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RESEARCH ARTICLE

STABILIZATION OF CLAYEY SOIL USING CEMENT, GYPSUM AND RECYCLING CONCRETE IN JARESH CITY-JORDAN

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ABSTRACT

This study investigates the effects of Cement, gypsum and recycling concrete on compaction properties of the clayey soil. Inorganic clay with low Plasticity was used in this study as a natural soil. For this purpose a series of laboratory experiments have been implemented and varieties of samples were made by mixing cement, gypsum and recycling concrete with natural soil. Three different percentages of cement (3%, 6% and9%), three different percentages of gypsum and recycling concrete (3%, 6% and 9%) were used as stabilization materials. The results demonstrated that adding cement has a significant effect on increasing the degree of compaction of the soil. In general, the results show that the performance of cement-stabilized soils was superior to gypsum in all the characterizations performed.

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INTRODUCTION

Soil stabilization is a collective term for any physical, chemical or biological methods, employed to improve certain properties of a natural soil to make it serve adequately for an intended engineering purpose. Gypsum (calcium sulphate dihydrate) is another additive that can be mixed with soil to improve soil properties and has been used in New South Wales, Australia, in some infrastructure projects by introducing small quantities (~5%) of gypsum to stabilize the soil. Also bassanite (calcium sulphate hemihydrate) has been investigated for use in ground improvement because of the significant increase in the production and demolition of plasterboards in the construction industry (Ahmed, 2013; Ahmed, 2015; Ahmed and Issa, 2014; Ganjian *et al*., 2008; Kamei *et al*., 2013). This study describes the effects of Cement, gypsum, and recycling concrete fine in compaction properties of the clayey soil. Inorganic clay with low Plasticity was used in this study as a natural soil. A series of laboratory experiments have been implemented and varieties of samples were made by mixing cement, gypsum, and recycling concrete fine with natural soil. Three different percentages of cement (3%, 6% and9%), three different percentages of gypsum (3%, 6% and 9%), and three different percentages of recycling concrete fine (3%, 6% and 9%) were used as stabilization materials.

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Soil stabilization is a technique introduced many years ago with the main purpose to render the soils capable of meeting the requirements of the specific engineering projects. These stabilized materials may be used as improved sub-grades or capping layers or sub-bases for road or airfield pavements. In order to control the movement of an excavation or road embankment on soft soil, ground improvement techniques are often needed to rapidly increase the strength and stiffness of the soil. These methods of ground improvement include partial or complete replacement; preloading with or without vertical drains; sand, stone, lime or cement columns and deep soil mixing (Leroueil *et al*., 1990; Lin and Wong, 1999; Mitchell, 1900; Mitchell, 1981). (Mohammad Jafari *et al*., 2012) investigated on Effect of waste tire cord reinforcement on unconfined compressive strength of lime stabilized clayey soil under freeze–thaw condition. In their paper, stabilization and fiber reinforcement are simultaneously examined as a soil modification method. A series of unconfined compression tests was carried out to investigate the effects of tire cord waste products on mechanical characteristics of a lime stabilized and un-stabilized clayey soil subjected to freezing and thawing cycles. Several specimens were prepared at three percentages of lime (i.e. 0%, 4%, and 8%) and four percentages of discrete short nylon fiber (i.e. 0%, 0.5%, 1%, and 1.5%) by weight of dry soil. (Ezekwesili Ene *et al*., 2009) investigated on Some basic geotechnical properties of expansive soil modified using pyroclastic dust. They report an investigation of the influence of pyroclastic rock dust on the geotechnical properties of expansive soil.

The plasticity, linear shrinkage, compaction, California Bearing Ratio (CBR) and shear strength characteristics of the soil when mixed with varying proportions of pyroclastic rock dust were investigated. The results show significant reduction in plasticity and linear shrinkage of expansive soil with increasing amount of pyroclastic rock dust. The maximum dry density, optimum water content, shear strength and CBR all increased with increasing pyroclastic rock dust content. (Armin Roohbakhshan *et al*., 2013) researched on influence of lime and waste stone powder on the pH values and Atterberg limits of clayey soil. Then in 2014 were investigated on the effect of lime and waste stone powder variation on the pH values, moisture content and dry density of clayey soil. They investigated on the percentage of lime and WSP used on the samples varied from 0 to 11%, which treatment of the samples with lime and WSP content show that the optimal moisture and maximum dry density values of the samples were changed. The results show increasing in the pH value of clayey soil with increasing amount of waste stone powder and lime. And the optimal moisture content increased with increasing lime and WSP content for all the samples. The main objectives of this study were to describe and to understand the primary effects of cement, gypsum and recycling concrete on the properties of a clayey soil, to determine the maximum dry density, optimum moisture content, for adding the percentages of 3%, 6% and 9% cement, 3%, 6% and 9% gypsum, 3%, 6%, 9% recycling concrete to the soil.

MATERIALS AND METHODS

Two tests were conducted on the clayey soil (with no additives), which are plastic - liquid limits and compaction characteristics tests. Firstly, A 5 kg of clayey soil was collected, and then the two tests were conducted to find out the liquid-plastic limit and max dry density-optimum water content. Secondly, three samples of 5 kg of clayey soil were mixed with three percentages of cement powder (3%, 6%, 9%) of soil sample size respectively, then the compaction characteristics tests were performed on these samples. Third, three samples of 5 kg of clayey soil were mixed with three percentages of gypsum (3%, 6%, 9%) of soil sample size respectively, then the compaction characteristics tests were performed on these samples. Finally, three samples of 5 kg of clayey soil were mixed with three percentages of recycling concrete (3%, 6%, 9%) of soil sample size respectively, then the compaction characteristics tests were performed on these samples.

