



IJRTSM

INTERNATIONAL JOURNAL OF RECENT TECHNOLOGY SCIENCE & MANAGEMENT

“EXPERIMENTAL STUDY FOR STABILIZING CLAYEY SOIL WITH EGGSHELL POWDER AND PLASTIC WASTES”

Govind Kumar Gupta¹, Vijay Kumar Meshram²

¹ M.Tech Scholar, Lakshmi Narain College of Technology, Bhopal, MP, India

² Associate Professor, Lakshmi Narain College of Technology, Bhopal, MP, India

ABSTRACT

Using of chemical admixtures such as lime, cement, bitumen etc. in soil stabilization is highly expensive. Therefore, it is preferable to replace these manufactured materials by another kinds of soil additives to reduce the cost. This research investigates an experimental study for stabilizing a clayey soil with eggshell powder as a replacement of commercial lime and plastic wastes strips in order to reduce the brittleness of soil stabilized by eggshell powder, and its effect in the engineering properties of the soil. Three various proportions of eggshell powder (2%, 5% and 8% by weight of dry soil) and plastic wastes strips (0.25%, 0.5% and 1% by weight of dry soil) have been used to make nine groups of stabilized soil samples to obtain the optimum percentage of each additive. The analysis was done by conducting compaction, unconfined compression, swelling potential, direct shear and California bearing ratio tests. It was observed that eggshell powder, plastic waste fibre contents and curing duration had significant effect in the engineering properties of the stabilized soil. The results showed that the unconfined compression strength, California bearing ratio values and shear strength parameters had increased with increase in eggshell powder content up to certain limit, thereafter it will slightly decrease, while an increase in eggshell powder led to a reduction of swelling potential. On the other hand, an increase in plastic wastes fibre content led to an increase in the strength properties mentioned and reduction of swelling potential. Moreover, it is observed that curing duration had significantly improved the strength properties mentioned of the stabilized soil samples.

Keyword: black cotton soil, expansiveness, swelling, shrinkage, stabilization

I. INTRODUCTION

Construction of any buildings such as highways and other civil engineering structures on clayey soil is considered risky, because such soil is susceptible to differential settlements and volume change either in compressibility or swelling. Hence, there is a desire to enhance certain required properties such as bearing capacity, shear strength parameters and reduce the volume change of the soil.

For any land-based structure, the footing is so important and should be strong to support the load of the structure. To make the footing strong, the soil around it plays a very critical role, so to work with soils, we should have proper knowledge for their properties and factors which influence in their behaviour.

Stabilization: Soil stabilization method is widely used to enhance the strength of soil and reduce its compressibility through bonding the soil particles together. By this process, it makes the soil more stable and reduces its volume change and makes it proper for use. This process is mainly used where the available soil is not fit for the intended

purpose, where the soil does not have desired engineering properties, it requires to be enhanced. For this purpose, some admixtures should be added to enhance their properties.

Soil stabilization can be achieved by crushing the natural soil, and mixing it with a particular chemical additive, then compacting the mixture. Under this process, soil stabilization depends mainly on the chemical reactions between the additive (i.e. lime, cement, fly ash, bitumen) and the soil to achieve the desired change. Many of the researchers have been used those previous admixtures in soil stabilization and gave good results in enhancement of the engineering properties of the soil, but the cost of this additives is quite expensive so, reuse of solid wastes in the stabilization of soils has rapidly increased in recent years. Solid wastes have been used in soil stabilization as standalone stabilizers [1] as well as auxiliary additives to conventional stabilizers like lime and cement [2]. A lot of solid wastes have been probed by researchers for their effectiveness in soil improvement.

Eggshell: Eggshell Powder (ESP) has not been in use as a stabilizing material and it could be a good replacement for artificially synthesized lime, since its chemical composition is similar to that of lime. Its composition primarily contains calcium, magnesium carbonate (lime) and protein [3]; chicken eggshell is a waste material from domestic sources such as poultries, hatcheries, homes and fast food joints [4]. According to international egg commission [5 and 6] in 2011, Iraq egg production was 42,000 tons and about 188,000 tons had to be imported, combining these two numbers the total annual consumption in the 2011 was 230,000 tons, the shell constitutes (10-11%) from the total weight of egg [7]. Based on the above statistics, considering the weight of shell is (10%), the annual production of eggshell waste in Iraq is 23,000 tons. This is a huge quantity of waste produced and needs to be effectively managed for reducing the load on landfills in the country. Therefore, in the absence of an effective waste disposal policy, the utilization of eggshell in soil stabilization will be an available choice.

In recent years, ESP has been used as an admixture into soils to improve its strength behaviour. Amu et al., [4] have studied the stabilization of soil with ESP in potential replacing of lime in an expansive soil. They found that the MDD, CBR (soaked), UCS (cured and uncured) and the cohesion increased significantly and decreased the plasticity with (4% ESP-3% lime) stabilized soil. Olarewajuet al., [8] have studied the suitability of ESP stabilized lateritic soil as subgrade material for road construction. Walia and Singh [9] studied the influence of the combination of ESP and stone dust in the compaction characteristics and CBR value of clayey soil. They found that ESP had improved the soaked CBR value. The curing duration for the stabilized soil samples with ESP had significantly enhanced the strength properties of the soil. Prasad et al., [10] have studied the effect of curing in clayey soil stabilized with various proportions of ESP. they found that the UCS significantly increased after 7 days curing duration.

