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The Influence of Nano-Clays on Compressive Strength of Earth Bricks as Sustainable Materials

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Abstract

Nanotechnology literally means any technology done on a Nan scale that has applications in the real world. The earth bricks are as a building material in construction. The existing earth bricks don't have a good strength in compressive strength. The current research is used earth bricks with 5 percent nano-clay as a nanomaterial. Nanoclay is nanoparticles of layered mineral silicates. Depending on chemical composition and nanoparticle morphology, nanoclays are organized into several classes such as montmorillonite, bentonite, kaolinite, hectorite, and halloysite. Nano-kaolin as a nano-clay in current research is used. The compressive strength was recorded at 3,7,14 and 21 test days. The results have shown the importance of nano-clays in compressive strength because earth bricks using nano-clays is 4.8 times of normal earth bricks that were without nanoclay in their mixture at 14 days. The results have shown the good performance of earth bricks using nano-clays rather than normal earth bricks.

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1. Introduction

Earth bricks have been used in the construction of shelters for thousands of years and approximately 30% of the world's present population still lives in earthen structures. Earth bricks must ideally be made with earth containing a clay content of not more than 80% and not less than 50%, the remainder being sand and granular material. That is helpful to know a little about the crystal structure of cohesive soil. The actual clay minerals are the hydrated aluminum silicates, which may be divided into three main groups: the kaolin group, the montmorillite group and the illite group. Kaolin clays have a non-expanding crystal

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structure, while clays of the other two groups have expanding crystal structures. Clays with expanding crystal structures will expand in volume when water is added, and this moisture is evaporated, drastic shrinkage and cracking will do. They are also very strong, with a high heat resistance, and show little water damage even if moisture shortly after they have been made. Pure kaolin is white and typically occurs as subsurface clay. The present research examines nanoclay in earth bricks under compressive strength test. Kaolin is a clay mineral with the chemical composition $Al_2Si_2O_5$ $(OH)_4$. Endothermic hydroxylation (or alternatively, dehydration) start at 550-600 °C to produce disordered metakaolin, $Al_2Si_2O_7$, but continuous hydroxyl loss (-OH) is increased up to 900 °C and has been attributed to gradual oxidation of the met kaolin.

$$2\, Al_2Si_2O_5\, (OH)_4 = 2\, Al_2Si_2O_7 + 4\, H_2O$$

Further heating to 925-950 °C converts metakaolin to a defect aluminum-silicon spinal, $Si_3Al_4O_{12}$, which is sometimes also referred to as a gamma-alumina type structure:

$$2\, Al_2Si_2O_7 = Si_3Al_4O_{12} + SiO_2$$

Upon calcinations to ~1050 °C, the spinal phase ($Si_3Al_4O_{12}$) nucleates and is transformed into mullite, 3 $Si_3Al_4O_{12}$, and highly crystalline cristobalite, SiO_2:

$$3\, Si_3Al_4O_{12} = 2\, Si_2Al_6O_{13} + 5\, SiO_2$$

Nanoclays are nanoparticles of layered mineral silicates. Depending on chemical composition and nanoparticle morphology, nanoclays are organized into several classes such as montmorillonite, bentonite, kaolinite, hectorite, and halloysite. Organically modified nanoclays are an attractive class of hybrid organic-inorganic nanomaterials with potential uses in polymer nanocomposites, as rheological modifiers, gas absorbents and drug delivery carriers.

2. Experimental procedure

2.1 Materials

Kaolin is used pure and without additive materials (China)

2.2 Sample preparation

2.2.1. Nano clay preparation

In order to produce the nano kaolin, the clay was pulverized using a ball mill (Planetary Mono Mill Pulverisette, Germany). The clay specimens were loaded in small amounts in a ball mill. The 20 sintered corundum balls used for grinding have the diameter of 5 mm. The milling time to prepare each batch was between 12-14 hours while water was added to specimens during the operation to decrease the heat.

2.2.2. Specimen setup

The designation of mixture in earth bricks is shown in Table1. The materials mentioned in Table1, were mixed thoroughly in dry state and added to water as proportions given to obtain two different specimen groups. The dry kaolin is combined with optimum moisture content by kneading until it turns to a cohesive soil. The sizes of bricks are made 10cm×10cm×10cm and the mixture is placed in three layers in steel moulds.

Table1. Designations of mixtures

Type	Name of Specimen	Kaolin (Kg)	Water (Lit)	Nano-clay (Kg)
A	Normal Earth Bricks	10	2	-
B	Nano - Earth Bricks	9.5	2	0.5

Eventually, the earth bricks were taken out from their moulds after 48 hours. The earth bricks were covered by moisture gunny after they were taken out from their moulds. Performance of moisture gunny was prevented to transfer moisture. Figure 1 shows different steps of production of earth bricks.

Figure1. Earth bricks

2.3 Sample characterization

2.3.1. Particle size analyzer

The pulverized Kaolin was analyzed by a particle size analysis system. For particle size analysis, the sample was carefully mixed with water. The particle size analysis was used to characterize the size or average size of nano Kaolin particles.

2.3. 2. Standard compressive strength test

The compressive strength tests on earth bricks were performed in accordance with the standard proctor test where the kaolin is compacted by 5.5lb hammer and the mold was filled with three equal layers of kaolin and each layer is subjected to 25 drops of the hammer and then they were tested for compressive strength for 3,7,14 and 21 days.

