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INFLUENCE OF LIME AND WASTE STONE POWDER ON THE PH VALUES AND ATTERBERG LIMITS OF CLAYEY SOIL

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ABSTRACT: *This paper reports an investigation of the influence of waste stone powder and lime on the geotechnical properties of clayey soil. The plasticity and changes in the chemical properties of the soil with pH test when mixed with varying proportions of waste stone powder and lime were investigated. The results show significant reduction in plasticity and increasing in the pH value of clayey soil with increasing amount of waste stone powder and lime. Also there is a decrease in liquid limit and increase in plastic limit with increasing waste stone powder and lime content. The behavior of the geotechnical properties of the clayey soil when blended with waste stone powder and lime indicates that these materials are a good modifier for this soil.*
KEYWORDS: *waste stone powder, lime, pH test, the plasticity, clayey soil*

INTRODUCTION

Lime stabilization is achieved by adding measured quantities of hydrated lime or calcium hydroxide, and quick lime or calcium oxide, to the fine-grained soils. The interaction of the lime and soil is immensely complex with the reaction occurring rapidly when they are mixed [1].

These reactions can be divided and explained as follows: Cation exchange and flocculation-agglomeration. Practically all fine-grained soils display cation exchange and flocculation-agglomeration reactions when treated with lime. The general order of replaceability of the common cations associated with soil is given by the series $Na^{+} < Ca^{2+} < Mg^{+}$ [2].

Cations tend to replace cations to their left in the series and monovalent cations are usually replaceable by multivalent cations. The addition of lime to a soil in sufficient quantities supplies an excess of Ca^{2+}, and cation exchange will occur with Ca^{2+}replacing dissimilar cations from the exchange complex of the soil, thus acting to change the electric charge density around the clay particles. These clay particles then become electrically attracted to one another, causing flocculation and agglomeration which produce an apparent change in texture with the clay particles 'clumping' together to form larger-sized 'aggregates'. Carbonation Lime carbonation is an undesirable reaction which may occur in soil-lime interaction. Lime reacts with CO_2 from the air to form calcium and magnesium carbonates which are relatively weak cementing agents. Carbonation is more pronounced in industrial areas, where the CO_2 content in air may be twice that in rural areas, and thus the CO_2 content of rainwater is sometimes increased several hundred per cent. Because of the undesirable effects of carbonation it is now widely considered that uncarbonated lime can be used in a more beneficial way if it is combined with silicates and aluminates, ie through a pozzolanic reaction [3].

Pozzolanic reaction the most important reaction in lime soil stabilization is that termed pozzolanic. This interaction between the lime and the silica and alumina present in the soil-water system forms cementitious gels which bind the particles together, thus stabilizing the mixture. This interaction of the lime and soil is affected by the soil pH, organic carbon content, presence of quantities of exchangeable sodium ions, and clay mineralogy. When a significant quantity of lime is added to a soil, the pH of the soil-lime mixture is elevated to approximately 12.4.This is a substantial pH increase of natural soils, resulting in an increased solubility of silica and alumina. The interaction of the lime and the soil described above has an effect on the engineering properties of the soil mixture. While the investigation described in this paper has examined the effect of lime on the pH and Atterberg limits of the soil mixture, it must be recognized that other engineering properties, such as permeability [4], are also altered and, depending on the engineering application, suitable investigations would have to be carried out.

In an early study of soil-lime reaction, Eades [5] suggested that the high pH causes silica to be dissolved out of the structure of the clay mineral that makes it available to react with the Ca^{2+} to form calcium silicates.

Also in tests carried out by Faluyi and Amu [6], three selected burrow pit lateritic soil materials used for road rehabilitation in Ado-Ekiti and its environments were used and the effects of the lime stabilizer on the pH values were determined in the laboratory.

MATERIALS USED

Three different materials were used in this research: clayey soil, lime and waste stone powder (WSP), which are derived from waste slab marble as sludge. Waste stone powder cause great amount of environmental pollution that By reusing and recycling of these waste materials as an additive in the geotechnical properties of soils have great contribution to the economy and to the environment by minimizing polluting effects coming from stone quarries and stone plants. The clay soil used in this study is classified as (CL) by Unified Soil Classification System (USCS). Recycled stone used in this research was produced from slab stone processing and plant in Iran, and the commercial grade lime was used in this present study.

