Australian Journal of Basic and Applied Sciences, 8(19) Special 2014, Pages: 310-314

AENSI Journals

Australian Journal of Basic and Applied Sciences

ISSN:1991-8178

Journal home page: www.ajbasweb.com

Assessment of Heat Treatment on Clays Mixed with Silica Sand

A. Akbar Firoozi, M. R. Taha, A. Asghar Firoozi, Tanveer A.

Department of Civil and Environmental Engineering, University Kebangsan Malaysia, Malaysia.

ARTICLE INFO

Article history:
Received 15 April 2014
Received in revised form 22 May 2014
Accepted 25 October 2014
Available online 10 November 2014

Key words:
Elastic-plastic; Bangalore; Mohr Coulomb; PLAXIS 2D; Sheet

ABSTRACT

This study examines the effects of heat treatment on two types of clays mixed with silica sand under laboratory conditions. Soils were subjected to three varied temperatures, i.e. 100, 250 and 500^oC. The soil properties studied were Atterberg limits, optimum water content and unconfined compressive strength. Experimental results showed that the temperature greater than 100^oC resulted in a reduction in Atterberg's limits, optimum water content and unconfined compressive strength. For illite and silica mixture heating the soils at 500^oC decreased the liquid limit, plastic limit, optimum water content and unconfined compressive strength reduced to 12%, 0%, 40% and 0%, and for kaolinite and silica mixture the above characteristics reduced to 18%, 0%, 50% and 0% respectively when matched to soil specimen's properties at ambient temperature. Whereas maximum dry density for illite and kaolinite increased by 5% and 8% respectively for the two clays.

To Cite This Article: A. Akbar Firoozi, M. R. Taha, A. Asghar Firoozi, Tanveer A., Assessment of Heat Treatment on Clays Mixed with Silica Sand. ***Aust. J. Basic & Appl. Sci.,*** *8(19): 310-314, 2014*

INTRODUCTION

The temperature modifies the physical and mechanical properties of clays. When the clayey soils are treated with heat, some of the changes in properties are permanent. The huge fires in the forests across the world have brought the thought to measure the effect of heat on clayey soils (Alcocer, C. and H. Chowdhury, 1993).

Many researchers have investigated the effect of heat treatment on the clayey soils. Mitchell (1969) showed that the heat treatment changed some of the physical properties of the clayey soils such as angle of friction, cohesion and strength. Joshi et al. (1994) investigated the effect of the heat treatment on the strength of clayey bricks at temperatures ranging from 300 to 700 ^oC. And it was found that an increase in strength was accompanied with increase in temperature. Yang and Farouk (1995), Akinmusuru (1994) and Ma and Hueckel (1992) investigated the effect of heat on the thermal conductivity of clayey bricks. Tanaka et al. (1997) evaluated the stress-strain behaviors of the remodeled illite clay at different temperatures. It was found that peak undrained strength was increased due to development of reduced pore water pressure during testing.

The main objective of this study was to investigate the effect of temperature on physical properties of clayey soils. The parameters investigated in this study include Atterberg limits, optimum water content and unconfined compressive strength.

Experimental Procedure:

The clay minerals used in this study were kaolinite and illite. Silt which was mixed with clay minerals in the present study was silica sand with fine grained particles (45 μm). Kaolinite and illite clay minerals were obtained from Kaolin (Malaysia) factory under the trade name "S-300" and "KM800" respectively. Table 1 & 2 present properties of kaolinite and illite, which were determined during this study by performing a series of geotechnical laboratory experiments using procedures recommended by relevant ASTM standards. In Figure 1 and 2 scanning electronic microscope (SEM) images are given which show the kaolinite and illite layers.

