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Evaluation the Swelling Soil Stabilized by Waste Corn Ash (WCA)

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Abstract: Swelling soil is a problematic soils which can be observed in both semi-arid and arid zones on the earth surface and these zones very plentiful where the average rainfall is less than the average evaporation every year. To improve their geotechnical characteristics, a Waste Corn Ash (WCA) is used as a chemical stabilization material. Waste corn is a waste material which is products in factory of disperse of corn plant with high amount in Iraq especially in Babylon city/Iraq. Swelling soil used is taken from a Hilla city/Iraq. In this study, Waste Corn Ash (WCA) is produce by burn the waste corn till 900°C. Two types of soils sample group are used. One group, the samples without treatment and the second group, samples are treated by (WCA) with (5, 10, 15 and 20%) from the dry weight. The tests are carried out on this mixture including Atterberge's limits, compaction test, micro-scanning pictures and finally swelling potential test. All the samples treated are subjected to the curing at (7, 14 and till 28 days). The results showed that the soil employed in this research gives a great value of Atterberge's limit, swelling poetical and swelling pressure. The Atterberge's limit of all treated samples gives a decreasing with increasing of (WCA) percentage. The results of all treated soil sample at all ages tests showed a significant decrement in swelling-Potential and swelling-pressure up to 10% of (WCA) mixed. After this percentage of (WCA) mixed, slightly.

Key words: Problematic soils, waste material, swelling soil, geotechnical, products, micro-scanning

INTRODUCTION

Swelling of soils are defined as soils problematic that appear a high change in volume regarding to the changing in content of moisture for the soil. For example soils are swelling with increasing the moisture content while soils suffering from shrinkage due to decreasing the moisture content. Therefore, use such kind of soil as construction material under the structures cause distress and damage of the structures foundations.

Many studies have been carried out to stabilize swelling soils using various material such as fly ash, lime, cement, nano material and waste materials (Al-Rawas *et al*., 2002; Basm and Tuncer, 1991; Bell, 1996; Croft, 1967; Miller and Azad, 2000; Mitchell, 1993; Nalbantoglu and Gucbilmez, 2001; Rao *et al*., 2001; Sherwood, 1993; Hussan and Al-Janabi, 2018). Nevertheless, the reuse of the waste material to improve soil have been literature specifies minimal revisions on the stabilization of expansive soils in Iraq. Consequently, this research was done by treated the soil used with Waste Corn Ash (WCA) to provide a new information to the literature.

MATERIALS AND METHODS

Experimental program

Soil used: The soil that employed in this study has been collated from the center city of Halla, Babylon which is located on the edge of the center plateau desert of Iraq. The physical and chemical features are shown in Table 1.

Table 1: Mineral physical and chemical features of soil used

Variables	Values
Physical features	
Specific gravity (g/cm^3)	2.7
Initial water content wc (%)	5-10
Liquid limit (%)	50
Plastic limit (%)	31
Plastic index (%)	19
Clay (%)	57
Silt (%)	33
Sand (%)	10
Classification (ASTM D248)	Silty clay
Swelling potential (%)	5
Swelling pressure (kPa)	408
Chemical features	
SO_3	0.1
Gypsum content	0.32
pH	8.1
Mineral analysis	
Montmorillonite (%)	45
Illite (%)	25
Kaolinite (%)	20
Chlorite (%)	10

Waste Corn Ash (WCA) additives: Waste Corn Ash (WCA) additives is used in this study as a chemical stabilizer. It has been brought from the Najaf factory in Iraq. To prepare (WCA), firstly, the waste corn was cut to small pieces and then grinding and after that it was

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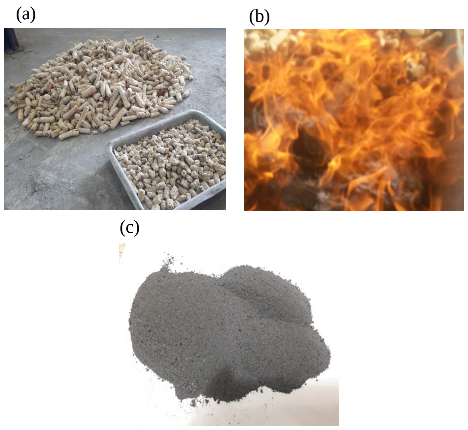

Fig. 1: The steps to preduce the Waste Corn Ash (WCA) a) Cutting the waste corn; b) Burning at 900°C and c) Waste Corn Ash (WCA)

burned at temperature of 800-1000°C for one hour to obtain on pozzolanic materials as shown in Fig. 1.