Plastic wastes: There is a rapid increase in the consumption of plastics all around the world due to economic development. The annual consumption of the world for plastic materials has increased from 5 to 100 million tons for fifty years ago. Therefore, this is big quantities of plastic wastes need to be disposed of. After food and paper wastes, plastic waste is the third major constitute at municipal and industrial waste in the urban. This situation gets worsened due to the fact that they are not even aware of the ill-effects of plastic waste to the environment[11].

Plastic wastes are often the most visible component in waste dumps that have a long period required for natural decomposition, using this material can provide an opportunity to collect and dispose of, it is in the most environmentally friendly way, and it can be converted into a resource.

Past researchers have found that the inclusion of plastic fibres significantly improve the engineering properties of soils. Cai et al., [12] have studied the influence of polypropylene fibre, lime admixture and curing duration in the engineering properties of a clayey soil. They observed that the increasing in fibre content caused an increase in strength properties and shrinkage potential and caused on the reduction of the swelling potential. Moreover, the curing duration had significantly enhanced the unconfined compression strength and shear strength parameters of the treated soil. Jadhao and Nagarnaik [13] have studied the influence of polypropylene fibres in the engineering behaviour of soil treated with fly ash additive by using various fibre lengths (6, 12 and 24) mm with the range of (0- 1.5% by dry weight of the soil). They found that the maximum enhancement in the strength properties could achieved at a fibre length of (12) mm, and the optimum percentage of fibre content was (1%).

According to the literature, the compressive the tensile strength values of reinforced stabilized soil with polypropylene fibres have increased to a great extent. The highest strength values were obtained with approximately (0.5–1.0%) fibres content for the (12) mm length. The shrinkage limits value increased with an increasing fibre content and length of fibre, whereas volume changes and cracks were decreased [14]. However, there are no studies done in stabilizing of

clayey soil with plastic fibre reinforcement and eggshell powder as a replacement of lime, and its effect in the engineering properties.

The objective of this research paper is to investigate the influence of plastic wastes, eggshell powder contents and the curing duration in the strength behavior of clayey soil, to reduce the cost of soil stabilization, and to propose an alternative solution for waste disposal.

II. MATERIALS AND EXPERIMENTAL PROGRAM

Materials

Soil

The soil used in this study has been obtained from a site in the east of Mosul city, Nineveh province, Iraq, at a depth of 2.0 m below the ground surface. Undisturbed soil samples were collected as block pieces with approximate dimensions of (250×250×300) mm. The samples are sealed immediately with aluminium and nylon containers to keep the water content without change. Disturbed soil samples were also collected from the site for index properties. A summary of the basic properties of the soil are presented in Table 1. Grain size distribution curve determined following ASTM D 422 [15] is shown in Figure 1. It can be seen that the soil is a mixture of silt and clay, light reddish in colour with a small lumps of CaCO₃, Atterberg's limits described in ASTM D 4318 [15]. The consistency of the soil can be described as stiff and it is over-consolidated, from the Atterberg's limits values, the soil can be described from Cassagrande's A-line chart as a clay with medium plasticity, and the classification of soil in accordance with the Unified Soil Classification System (USCS) is CL, specific gravity described in ASTM D 854 [15] and maximum dry density and optimum moisture content according to ASTM D 698 [15]. The properties of soil are listed in Table 1.

Table 1. Index and in-situ properties of the soil samples

Description	Values
Specific gravity, G _s	2.61
Gravel	0
Sand	4
Grain size distribution (%)	
Silt	56
Clay	40
Liquid limit, w _l	45
Atterberg's limits (%)	
Plastic limit, w _p	28
Plasticity index, I _p	17
In-situ properties	
Water content, w _o (%)	12.9
Dry density, γ _d (gm/cm ³)	1.54
Optimum moisture content, (%)	17.8
Compaction properties	
Maximum dry density, γ _{dmax} (gm/cm ³)	1.68
Unified Soil Classification System	CL

