ISSN 2347 - 3983
Volume 8. No. 10, October 2020
International Journal of Emerging Trends in Engineering Research
Available Online at http://www.warse.org/IJETER/static/pdf/file/ijeter1198102020.pdf
https://doi.org/10.30534/ijeter/2020/1198102020

EFFECT OF ADDITION OF NANO SILICON DIOXIDE TO CEMENT BRICKS: PREPARATION AND CHARACTERICTICS

Rehab Emad[1], Ibrahim M. I brahim[1], M. A. Radwan[1], M. A. Sadek[1], Hany A. Elazab[1,2]*
[1] Department of Chemical Engineering, The British University in Egypt, El-Shorouk City, Cairo, Egypt.
[2] Nanotechnology Research Centre (NTRC), the British University in Egypt (BUE), El-Sherouk City, Suez Desert Road, Cairo, 11837, Egypt.
* Corresponding Author: elazabha@vcu.edu

ABSTRACT

The aim of the research is to design and produce a durable, and high load, bearing build constructing bricks based on cement, sand, and aggregates with the addition of Nano silica, studying the effect of the added materials to get a background about the impact of the Nano silica on the the ability of using such a product. The cement used is 52.5 grade which represent the strength of the cement, sand with particle size 300-600 micrometer, aggregates with diameter lays between 0.5-1 cm better to use smaller size, water, and finally Nano-silica with particle size 17 nm with purity higher than 99.9%. the final size of the produced brick is a cubic shape with 4*4*4 cm in dimension.
The research results have been achieved and stated that as the percentage of the Nano silica increase the strength increase and the bricks withstood for more loads and nominated the 10% Nano-silica of the total weight or of the cement weight as the best percentage among the prepared samples percentages and gives a strength of 6.4 MPa.

Key Words: Silicon Dioxide, nanotechnology, Cement bricks

1. PROBLEM STATEMENT

Recently the government is prevented bulldozing the agricultural soils, the red or common bricks production was mainly depended on it as a main source and main raw material, but know because of that need to find another materials able to form a bricks used for constructing buildings so, now producing cement bricks is the new approach for having a building bricks and found that cement bricks are giving a better strength but not a good thermal insulator as the common bricks.

2. RESEARCH OBJECTIVE

Producing a cement bricks based on the addition of Nano silica to be mixed with the cement to design and produce a cheap cement bricks and reduce the added material environmental impact, with an excellent mechanical properties and thermal insulation.

3. RESEARCH METHODOLOGY

Preparing a standard sample based on cement, sand and samples based on cement, sand, and aggregates, then measure the standard sample compressive strength using the tensile machine. [1-12] After that start to prepare the samples which contain the Nano-silica particles by considering its percentage as a part of the cement weight or a part of the total sample weight and applying this with different percentage of the Nano particles. [13-25] After the curing of the samples start to test its compressive strength by the tensile machine, then comparing the modified sample results with the standard samples and test the effect of the Nano-silica on the cement bricks mechanical properties. Testing a various percentage of Nano silica added to the brick's mixture from 1% up to 10% and applying compression, sound, and thermal insulation tests then record the performance and determine at which percent or rang of acceptable percentage of Nano silica that get the best enhancement to the produced cement. [26-30]

4. INTRODUCTION

Bricks used to know as a clay shaped in a regular form and processed to be used for building, but now it produced with many different raw materials behind the clay, with known sizes and specifications. It's a very important product for constructing almost all the types of the buildings, pavements, walls, and so on. Bricks usually categorize based on the purpose it uses for and their shape. [31-40] Nanoparticles have a high surface area-to volume ratio. Silica nanoparticles are widely used due to their exceptional properties such as, low conductivity, high melting point, insulator behavior and hydrophobicity. The use of nanoparticles in mortars and concretes significantly modify their behavior not only in the fresh, but also in the hardened conditions, as well as the physical/mechanical and microstructure development. Studies shows that the addition of Nano silicon enhance the strength of the cement, reduce its porosity and decrease its required time to set. [41-52] Nano silica used because of it's a good pozzolanic material, due to its fine size as its very small than cement by about 100 times it fill all voids between cement particles support its strength, also using Nano silica reducing the environmental pollutants and hazards caused by CO2 emissions during the production processes and from the pollutant causing by burning the rise husk by recycling it and extract Nano silica from it as the rice husk contains high amount of Nano silica .Experimental results showed that replacing 5% cement by Nano-silicon improved the strength by 20% more than the normal procedure which include the Portland cement only at 7 days setting period, and 17% when the test done after 28 days, more experimental results showed in the table below. [53-62] Also, it cleared that the optimum replacing percent doesn't fixed, it depends on cement water mixing ratio.