Preparation of samples tests

Proctor test: The percentage of (WCA) (5, 10, 15 and 20%) from dry weight are mixed with soil used with distilled water. Stander proctor test was carried out of each mixture to find out the Optimum Moisture Content (OMC) and Max. Dry Density (MDD).

Swelling testing samples: Soil mixture are prepared by mixed the soil with (5,10,15 and 20%) of WAC from dry weight. The mixture of each sample was kept in pluvzer container for one hour to be homogenous. At Optimum Moisture Content (OMC) and Max. Dry Density (MDD) obtained from stander proctor test, the samples are prepared with (5 and 2.5 cm) diameter and height respectively. After that, the specimens prepared are kept in plastic container at 25°C to subjected curing. The samples are testing at (7, 14 and 28 days) to find out the possible swelling and swelling presuer by oedometer test.

Swelling testing: The oedometer tests are characterized by Nelson and Miller (1992). Generally, there are two oedometer tests types. The first test is namely swelling-potential test and the second is namely swelling-pressure. In swelling-potential test, a vertical load is applied to the specimen (the inundation pressure) and then adding the water to the specimen and the sample let to swell in termed the percent swell. While in swelling-pressure test, the applied load to the specimen is increasing and the requirement stress to compress the specimen to its first thickness at that it was inundated is termed swelling-pressure.

RESULTS AND DISCUSSION

Atterberge's limits: The Atterberge's limits tests were carried out on both the untreated and treated soil by mixing with (5, 10, 15 and 20%) by dry weight of (WCA). After the analysis of test results following results were drawn are shown in Fig. 2. It can noticed that the liquid and plastic limits; as well as plasticity index for untreated soil are high which it gives a clearly indication that this soil is a swelling soil.

On other hand, the adding of (WCA) with all percentage to the soil caused a decreasing in Atterberge's limits. The results indicate that the adding of (WAC) caused modification and improvement to the geotechnical characteristics of swelling soil. It means that there is a possibility to decrease in the swelling-potential and swelling-pressure of the soil. It can summary that the (WCA) particles fill the fine pores of the soil structure and allow less water to entry and hence reduce the swelling of the soil.

Procter tests: To find (MDD) and (OMC), The stander proctor test was carried out. The results of this test for both untreated and treated soil that mixed with (5, 10, 15 and 20%) by dry weight of WCA are shown in Fig. 3.

It can be noticed that mixing a swelling soil used with 5,10 up 15% of (WAC) there is an increases in OMC and decreasing in MDD with compared with untreated soil see Fig. 3 and 4. This is can be attributed that WCA act as stabilized material which caused modification to geotechnical characteristics of swelling soil. As well as the an increases in OMC can be explained to a high surface area of WCA which need more water to reacted it with soil. On other hand, the decreasing in MDD is due to the low value of specific gravity of WCA (G.S =1.1 g/cm^2) (Saeed, 2016).

Swelling-potential and swelling-pressure: Oedomter test is conducted to determine the swelling-potential and swelling-pressure for both untreated and treated soil by mixing with (5, 10, 15 and 20%) of (WAC) at different age tests (7, 14 and 28 days). The results are plotted in Fig. 5 and 6. The results show that the untreated soil gives high value of swelling-potential (S = 5%) and high value of Swelling-Pressure (SP = 410 kPa). This is can be attributed that based on the chemical characteristics of this soil (Table 1), the clay classified as a (Montmorillonite-Na^{+2}). During to the increment the content of water, the hydration of the Na^{+2} ions and the exchangeable cations occur with increasing the thickness of the double layer and corresponding decreasing of the attraction forces among the clay particles occur.