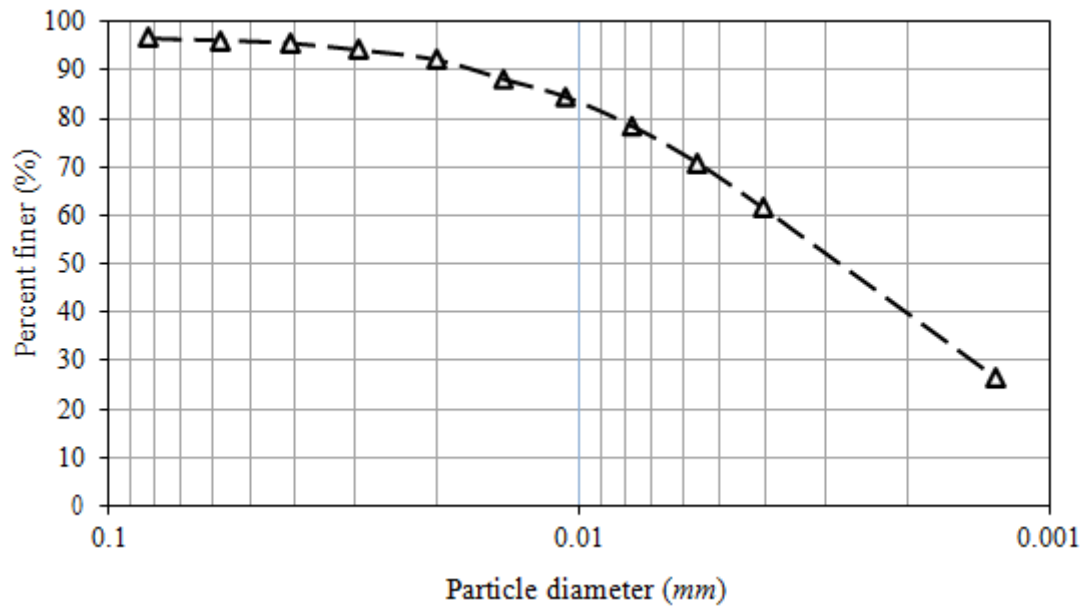


Figure 1. Grain size distribution of the soil.

Eggshell

White chicken eggs have been used for stabilizing soil as a replacement for the commercial lime. The chemical composition of the eggshell waste powder sample was analyzed by [16] with X-ray fluorescence machine. The results are shown in Table 2. The results show that the calcium oxide was the dominant percentage component. The high amount of calcium oxide is associated with the presence of calcium carbonate, which is the main percentage component of eggshell. Thus, the eggshell waste can be considered from the chemical analysis quite similar to calcite/calcareous. ESP used in this study was collected from one of the restaurants in Mosul city, Iraq. The samples were rinsed with water to remove the residue egg contains that attached on the eggshell, then drying the samples under sunlight. The inner membrane was removed, then grounded the samples and passed through # 200 (75 μ m) sieve in order to achieve a uniform powdery material, since chemical reaction will be completely better, faster and more effective for bigger surface areas [4]. Figure 2 shows samples of the ESP used in the study.

Table 2. Chemical composition of the eggshell powder, [16]

Chemical composition	Weight (%)
C	21.1286
Na ₂ O	0.1046
MgO	0.9261
P ₂ O ₅	0.4149
SO ₃	0.3264
K ₂ O	0.0542
CaO	76.9922
Fe ₂ O ₃	0.0132
SrO	0.0396

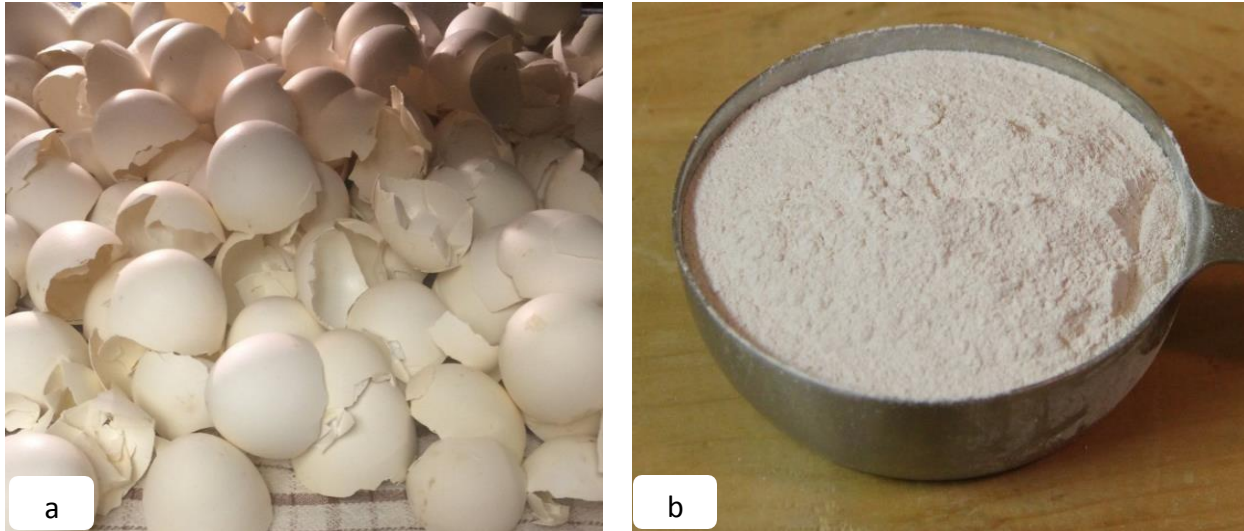


Figure 2. Eggshell powder used, a) Samples of the white eggshell, b) ESP after grinding.

Plastic wastes

The plastic wastes used in the stabilization of soil have been collected nearby disposal sites obtained from plastic waste bottles as shown in Figure 3. They are cut into small strips, at 20 approximately aspect ratio, then added to the soil as reinforcement at varying proportions with a randomly distributed. A summary of the physical and mechanical properties of the plastic wastes are illustrated in Table 3.