3. Results and discussions

3.1 Particle size analysis

Conventionally, Kaolin is known as a layered silicate mineral, with one tetrahedral sheet linked through oxygen atoms to one octahedral sheet of alumina. In the group of silicate layers kaolin has small surface area due to the difficulty of their delamination [1-4]. The mechanical treatment of clays is one of the reduction size methods such as grinding. The use of particle size reduction methods can ameliorate sorption capacity and the surface area for eventual applications. The size of nano particles was below 100 nm. Grinding destruct kaolinite structure and leads to form amorphous Kaolinite and produce a high surface area material [5-6]. Amorphization of Kaolinite occur owing to the fact of its laminar structure [7-8]. Nano Earth Brick mixture as a nano suspension in comparison with Normal Earth Brick mixture is thermodynamically more unstable, due to large surface energy [9]. In a time dependent process, the suspended particles in each sample in dispersion will tend to coalesce or adhere through collision with each other or with another surface to reduce the surface energy and finally reduce the potential energy of the system.

3.2 Compressive strength behavior

This research is related to compressive strength tests on earth bricks that are included 5% nano clay rather than normal earth bricks. The moisture content was 20% in pure kaolin due to compaction test on kaolin in soil laboratory. The compressive strength values of earth bricks tested in the current research vary from 1.49 to 12.07 N/mm. The result shows that nano-earth bricks were higher than normal earth bricks in compressive tests. As the main item of both bricks was kaolin clay and the role of water was lubricant, nano-clays affect the bricks for creating an exfoliated zone. The nano clay has increased the compressive strength of earth bricks because it created an exfoliated area for bricks. The weather condition was tropical with very warm days and fairly cool nights that it could reduce compressive strength in earth bricks after 14 days due to climate effects on materials and their parameters such as absorption moisture and loss of weight in earth bricks. Table3 is shown result of compressive tests on earth bricks.

Table2. The Compressive Strength of Earth Bricks

Type	Name of Specimen	**Compressive Strength** (N/mm^2)			
		3 days	**7 days**	**14 days**	**21 days**
A	Normal Earth Brick	1.90	2.94	2.52	1.49
B	Nano – Earth Brick	8.14	11.17	12.07	6.97

4. Conclusion

The results of compressive strength tests have shown that performance of nano-clay was great in earth bricks because it increased the compressive strength of earth bricks 4.8 times rather than normal earth bricks. The results show increase of compressive strength until 14 days and then it decreased. It was evident that nano-clay increased the compressive strength of earth bricks in long time. Using the nano-clay can be increasing the level of earth bricks in building industry.

References

L. Pérez-Maqueda, *et al.*, "Study of natural and ion exchanged vermiculite by emanation thermal analysis, TG, DTA and XRD," *Journal of Thermal Analysis and Calorimetry,* vol. 71, pp. 715-726, 2003.

F. Franco, *et al.*, "The effect of ultrasound on the particle size and structural disorder of a well-ordered kaolinite," *Journal of Colloid and Interface Science,* vol. 274, pp. 107-117, 2004.

L. A. Pérez-Maqueda, *et al.*, "Preparation of submicron talc particles by sonication," *Applied Clay Science,* vol. 28, pp. 245-255, 2005.

J. L. Pérez-Rodríguez, *et al.*, "The influence of ultrasound on the thermal behaviour of clay minerals," *Journal of the European Ceramic Society,* vol. 26, pp. 747-753, 2006.

S. J. Gregg, *et al.*, "The grinding of kaolinite. I. A preliminary study," *Journal of Applied Chemistry,* vol. 4, pp. 631-632, 1954.

R. S. Front, E. Mako, J. Kristof, and J.T. Kloprogge,, "Modification of kaolinite surfaces through mechanochemical treatment-a mid-IR and near-IR spectroscopic study," *Spectrochimica Acta, Part A: Molecular and Biomolecular Spectroscopy,* vol. 58A, 2002.

M. Zbik and R. S. C. Smart, "Influence of dry grinding on talc and kaolinite morphology: inhibition of nano-bubble formation and improved dispersion," *Minerals Engineering,* vol. 18, pp. 969-976, 2005.

E. F. Aglietti, *et al.*, "Mechanochemical effects in kaolinite grinding. I. Textural and physicochemical aspects," *International Journal of Mineral Processing,* vol. 16, pp. 125-133, 1986.

J. J. Bimal P. Singh, Laxmidhar Besra and Sarama Bhattacharjee, "Dispersion of nano-silicon carbide (SiC) powder in aqueous suspensions," *Journal of Nanoparticle Research* vol. 9, 2007.

Niroumand, H., Zain, M.F.M., Jamil, M. (2012), Hill development by Earth architecture. *International Journal of Physical Sciences*, 6 (6), 1249-1256

Niroumand, H. (2011), Nanotechnology in Architecture. *Academic Publishing*, Germany

Niroumand, H., Zain, M.F.M., Jamil, M. (2012), *Advanced Materials Research*. 457-458, 354-357

Niroumand, H., Zain, M.F.M., Jamil, M. (2012), *Advanced Materials Research*. 457-458, 395-398

Niroumand, H., Zain, M.F.M., Jamil, M. (2012), *Advanced Materials Research*. 457-458, 403-406 Niroumand, H., Zain, M.F.M., Jamil, M. (2012), *Advanced Materials Research*. 457-458, 399-402