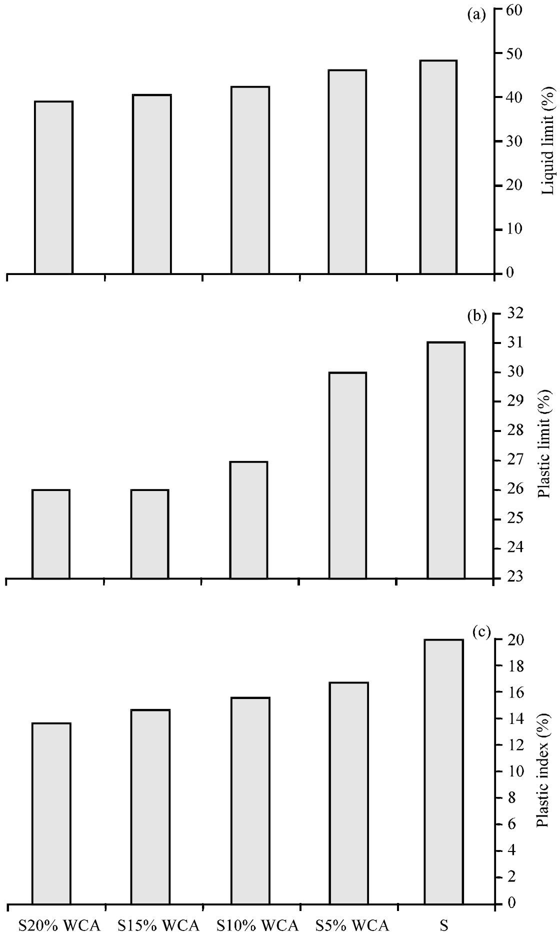

Fig. 2a-c): Atterberge's limits for different soil samples used

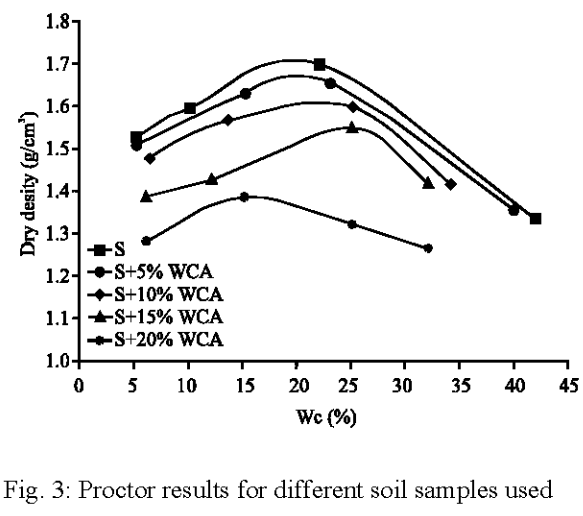

Fig. 3: Proctor results for different soil samples used

Therefore, the primary mechanism of the swelling potential is depended to the double layer theory (Al-Janabi, 2014; Mitchell, 1993) (Fig. 7).