Table 3. Physical and mechanical properties of the plastic wastes

Description	Values
Colour	Clear
Unit weight, gm/cm^3	0.91
Length, mm	10-20
Width, mm	1-1.5
Water absorption, (%)	0.02
Compressive strength	Poor
Ultimate tensile strength, MPa	55
Modulus of Elasticity, MPa	110-450
Burning point, ($^{\circ}C$)	200
Acid and Alkali resistance	Very good

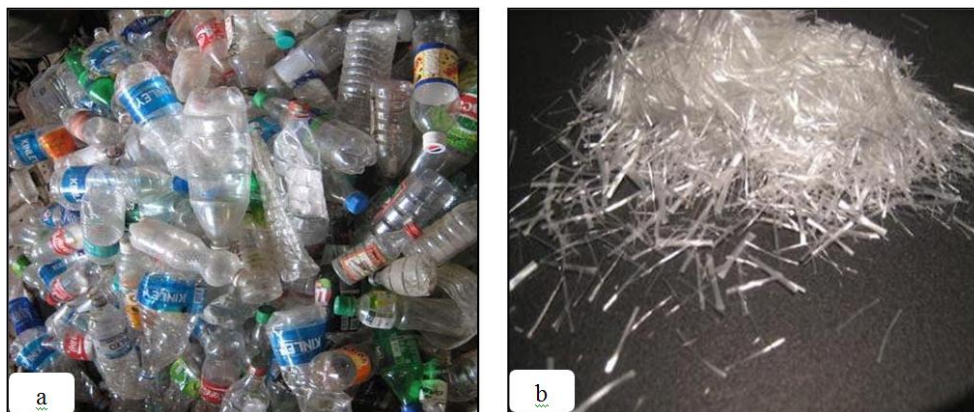


Figure 3. Plastic wastes used, a) Samples of the plastic bottles wastes, b) Plastic wastes strips

Sample Preparation

The oven-dried soil was ground and sieved through # 40 (425 μm) sieve. According to the review of literature on plastic fibres reinforcement and eggshell powder, the PWS and ESP are mixed with the soil in three proportions of PWS consisted of (0.25%, 0.5% and 1.0%), and three proportions of ESP consisted of (2.0%, 5.0% and 8.0%) by weight of the dry soil.

Optimum Moisture Content (OMC) determined from standard Proctor compaction test was gradually added to the various mixtures described above. The mixing process was continued until to get a homogeneous paste mixture. The mixture was kept later in nylon sacks for 24 hrs. in the laboratory at control temperature ($22 \pm 2^\circ\text{C}$) to achieve uniform mixing of soil-water. This mix was used for the preparation of the samples for the various tests. To study the influence of curing duration, all stabilized samples were put in desiccators ($22 \pm 2^\circ\text{C}$, $96 \pm 2\% \text{RH}$) for testing later at 7, 14 and 28 days [12]. Unstabilized soil samples were also made to make a comparison with ESP-PWS stabilized samples.

Experimental program

The following experiments have been conducted on the soil samples:

Compaction test

Standard proctor test was conducted according to ASTM D 698 [15], to draw the relationship between dry density and moisture content, to determine the maximum dry density and optimum moisture content.

Unconfined compression test

UCS is widely used as an economical and quick test to determine the compressive strength value of a particular cohesive soil. UCS using strain-controlled system of the axial load was conducted in accordance with ASTM D 2166 [15]. Samples were formed in a standard mould of 80 mm in length, and 39.1 mm in diameter. The strain rate of 1.25 mm/min was used for the testing. The samples were prepared by compacted materials in 3 layers in the UCS mould at optimum moisture content and maximum dry density conducting from the standard proctor test.

Swelling potential test

The one-dimensional swell test was carried out to investigate the swelling potential of unstabilized and ESP-PWS stabilized soil samples. The oedometer ring is 63.5 mm in diameter, 19 mm in height were retrieved by trimming the samples at required maximum dry density and optimum moisture content. Samples were installed into the oedometer device and the swell was conducted. The samples were allowed to swell freely under a light stress 6.9 kPa until full swell achieved.

California bearing ratio test

CBR test was conducted according to ASTM D 1883 [15]. It is a penetration test used to determine the bearing capacity of the soil for the pressure. The samples were compacted statically in standard moulds at optimum moisture content and maximum dry density. A standard penetration rate of the plunger is 1.25 mm/min. Soaked CBR samples were also carried out after 4 days soaking. Soaking specimens were placed in a container and submerged with water.

Direct shear test

Direct shear test was conducted according to ASTM D 3080-03. Specimens with dimensions of (60 \times 60 \times 20) mm were used in the test with drained condition to determine the effective shear strength parameters (c' & ϕ') with strain rate of 0.1 mm/min, and normal stresses of (100, 200 and 300) kPa. The specimens were retrieved by trimming the mould at the specific optimum moisture content and maximum dry density obtained from the standard compaction test.