Table 1: Physical property of materials

Kaolinite		Illite	
Moisture content	Below 1.5%	Moisture content	Below 2.0%
pH	4.0	pH	4.5
100 mesh residue	Below 10%	325 mesh residue	Below 3.0%
60 mesh residue	Below 0.5%	Average particle size	2.5-5.0μm
Specific gravity (G_s) ASTM D854	2.723	Specific gravity (G_s) ASTM D854	2.701

Corresponding Author: Mahmoud Bensaibi, National High School of Public Works, Algiers, Algeria.
+213 555 416 787; E-mail: bensaibim@yahoo.co.uk

Table 2: Chemical compositions of clay minerals and silica sand

Kaolinite		Illite		Silica Sand	
Formula	Concentration (%)	Formula	Concentration (%)	Formula	Concentration (%)
SiO_2	85.76	SiO_2	29.43	SiO_2	97.29
Al_2O_3	9.11	Al_2O_3	52.37	Al_2O_3	2.71
Fe_2O_3	0.38	Fe_2O_3	1.85	-	-
K_2O	1.34	K_2O	8.21	-	-
Heat loss	3.41	MgO	1.76	-	-
-	-	TiO_2	1.36	-	-
-	-	Heat loss	5.02	-	-

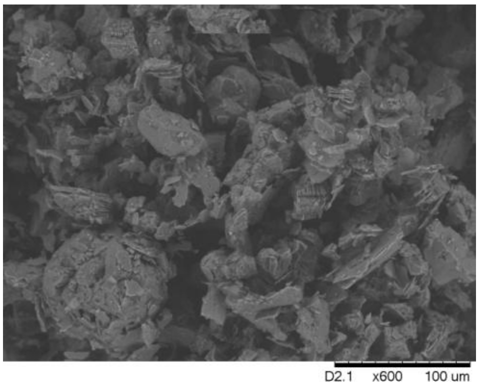

Fig. 1: Kaolinite particles under SEM

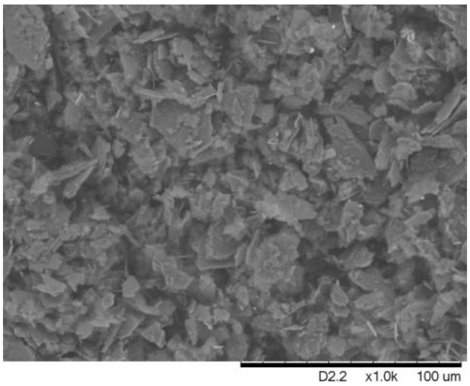

Fig. 2: Illite particles under SEM

The mix selected for the test was, 50% clay (kaolinite / illite) + 50% silica sand. Physical properties including plastic and liquid limits, maximum dry unit weight and optimum water content of untreated and treated specimens were determined by using ASTM standards D4318-10 and D698 -12 respectively. For the unconfined compressive strength experiment, soil samples were compacted with standard Proctor test (D698-12: 3 layers, 25 blows per layer) and then tested in accordance with ASTM D2166-06. Soil specimens were compressed until failure under a strain rate of 1.5 mm/min. and deformations were noted during the whole test.

RESULTS AND DISCUSSION

The effect of temperature on liquid limit and plastic limit for kaolinite and illite are shown in Figure 3 & 4. Liquid and plastic limits progressively decreased with increasing temperature and the plastic limit finally reached a value of zero at 500^oC. Liquid limit was decreased by a little up to 100^oC, whereas plastic limit remained almost same for this variation. Between 100^oC and 250^oC Atterberg limits decreased by more than 50% for both the samples. Beyond 250^oC liquid limit appeared to get less affected by temperature rise to reach a value of about 5% for the two specimens.