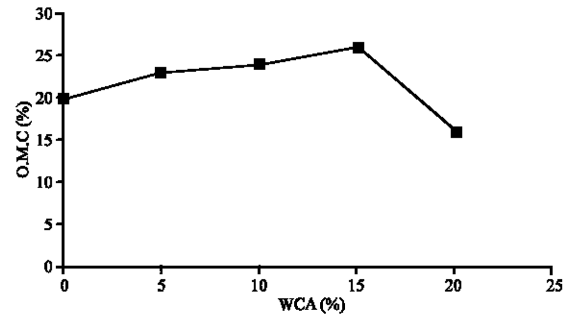

Fig. 4: Optimum moisture content (O.M.C.) vs. (WCA %) for different soil used

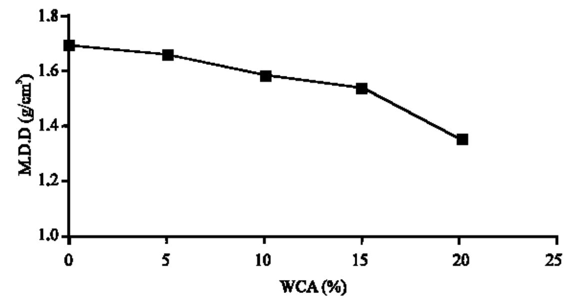

Fig. 5: Max. Dry Density (M.D.D) vs. (WCA %) for different soil used

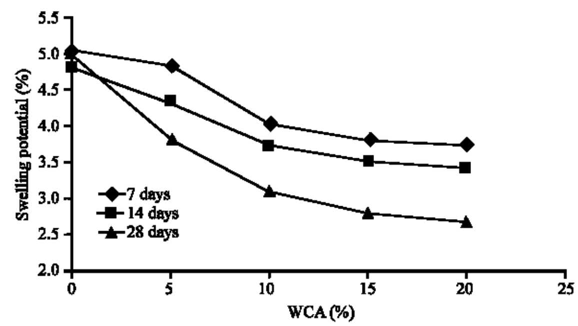

Fig. 6: Swelling potential vs. (WCA %) for different soil used

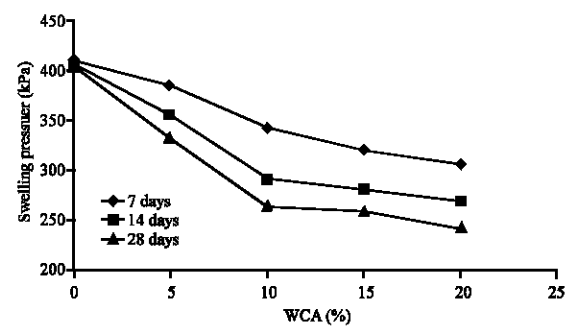

Fig. 7: Swelling pressure vs. (WCA %) for different soil used

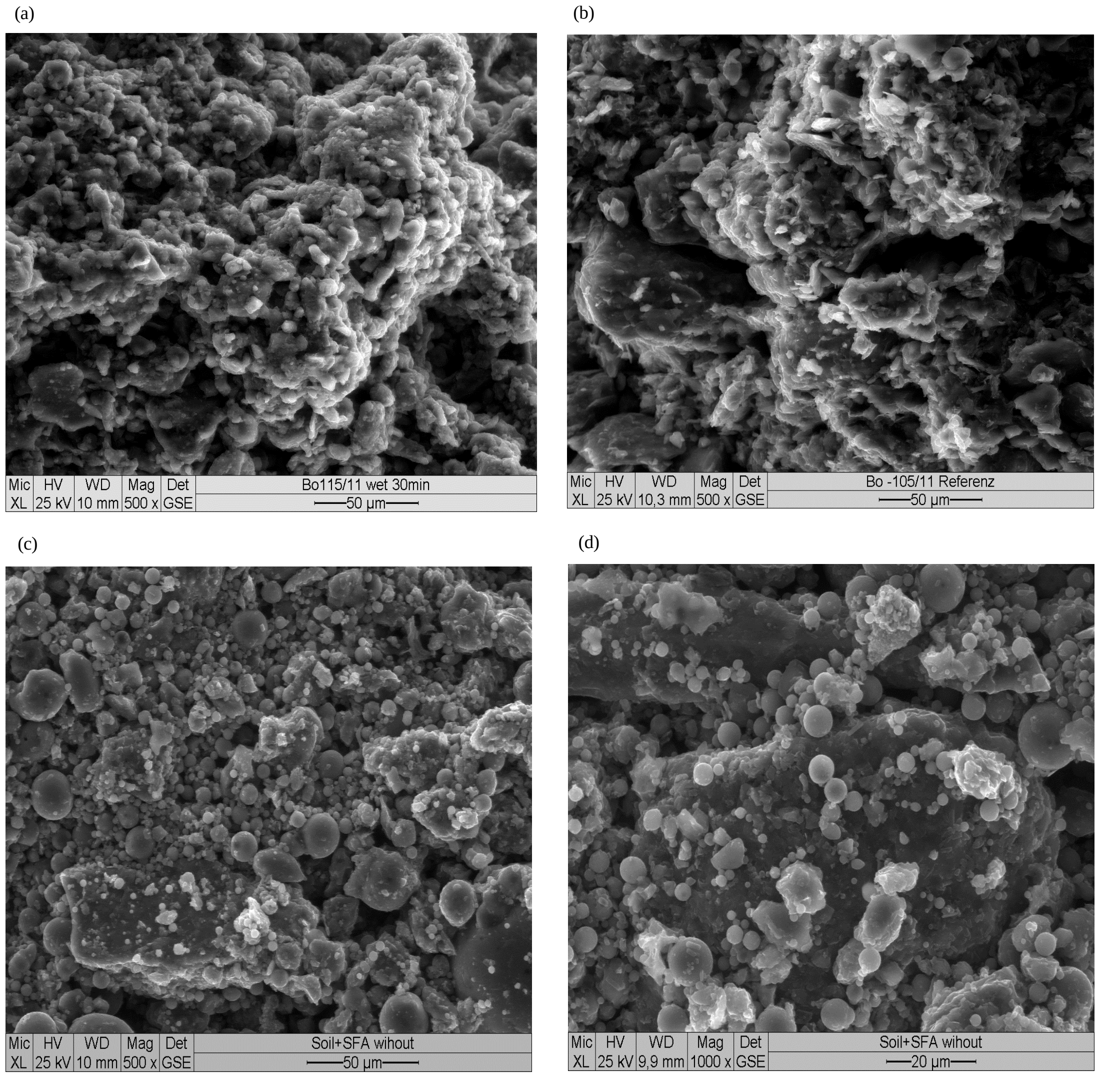

Fig. 8: Micro-scaring pictures for different soil used a) Soil mixed with 5-10% WAC; b)Untreated soil; c) Soil mixed with 20% WAC and d) Soil mixed with 15% WAC

On other hand, it can be noticed that when the soil used are mixed with 5,10, 15 and 20% of (WAC), there is a decreasing in swelling-potential and swelling-pressure to [(S = 3.7%, S.P. = 305 kPa), (S = 3.4%, S.P. = 270 kPa) and (S = 2.7%, SP = 245 kPa)] at (7, 14 and 28 days), respectively with compared with untreated soil (S = 5%, S.P. = 410 kPa). This is can be attributed that WCA act as stabilized material which caused modification to geotechnical characteristics of swelling soil.

Also, It can see in these figure that, at all ages test, the decreasing is significantly in swelling-potential and swelling-pressure of treated soil used up to 10% of (WAC), after this percentage, the decreasing is slightly. It can explained that the pozzolanic reaction between soil water and WCA is completed and all particles of (WAC) are reacted up to 10%. The behavior of soil after this percentage could be explanation that, there is some material of (WAC) still incomplete reaction that caused flocculated, agglomeration and incomplete interaction of (WAC) and soil particles (Ghobadi and Babazadeh, 2014). It can see it in micro-scanning test picture (Fig. 8), there are some free particles of (WAC) after 10 %. From this fact, It can concluded that the optimum percentage of (WAC) is that 10-15%.

CONCLUSION

This study evaluated the swelling soil treated with a Waste Corn Ash (WCA). The results showed that the soil employed in this research give great value of Atterberge's limit, swelling poetical and swelling pressure. On other hand, the Atterberge's limit of all treated samples gives a decreasing with increasing of (WCA) percentage. The results of all treated soil sample showed a decrement in swelling-potential and swelling-pressure by mixing with different percentage of WCA. As well as these decreasing in swelling-potential and swelling-pressure were slightly when the percentage of (WCA) mixed is more than 10%.

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