III. RESULTS AND DISCUSSIONS**3.1. Effect of ESP-PWS in compaction characteristics**

The values of MDD and OMC for the different ESP-PWS stabilized and unstabilized soil samples are shown in Table 4. Figures 4 and 5 show the variation of MDD and OMC of ESP-PWS stabilized samples respectively. Generally, MDD reduces as ESP and PWS increased, and the reason can be explained to the reduction in the average unit weight of the solids in the mixture of ESP-PWS stabilized soil samples. For any specific ESP, MDD slightly decrease with increasing PWS, this is because of the low specific gravity of PWS. The maximum value of MDD was 1.673 gm/cm^3 is observed at 0.25% PWS and 2% ESP content, whereas the minimum value was 1.646 gm/cm^3 at 1.0% PWS and 8% ESP content. On the other hand, OMC increases as ESP increased, this increasing was a result of the porous

characteristics of ESP and subsequent water absorption needs for the pozzolanic reaction between ESP and soil particles. For any specific ESP, OMC does not show a significant change with increasing of PWS. The maximum value of OMC is recorded as 19.73% at 0.25% PWS and 8% ESP content, whereas the minimum value is recorded as 18.38% at 1.0% PWS and 2% ESP content.

Table 4. Results of compaction characteristics and California bearing ratio

No.	ESP content (%)	PWS content (%)	MDD (gm/cm ³)	OMC (%)	CBR values (%)	
					Soaked	Unsoaked
1	2	0.25	1.673	18.64	3.86	6.36
2	5	0.25	1.660	19.00	5.75	8.05
3	8	0.25	1.655	19.73	5.33	7.63
4	2	0.5	1.671	18.50	4.41	6.71
5	5	0.5	1.659	18.81	7.00	8.70
6	8	0.5	1.648	19.65	6.30	8.20
7	2	1.0	1.669	18.38	5.06	6.96
8	5	1.0	1.655	18.76	7.70	9.20
9	8	1.0	1.646	19.61	7.20	8.70
10	0	0	1.680	17.80	2.71	4.40

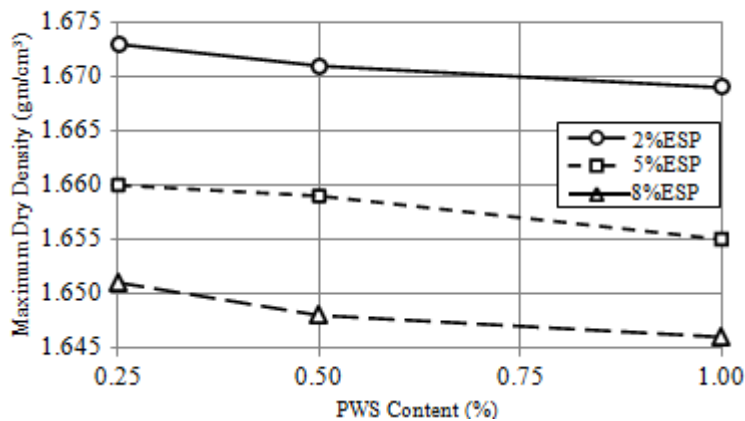


Figure 4. Maximum dry density of ESP-PWS stabilized soil samples

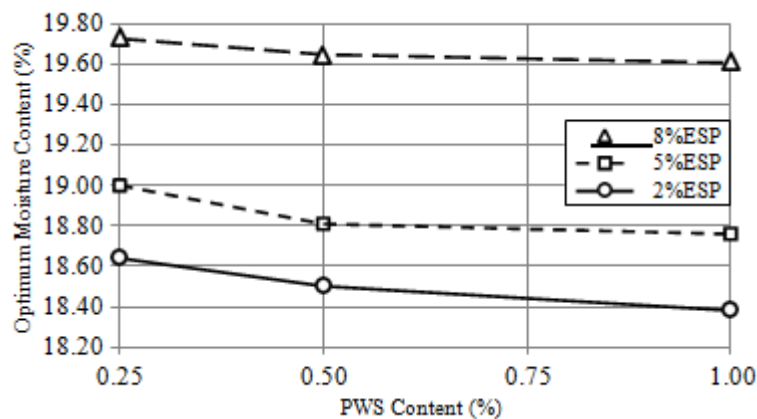


Figure 5. Optimum moisture content of ESP-PWS stabilized soil samples

Effect of ESP-PWS in unconfined compressive strengthbehaviour

The values of the UCS for the different ESP and PWS are shown in Table 5. It is obvious that the curing duration had a significantly improved the strength of ESP-PWS stabilized soil samples, this is because of the gradual formation of the cementitious compounds (calcium silicate hydrate) as a result to the reaction between the calcium carbonate existed in the ESP, soil and water. Figure 6 shows the variation of the UCS values of ESP-PWS stabilized samples after 28 days curing duration. It is obvious that the PWS had a gradual improvement in the strength (about 50 kPa) when increase from 0.25% to 1.0%. for any specific PWS content the strength increases up to a certain limit and then decrease when ESP increase from 2% to 8%. The maximum strength value as 591 kPa is observed at 1.0% PWS and 5% ESP content, which is 7.4 times compared with the unstabilized sample. While the minimum strength value was 211 kPa at 0.25% PWS and 2% ESP content, which is 2.6 times compared with the unstabilized sample.