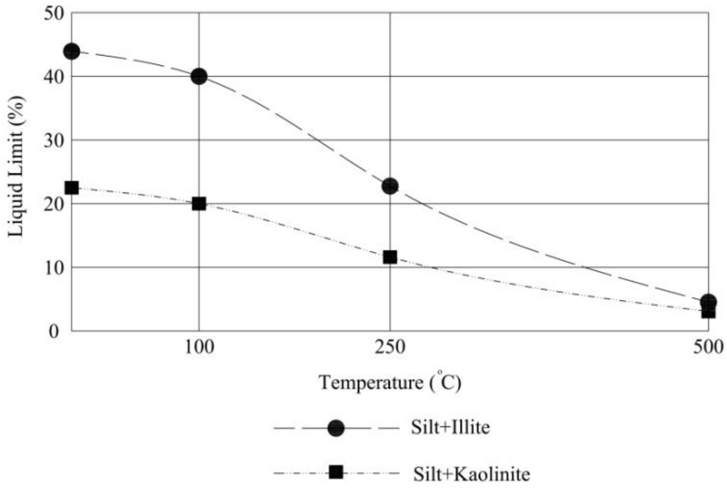

Fig. 3: Effect of heat treatment on liquid limit

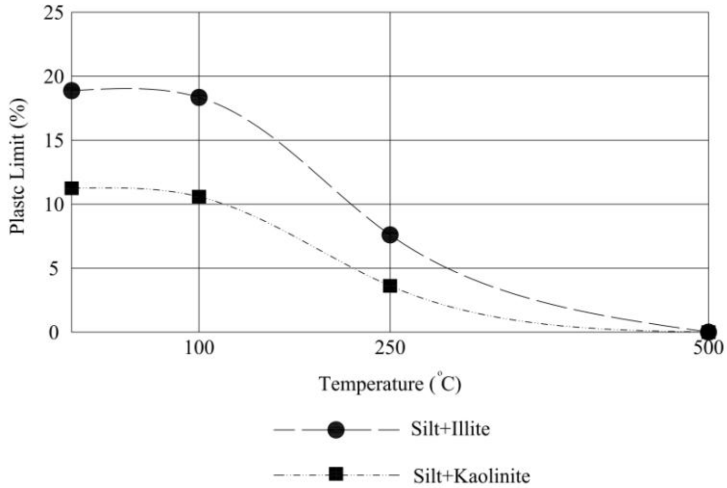

Fig. 4: Effect of heat treatment on plastic limit

Figure 5 & 6 show the effect of temperature treatment on optimum water content and maximum dry density, respectively. Optimum water content decreased with increasing temperature, though it was less affected by temperature below 100^{o}C. At a temperature of 500^{o}C the optimum water content of illite and kaolinite reduced to 40% and 50% respectively. A rise in maximum dry density was observed for both the clays reaching the increase up to 5% and 8% for illite and kaolinite respectively at 500^{o}C.