SAMPLE PREPARATION AND EXPERIMENTAL PROCEDURES

The quantities of lime and waste stone powder were 0%, 3%, 6%, 9%and 11% by weight of the dry soil. The following tests; Atterberg limits and pH test were carried out on the natural (0% waste stone powder and 0% lime content) and treated soil samples.

ATTERBERG LIMITS

The results of the Atterberg limits test on the soil samples in natural state and when mixed with varying percentages of lime and waste stone powder (WSP) are shown graphically in Figs.1, 2. From the results, there is a decrease in liquid limit and increase in plastic limit with increasing waste stone powder and lime content. The plasticity index also show decreasing trends. The reduction of each of these properties is obviously a change in water content due to increase in waste stone powder content. The implication of these reductions in the plasticity properties of the soil with increasing amount of waste stone powder and lime is that the soil becomes friable and workability is improved.

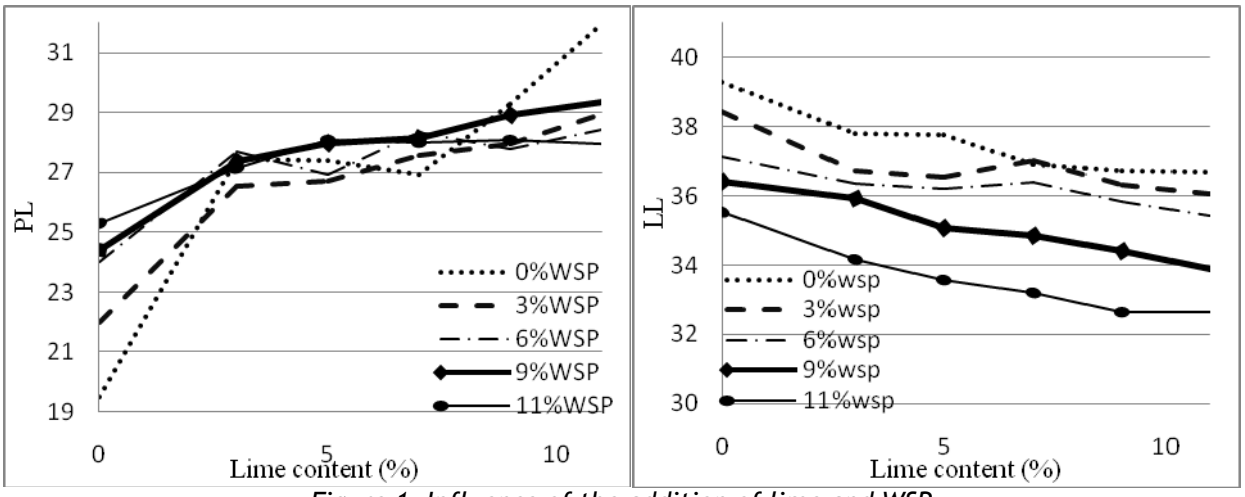

Figure 1. Influence of the addition of lime and WSP on the plastic limit and liquid limit of clay soil