Figure 7 shows the axial stress-strain curves of 8% ESP-different percentages of PWS stabilized (after 7 days curing duration) and unstabilized soil samples. It is obvious that ESP and PWS contents had a significant effectiveness in the failure characteristics. For the mentioned ESP content, the increasing in PWS content causes an increase in the residual strength value varying from 0 to 165 kPa, in other words, an increase in PWS content causes an increase in ductility behaviour and decrease the loss of peak compared with the unstabilized soil sample.

Table 5.Results of unconfined compressive strength and swelling potential

No.	ESP content (%)	PWS content (%)	Unconfined compressive strength (kPa)			Swelling potential (%)
			7 days	14 days	28 days	
1	2	0.25	105	141	211	0.77
2	5	0.25	141	202	549	0.59
3	8	0.25	116	151	422	0.53
4	2	0.5	135	167	226	0.75
5	5	0.5	172	223	578	0.56
6	8	0.5	141	179	443	0.49
7	2	1.0	157	205	254	0.61
8	5	1.0	197	292	591	0.49
9	8	1.0	181	236	472	0.46
10	0	0	80*	----	----	8.10

*The value was gained without any curing.

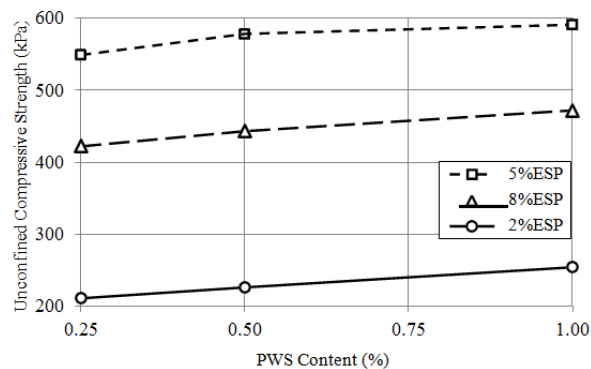


Figure 6.Unconfined compressive strength of ESP-PWS stabilized soil samples after 28 days curing

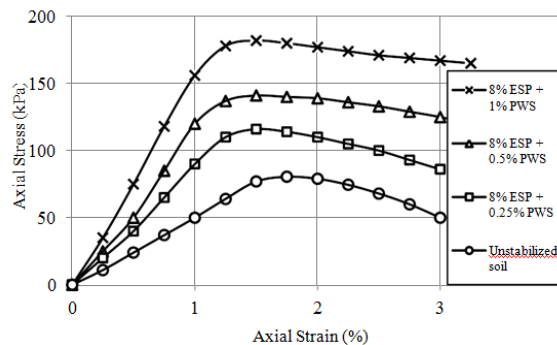


Figure 7.Axial stress-strain curves of different samples after 7 days curing

Effect of ESP-PWS in swelling potential

The swelling potential values for ESP-PWS stabilized and unstabilized soil samples are presented in Table 5. The variations of the swelling potential after 7 days curing is shown in Figure 8. For any specific PWS content, an increase in ESP content leads to a significant decrease in the swelling potential, whereas for any specific ESP, an increase in PWS content leads to a slight decrease in the swelling potential. The maximum swell percent is recorded as 0.77% at 0.25% PWS and 2% ESP content, which is 9.5% of the swell percent of the unstabilized samples. While the minimum swell percent is recorded as 0.46% at the amounts 1.0% PWS and 8% ESP content, which is 5.7% of the swell percent of the unstabilized samples.

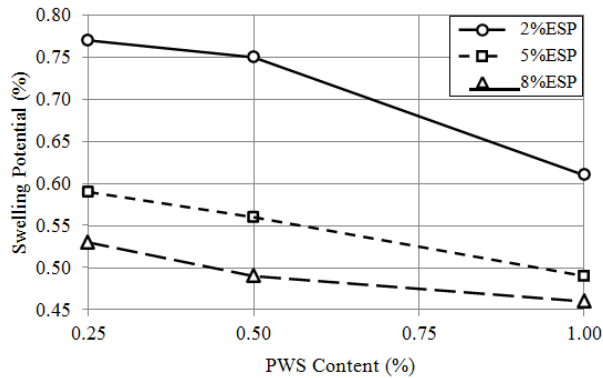


Figure 8.Swell percent of ESP-PWS stabilized soil samples after 7 days curing

3.4. Effect of ESP-PWS in CBR value

CBR tests were carried out for samples at a maximum dry density and optimum moisture content based on compaction characteristics. The values of CBR are presented in Table 4. Figure 9 a and b shows the variation of the CBR values of ESP-PWS stabilized samples in soaked and unsoaked conditions respectively. It is observed that the un soaked CBR values were higher than those of the soaked values. The maximum soaked and un soaked CBR values were found to be 7.70% and 9.20% respectively at 1.0% PWS and 5% ESP content. These values are 2.8 and 2.1 times respectively compared with the unstabilized soil sample value. The minimum values were found to be 3.86% and 6.36% respectively at 0.25% PWS and 2% ESP content, which is 1.4 and 1.5 times respectively compared with the unstabilized sample value.

