

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary:

An investigation was carried out for evaluation of the effect of waste materials (cement, fiber glass and plastic (PET bottle) strips) on the engineering properties of clayey soil taken from Alneel street in Khartoum state. Different soil- mixes were prepared manually, standard proctor tests, triaxial tests and CBR tests were carried out

5.2 Conclusion:

From the results of the laboratory tests conducted to investigate the effect of using the various percentages of cement waste as chemical stabilizer, fiber glass waste and plastic PET bottle waste with different length as reinforcing material to improve the strength behavior of clay soil, the following conclusions are drawn:

1. Based on liquid limit and plastic limit it was observed that:
 - a. With increase in cement waste content the liquid limit and plastic limit of treated soil increase up to 9% addition and an increase in cement waste content causes a reduction in plastic index.
 - b. The addition of 9% and 12% of cement waste soil make the soil non plastic
 - c. Equation 4.1 was predicted by excel sheet to determine the relation between the plastic index and the % added of cement waste
2. Based on Standard Procter Test concluded that:

- a. An addition of cement waste causes same results of optimum moisture content for various percentage 3%, 6%, 9% and 12% of cement waste (OMC = 30%) and decrease at 15% of cement waste content (OMC = 28%). The maximum dry density decreased with the increase of cement waste from 1.56 g/cm^3 to 1.48 g/cm^3 .
 - b. For soil reinforced by plastic PET bottle waste the results indicate that the maximum dry density decreased with the increase in the PET content from 1.50 g/cm^3 to 1.08 g/cm^3 , which is due to lower density of PET compare to the soil particles. Also an increasing of PET bottle waste content decreased the optimum moisture content from 27% to 35%.
 - c. An increase in fiber glass waste content causes a reduction in dry density from 1.24 g/cm^3 to 1.28 g/cm^3 . This is due to reduction of average unit weight of the solids in the soil-fiber mixture. The effect of an increase in fiber glass waste content is to increase the optimum moisture content from 34% to 52%
 - d. Equations from 4.2 to 4.6 was predicted by excel sheet to determine the relation between the optimum moisture content (OMC) and maximum dry density (MDD).
- 3.** On comparing the results from Triaxial test of soil treated by cement waste and soil reinforced by plastic PET bottle waste and fiber glass it is found that:
- a. For soil treated by cement waste the cohesion value decreased from 165.4 kPa to 60 kPa and the angle of friction decreased from 19° to 12° with an increasing of cement waste content and the maximum shear strength (385.38 mPa at age 2hours) was achieved at 9% of cement waste content.

- b. For soil reinforced by fiber glass waste the cohesion value (c) decreases from 165.4 kPa to 20 kPa and the angle of friction (ϕ) rise and fall between 29° to 2.93° with an increasing of cement waste content and the maximum shear stress strength (386.82 mPa) achieved at 3% of fiber glass waste content.
 - c. For soil reinforced by PET bottle waste an increases of PET waste reduced the cohesion(c) of soils significantly, this may be due to the separation of clay particles by plastic pieces and the angle of friction (ϕ) up to 6% of PET waste content, and the maximum shear strength (386 mPa) achieved at 1.5% of PET bottle waste content
 - d. Equations from 4.7 to 4.6 was predicted by excel sheet to determine the relation between cohesion (c), angle of friction (ϕ) and compressive strength and the % of cement, fiber glass and PET wastes respectively.
4. Based on CBR Test concluded that:
- a. An increasing of cement waste content increased the CBR values of clay soil and the highest value was 8.3 times the CBR of non treated soil and it was achieved at 9% of cement waste.
 - b. An increasing of fiber glass waste content increased the CBR values of clay soil and the highest value was 3.6 times the CBR of non reinforced soil and it was achieved at 3% of fiber glass waste.
 - c. An increasing of PET bottle waste content increased the CBR values of clay soil and the highest value was 2.1 times the CBR of non treated soil and it was achieved at 3% of cement waste.

- d. Equations from 4.7 to 4.6 were predicted by excel sheet to determine the relation between the CBR and %s of cement, fiber glass and PET wastes respectively.
5. Addition of cement, fiber glass and PET bottle waste reduced the swelling of clay soil
6. Overall it can be concluded that cement, fiber glass and PET bottle wastes can be considered to be good ground improvement technique especially in engineering projects on weak soils.

6.2 Recommendations:

5.2.1 General Recommendation:

The reuse of waste materials in civil engineering applications is recommended because of the suitable engineering properties of the materials, the lower cost compared to traditional construction materials, and the fact that reusing these materials keeps them from being dumped into landfills.

As a result of this study it is recommended to use not more than 9% of cement waste, 3% fiber glass waste and (1.5 to 3)% PET bottle waste as stabilizers to improve the shear strength and California bearing capacity of clayey soil. Also recommended to use the wastes material to stabilize the expansive soil

5.2.2 Recommendations for Further Research

Based on the study results, further research is recommended in the area of soil stabilization. The following are recommendations for future research:

1. Study of the effect of waste materials for others soil properties such as permeability.
2. Study of the effect of waste materials to stabilize soil against erosion.

3. Study of the effect of curing time on shear stress for soil treated by cement waste.
4. For soil treated by different percentages of cement waste XRD can be conducted to find out why the addition of cement waste gave similar results of optimum moisture content (OMC = 30%)
5. Study of the effect of the length of fiber glass on stabilized soil
6. Study of the effect of stabilization of clay soil using different aspect ratio (L/d) of PET bottle
7. Study the effect of powder PET bottles on stabilization of clay soil
8. Study of other types of fiber such as polypropylene and other plastic waste such as E-Plastic for the same applications because some of them might gave better performance.
9. Study of the effect of PET on asphalt concrete mixes
10. Study of the effect of fiber glass and PET bottle to solve the decrease of roads such as rutting.
11. Study the effect of reinforcing the clay soil by mesh of fiber glass with adhesive materials as shown in Fig (3.11)