RESULT AND DISCUSSION

The maximum dry density for clayey samples without addictive materials is 1.57 whereas the corresponding optimum moisture content 20.1, in addition, the liquid limit is measured to 33% and the plastic limit is 18.44%, see figure 1. On the other hand, by adding 3% of cement to the sample, the maximum dry density increased to 1.8 with corresponding moisture content of 19.5. Figure 2 also demonstrated that adding 6% and 9 % of cement increased the dry density to 1.6 and 1.62, respectively. Addition of 3% of gypsum to soil samples results in increasing the dry density to 1.63 whereas the optimum moisture content is 18. When adding 6% and 9% of gypsum to the samples, the maximum dry density recorded to 1.6 and 1.61, respectively. Addition of 3% of recycling concrete to the samples resulted to 1.46 of dry density, whereas the measured value of dry densities were 1.45 and 1.45 by adding 6% and 9% of recycling concrete, respectively (figure-2-). According to the given results the maximum dry density without addictive materials is 1.57 and this value increased by 16 % when adding 3% cement. By adding 3% gypsum the dry density increased by 4 %. The dry density increased by 2% when adding 9% of gypsum in sample as compared to sample without addictive materials. Recycling concrete material added to the soil samples with given ratio (3%, 6% and 9%), resulted in decreasing the dry density of samples. To sum up, adding 3% of cement or gypsum resulted in high value of dry density (Table 1 and Fig 2).

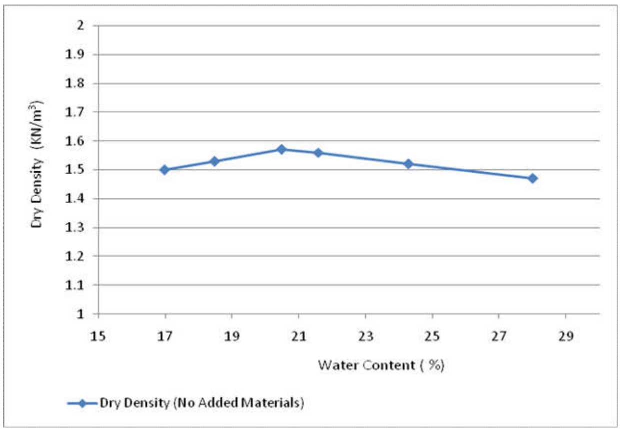

Fig. 1. The relationship between water content and dry density of samples without adding materials

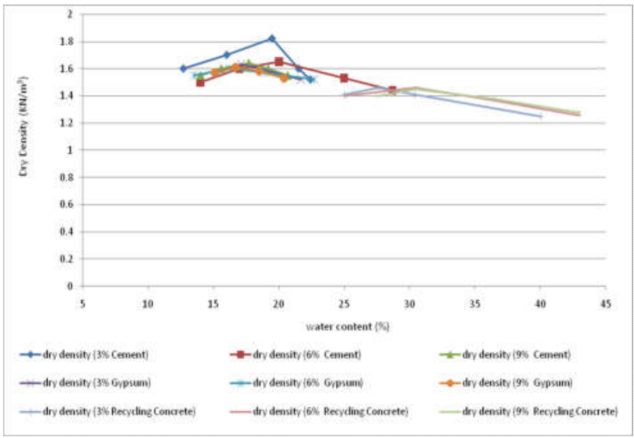

Fig. 2. The relationship between water content and dry density of all samples

Table 1. Test Results of All Samples

Type of Added Materials	Added Materials Ratio (%)	Average of Maximum Dry Density (KN/m³)	Standard Erorr	Average of (OMC)
Cement	0	1.57	0.00166	20
	3	1.82	0.0115	19
	6	1.6	0.0088	20
	9	1.62	0.00577	17.8
Gypsum	0	1.57	0.00166	20
	3	1.63	0.00577	19
	6	1.6	0.00577	19
	9	1.61	0.0033	18.5
Recycling concrete	0	1.57	0.00166	20
	3	1.46	0.01	34
	6	1.46	0.0088	32
	9	1.45	0.0033	30

Conclusion

This investigation was performed to evaluate the performance of cement, gypsum, and recycling concrete in stabilization and improving engineering properties of clay soil. The following are drawn based on the laboratory test results used in this study:

- Addition of cement, gypsum and recycling concrete had varying effects on the clay soil in terms of dry density and optimum water content.
- Adding cement increased the maximum dry density and decreased the optimum moisture content of the soil. In addition, 3% of cement resulted in high dry density more than 6% and 9% of cement ratio.
- Adding gypsum increased the maximum dry density and decreased the optimum moisture content of the soil. However adding of 3% gypsum increased the maximum dry density more than 6% and 9% of gypsum respectively.
- Adding recycling concrete decreased the maximum dry density and increased the optimum moisture content of the soil.
- Cement and gypsum stabilized soil-waste mixtures can be used in a variety of civil engineering applications.

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