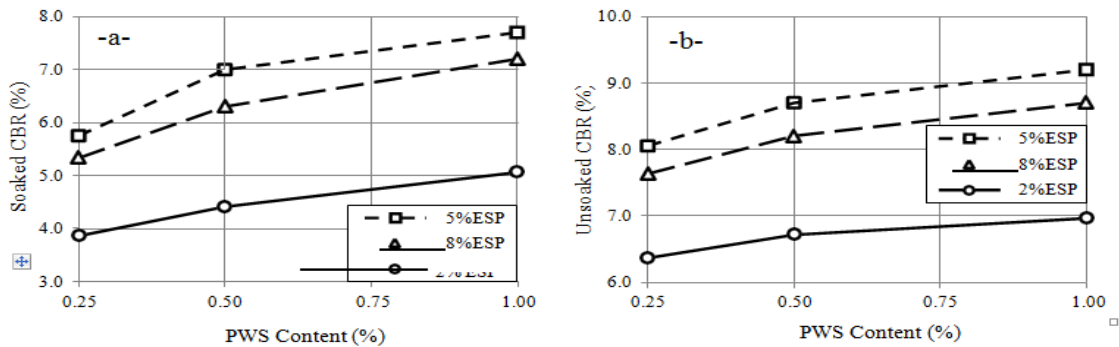


Figure 9.California bearing ratio values of ESP-PWS stabilized soil samples, a- Soaked, b- Unsoaked

3.5. Effect of ESP-PWS in shear strength parameters

The shear strength parameters of samples tested at different ages are shown in Table 6. It is obvious that the curing duration had a distinct effectiveness in the parameters. An increase in the curing duration leads to increase each of cohesion and angle of internal friction of the ESP–PWS stabilized soil samples. The amounts of ESP and PWS have also a positive influence in the development of these parameters. Figure 10 presents the variation of cohesion with PWS content after 28 days curing duration. It can be seen that for any specific ESP, an increase of PWS causes increasing of cohesion. In addition, for any specific PWS the cohesion initially increases then slightly decreases when ESP content increase from 2% to 8%. The maximum value of cohesion is recorded as 97.5 kPa at 1.0% PWS and 5% ESP content, whereas the minimum value is recorded as 50.6 kPa at 0.25% PWS and 2% ESP content. These values are

2.4 and 1.2 times respectively of cohesion values of the unstabilized soil samples. Figure 11 presents the variation of the angle of internal friction with PWS content after 28 days curing duration, which is seems to be similar to the cohesion variation. The maximum value was 39.6°, is also found at 1.0% PWS and 5% ESP content, whereas the minimum value was 25.8° at 0.25% PWS and 2% ESP content. These values are 1.9 and 1.3 times respectively of angle of internal friction values of the unstabilized soil samples. According to the above results, it can be saying that the optimum ESP and PWS requirement for the best strength improvement of the soil samples are about 5% and 1% respectively as a percentage of dry soilweight.

Table 6.Results of shear strength parameters

No.	ESP content (%)	PWS content (%)	Cohesion(kPa)			Internal friction Angle(°)		
			7 days	14 days	28 days	7 days	14 days	28 days
1	2	0.25	45.1	47.6	50.6	22.8	24.9	25.8
2	5	0.25	58.7	69.5	75.5	28.4	33.0	34.2
3	8	0.25	50.2	64.4	71.3	29.7	31.4	33.2
4	2	0.5	50.5	54.1	56.1	27.6	28.3	28.5
5	5	0.5	69.7	77.3	90.1	30.0	33.2	36.9
6	8	0.5	64.7	71.6	82.6	30.2	34.4	35.6
7	2	1.0	53.6	57.2	62.6	30.5	31.0	31.4
8	5	1.0	80.3	88.9	97.5	35.1	37.3	39.6
9	8	1.0	76.6	85.1	92.4	32.5	34.2	38.3
10	0	0	41.0*	----	----	20.5*	----	----

*The value was gained without any curing.