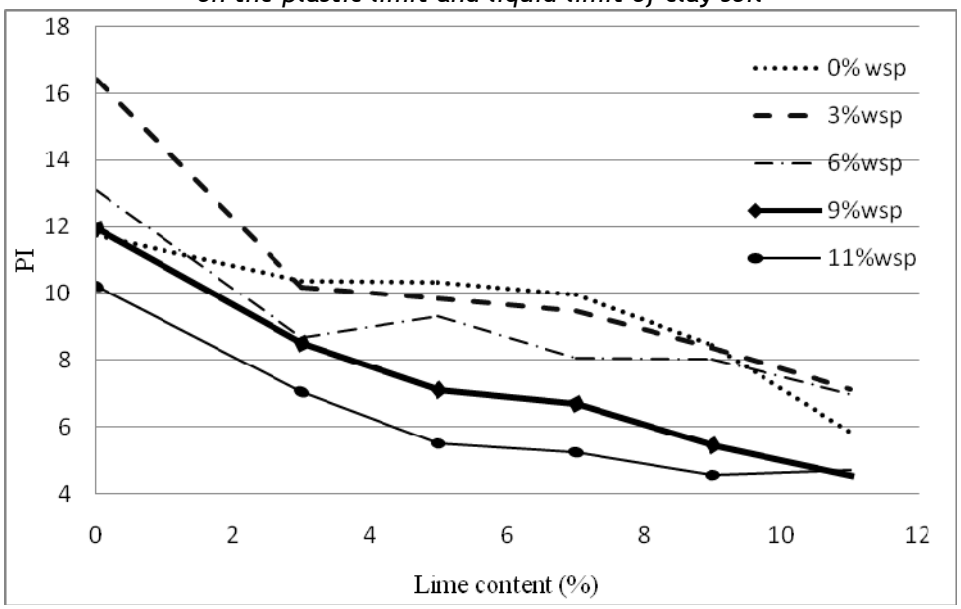

Figure 2. Influence of the addition of lime and WSP on the Plasticity Index of clay soil

pH test

Tests were carried out on samples to determine the pH values of the clay soil with multimeter apparatus that are shown in Fig.3. The clay soil mixed with lime and waste stone powder. Lime and waste stone powder was added in varying proportions of 0, 3, 6, 9 and 11%. The treatment of the samples with lime and waste stone powder content changed the pH values of the samples from acidic to alkaline and the value increased with increasing lime and waste stone powder content for all the samples. The procedures used in carrying out these tests were the ASTM D4972 - 01(2007) Standard Test Method for pH of Soils. The results of the pH test are given in table 1.Also the pH value for lime alone was 12.94 and for waste stone powder was 8.47.

Figure 3. Multimeter TWT apparatus

Table 1-pHvalues of the clay mixed with varying percentages of lime and waste stone powder

	(+0% wsp)	(+3% wsp)	(+6% wsp)	(+9% wsp)	(+11% wsp)
C+0%L	6.82	7.88	7.93	8	8.04
C+3%L	9.1	9.25	9.31	9.45	9.52
C+6%L	10.23	10.32	10.4	10.44	10.49
C+9%L	11.08	11.16	11.24	11.31	11.52
C+11%L	12.34	12.37	12.42	12.49	12.54

The pH value for samples with increasing materials used content changed from 6.82 at 0% lime and 0% waste stone powder content to 12.54 at 11% lime and 11% waste stone powder content. These changes were as a result of the changes in the chemical properties and composition of the samples due to their chemical reactions with the lime and waste stone powder additive.

CONCLUSIONS

The results of geotechnical investigation on lime-treated clayey soil from Iran were investigated and discussed. Lime and waste stone powder were added in the order of 3%, 6%, 9% and 11% by weight and experiments were conducted.

Relationships that correlate the geotechnical properties of lime and waste stone powder-treated soil were developed. The study has led to the following conclusions:

- There is a decrease in liquid limit and increase in plastic limit with increasing waste stone powder and lime content.
- The plasticity index show decreasing trends with increasing waste stone powder and lime content.
- Waste stone powder caused great amount of environmental pollution. By reusing and recycling of these waste materials as an additive in the geotechnical properties of soils have great contribution to the economy and to the environment by minimizing polluting effects coming from stone quarries and stone plants.
- The treatment of the samples with lime and waste stone powder content changed the pH values of the samples from acidic to alkaline and the value increased with increasing lime and waste stone powder content.

REFERENCES

[1] Thompson, M R.1966. Lime reactivity of Illinois soils. Journal of SoilMechanics and Foundations Div. ASCE, 91, SM5, 67-91.

[2] Anon.1976. State of the art - Lime stabilization. Circular prepared by Transportation Research Board Committee on Lime and Lime Fly ash Stabilization, Washington, DC, No. 180.

[3] S Z George, D A Ponniah and J A Little.1992.Effect of temperature on lime-soil stabilization. CONSTRUCTION & BUILDING MATERIALS, Vol. 6 No. 4.

[4] Al-Rawi, N M.1973. Correlation of properties of Iraqi limestone. Paperpresented at 52nd Annual Meeting of Highway Research Board, Washington, DC.

[5] Eades, J.L. 2002. Reactions of Ca $(OH)_2$ with clay minerals in soil stabilizations. Unpublished Ph.D. Thesis, University of Illinois USA.

[6] S.O. Faluyi and O.O. Amu.2005. Effects of Lime Stabilization on the pH Values of Lateritic Soils in Ado-Ekiti, Nigeria. Journal of Applied Sciences 5 (1): 192-194.

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