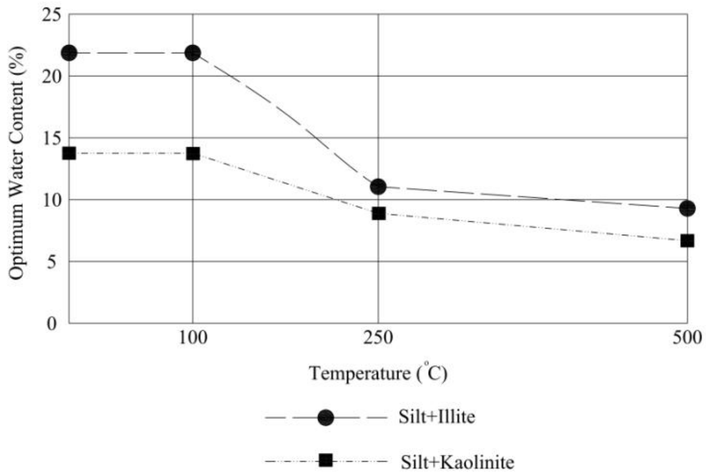

Fig. 5: Effect of heat treatment on optimum water content

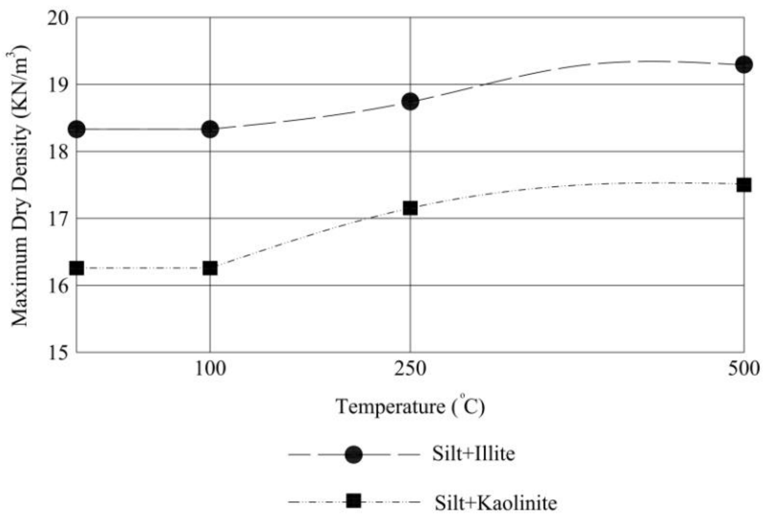

Fig. 6: Effect of heat treatment on maximum dry density

The effect of temperature on the unconfined compressive strength of the two soil samples is shown in Figure 7. Temperature increase beyond 100°C produced excessive decrease in unconfined compressive strength for the two soils. And finally it reached to 0% at a temperature of 500°C.

Conclusion:

This study displayed that temperature has a significant effect on soil physical properties such as, Atterberg limits, optimum water content and unconfined compressive strength. The relative change in these properties was higher when temperature ranged from 100 to 500°C. Soils were normally not affected in great deal by temperature below 100°C. Therefore it can be concluded that a temperature of 500°C brings drastic changes in the mechanical properties of the two soils and transforming them into very weak soils.

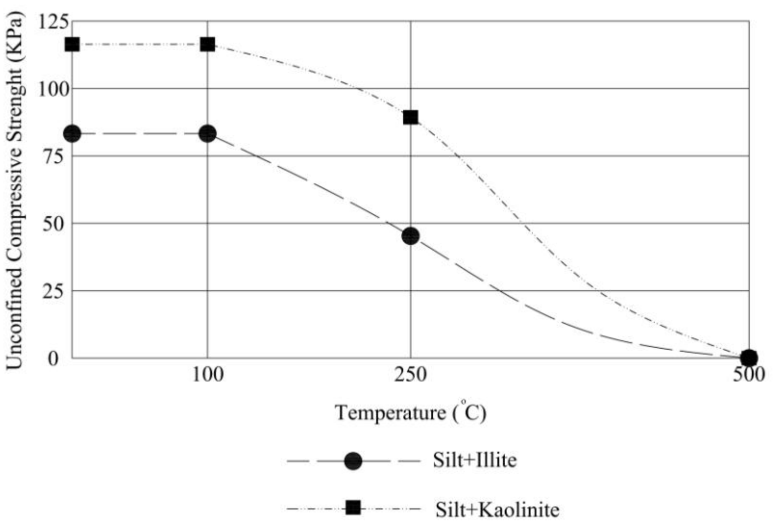

Fig. 7: Effect of heat treatment on unconfined compressive strength

REFERENCES

Akinmusuru, J., 1994. Thermal conductivity of earth blocks, Journal of Materials in Civil Engineering, 6: 3-341.

Alcocer, C. and H. Chowdhury, 1993. Experimental study of an environmental remedation of Gulf Coast crude-oil contaminated soil using low-temperature thermal treatment. In the Proceedings of the 1993 Western Regional Meeting, Louisiana. Society of Petroleum Engineers, Richardson, pp: 723-724.

Joshi, R., A.C. Gopal, D. Horsfield, T. Nagaraj, 1994. Effect of heat treatment on strength of clays, Journal of Geotechnical Engineering, ASCE., 120: 6-1080.

Australian Journal of Basic and Applied Sciences, 8(19) Special 2014, Pages: 310-314

Ma, C. and T. Hueckel, 1992. Effects of inter phase mass transfer in heated clays: a mixture theory, International Journal of Engineering Science, 30: 11-1567.

Mitchell, J.K., 1969. Temperature effects on the engineering properties and behaviour of soils, Highway Research Board, Special Report 103.

Tanaka, N., J. Graham and T. Crilly, 1997. Stress–strain behaviour of reconstituted illitic clay at different temperatures, Engineering Geology, 47: 339.

Yang, L. and B. Farouk, 1995. Modelling of solid particles flow and heat transfer in rotary kiln calciners, 30th National Heat Transfer Conference, American Society of Mechanical Engineers, p: 11.