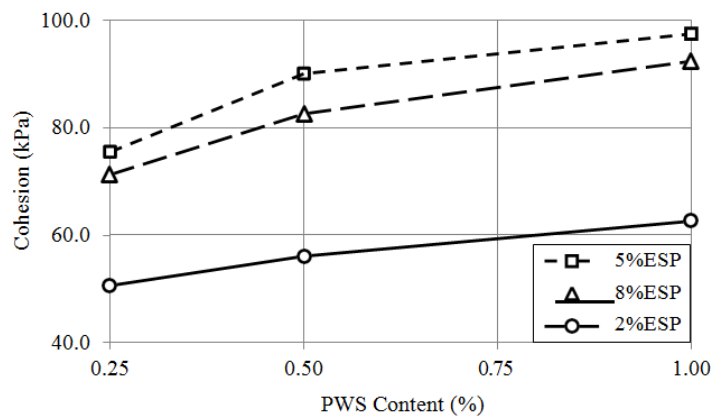


Figure 10.Cohesion of ESP-PWS stabilized soil samples after 28 days curing

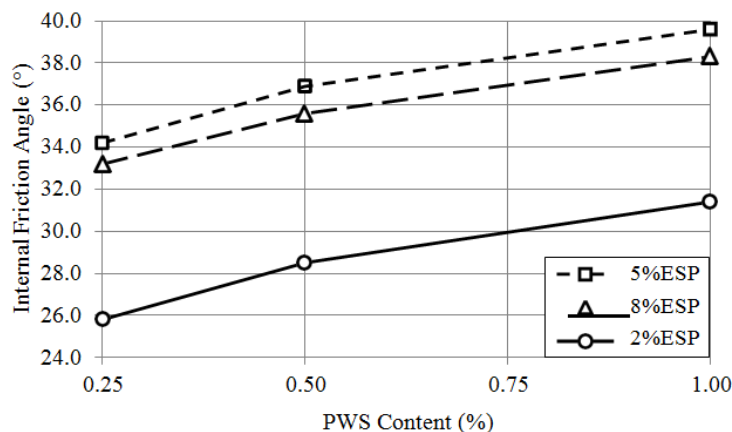


Figure 11.Internal friction angle of ESP-PWS stabilized soil samples after 28 days curing

IV. CONCLUSIONS

The effect of the combination of ESP and PWS in some engineering properties of clayey soil represented by compaction characteristics, unconfined compressive strength, swelling potential, California bearing ratio test and finally shear strength parameters have been studied in this research. The following conclusions were made:

- A significant positive change has been noticed in the engineering characteristics of the clayey soil after adding both of ESP and PWS. These beneficial changes depend on ESP, PWS contents and the curing duration.
- The curing duration had significantly improved the engineering characteristics of the stabilized soil samples. Unconfined compressive strength and shear strength parameters of the clayey soil had increased with increasing the curing duration.
- An increase in ESP content causes to an initial increase in unconfined compressive strength, California bearing ratio and shear strength parameters of the clayey soil followed by a slight decrease. The optimum ESP requirement for strength improvement is about 5% by dry weight of soil. On the other hand, the swelling potential had reduced with an increase in ESP content. However, its influence in the maximum dry density is seen to be limited or insignificant.
- On the other hand, an increase in PWS content causes to an increase in strength characteristics mentioned above and decrease swelling potential of the clayey soil used in this study.
- The contribution of ESP and PWS together in the stabilization of clayey soil, gives more improvement in the strength characteristics, shear strength parameters and swelling potential than stabilization of the soil with ESP only.
- Finally, PWS causes an increase in the residual strength value in the axial stress-strain curve of the unconfined compressive strength.

REFERENCES

1. James J and Pandian P K, 2015. Soil stabilization as an avenue for reuse of solid wastes: a review Act a Technica Napocensis: Civil Engineering Architecture, 58(1), pp 50–76.
2. James J and Pandian P K, 2016. Industrial wastes as auxiliary additives to cement/lime stabilization of soils Hindawi Publishing Corporation, Advances in Civil Engineering, 2016, pp 1–17.
3. Tocan A G J, 1999. Utilization of chick hatchery waste: The nutritional characteristics of day-old chick and eggshell Agric Wastes, 4, pp335-343.
4. Amu O O, Fajobi A B and Oke B O, 2005. Effect of eggshell powder on the stabilizing potential of lime on an expansive clay soil, Journal of Applied Science, 5(8), pp1474-1478.
5. Windhorst H W, 2014. Global egg production dynamics-past present and future of a remarkable success story, International egg commission.
6. Regional Food Security Analysis Network (RFSAN) 2016 The impact of ISIS on Iraq's Agricultural Sector.
7. Gupta L, 2008. Maintaining eggshell quality, the poultry site <http://www.thepoultrysite.com/articles/979/maintaining-eggshell-quality>.
8. Olarewaju A J Balogun M O and Akinlolu S O, 2011. Suitability of eggshell stabilized lateritic soil as subgrade material for road construction, Electron Journal of Geotechnical Engineering, 16, pp 899–908.
9. Walia S and Singh G, 2015. Effect of eggshell powder and stone dust on compaction characteristics and CBR value of clayey soil, in Proceedings of 50th Ind. Geotechnical Conf. 17th - 19th Dec.
10. Prasad K, Mathachan N, James P and Justine T L, 2016. Effect of curing on soil stabilized with eggshell, International Journal of Science and Technology & Engineering, 2 (12), pp259-264.
11. Pal S, Sonthwal V K and Rattan J S, 2015. Review on stabilization of soil using polypropylene as waste fibre material, International Journal of Innovate Research in Science Engineering and Technology, 4 (11), pp10453-10458.
12. Cai Y, Shi B, Ng C W and Tang C, 2006. Effect of polypropylene fiber and lime admixture on engineering properties of clayey soil, Engineering Geology, 87, pp230-240.

13. Jadhao P D and Nagarnaik P B, 2008. Influence of polypropylene fibers on engineering behavior of soil–fly ash mixtures for road construction, *Electronic Journal of Geotechnical Engineering*, 13, pp1-11.
14. Soganci A S, 2015. The effect of polypropylene fiber in the stabilization of expansive soils, *International Journal of Geology and Environmental Engineering*, 9 (8), pp 994-997.
15. ASTM Standard 2003 American society for Testing and Material Annual Book of ASTM standards.
16. Amal S M B and Yamuna M, 2015. Characterization of raw eggshell powder (ESP) as a good bio-filler, *Journal of Engineering research and technology*, 2 (1), pp56-60.