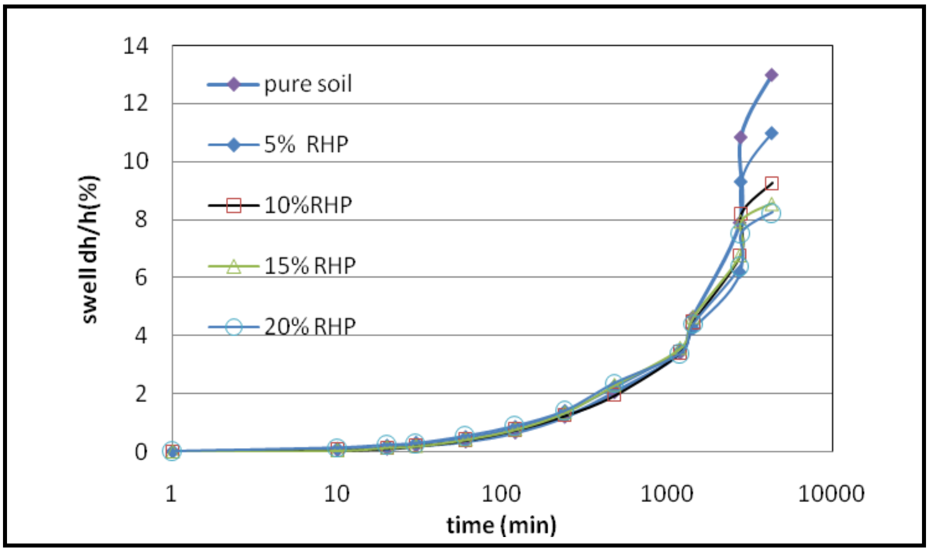


Figure.6 Effect of RHP on Swelling percentage

4 CONCLUSION

This study shows that there is potential in using different additives for specific soil treatments. The free swelling characteristic of clayey soils were improved by the use of usual additives as used in this trial. The results obtained suggest improve important engineering soil properties: they have demonstrated a considerable reduction of the potential free swelling.

Based on this study of using RHA and RHP wastes as a stabilizing agent on expansive soils, the detailed conclusion were:

1. Liquid limit and Plasticity index decreased for both and all amounts of additives (RHA and RHP).
2. RHA and RHP additions decreased the swell percentage of specimens.
3. The use of additive rich in silica such as RHA has shown their capacity to reduce free swelling of expansive soil.

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