Nano silica itself doesn't have any cementation property, but in the presence of water or humidity it react with the "calcium hydroxide" and "form compound possesses the cementation properties"[63-70] The compressive strength of the samples is measured by using tensile machine to know how much load the block could bear and determine if the blocks and their materials are applicable or not. Preferred at least to measure 5-12 samples of the production line. [71-78]

The settling time of the concrete measure using "Vicat needle" test, which is a standard test following "ASTM C191 - 19" used to determine the settling time of a hydraulic cement. This test is applied using the manual apparatus or by using the automatic machine, and the test standard units is the SI units, any other units are not acceptable. [88-93]

The test is used to determine the initial setting time of many types of cement bricks and stated that time to be "about 4-7 hrs.", and setting ends after "about 6-10 hrs." the study showed that the addition of Nano silicon dioxide had reduced the time required fir the cement bricks if compared by the cement bricks without Nano silica and that's because of the addition of Nano silica make the hydration reaction of the tri-calcium silicate faster, which also make the formation of the "C-S-H gel" faster and reduce the required settling time. The addition of only 1% of Nano silicon dioxide was able to reduce the settling time by about 20 min., and when the percentage of the Nano silica was raised to about 2% the settling time was reduced by about 90- 100 min., and as the particle size of the Nano silica and its content is increased more the settling time is decreased.

Chloride content main cause of the un-durability of the cement bricks, chloride content is measured by "measuring the penetration depth of chloride ions" in cement bricks, and it found to be about "6%" but the cement bricks with Nano silicon dioxide contain lower amount of chloride than the cement bricks without Nano silicon dioxide, and as the content of the Nano silicon dioxide increase, the penetration depth and the ions charge decrease. Cement bricks under 0.5 MPa pressure with 3.5% Nano silicon dioxide gives a penetration depth lower than 5 mm. the presence of Nano silicon dioxide divide the bulk porosity of the cement bricks into smaller pores which enhance the cement bricks permeability. The pore structure size decreases in the all cement bricks and blocks type as the curing time of the cement bricks and blocks increase, pores decrease by the time. Even small amount of Nano silicon dioxide could enhance the permeability of the cement bricks and it is also easier to disperse.

5. EXPERIMENTAL WORK

Standard samples are prepared depending on cement and sand, another samples depend on cement, sand, and aggregates with different ratios of cement: sand or cement: sand: aggregates as "1:2:4,1:2:6,1:4:4,1:4:6, and so one there is unlimited ratios to try" but basically the ration of sand is double the cement, and the ratio of aggregates is triple the sand.

The modified samples which is contain the Nano-silica with particle size of 17nm is prepared by adding a different percentage of Nano silica "1,3,6,9, and 10%" as a percent of the total weight.

The selected basic ratio to add the Nano silica for it depends on the strength of the standard samples, the highest compressive strength of the standard samples which obtained using the tensile machine is selected to modify it, and at the end the samples with the modification is tested using the tensile machine also.

All the samples compressive strength is measured by the "tensile machine".

Another standard and modified sample are prepared to measure the thermal resistance, and the heat conductivity is measured using "EXtech device".

6. RESULTS

6.1 Standard samples

The showed results in figure 1and 2 obtained that as the amount of cement increase the strength of the concrete bricks increase, also the addition of the aggregates support the strength of the bricks but its addition has a limits depend on its size and the cement:aggregates ration, as if its size is very large it will make it hard for the cement molecules to bind together and gives the required strength. Also, should take in consideration that the amount of water is a key ingredient which mean, if the amount of water is too high that make the brick weak, and if it too little that make the brick unworkable.

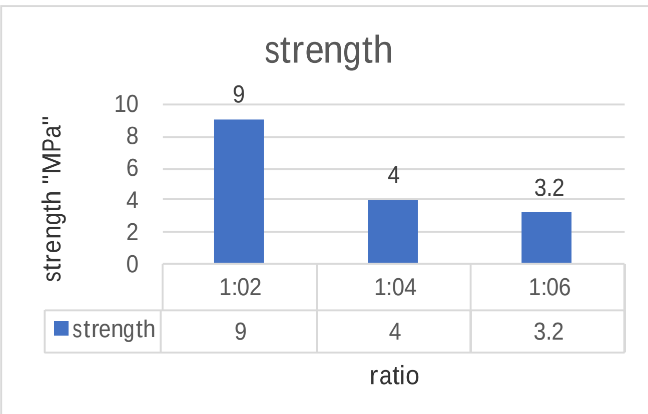

Figure 3 strength comparison based on cement and sand

Also, for the modified samples with the addition of Nano silica, the results obtained that as the amount of Nano silica increase the strength of the concrete bricks increase, Nano materials fill the voids between the different molecules of the raw material, and start to past it as it have a very good pozzolanic property, but to specific the property of the silica to support the bricks strength activated by its reaction with the cement “by the pozzolanic reaction with calcium hydroxide in the cement ingredient” resulting an improvement in the strength and durability of the material

6.2. Modified samples

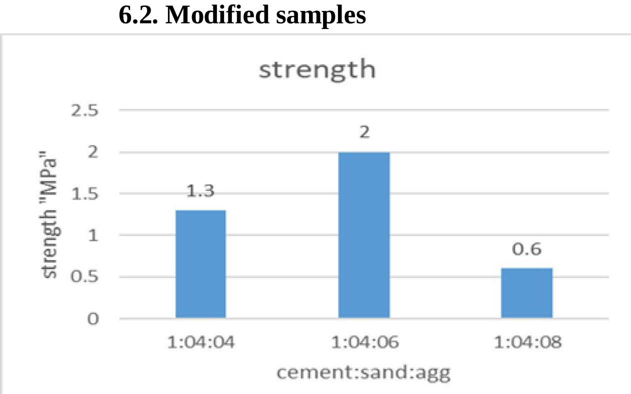

Figure 2 strength comparison based on cement, sand, and aggregates

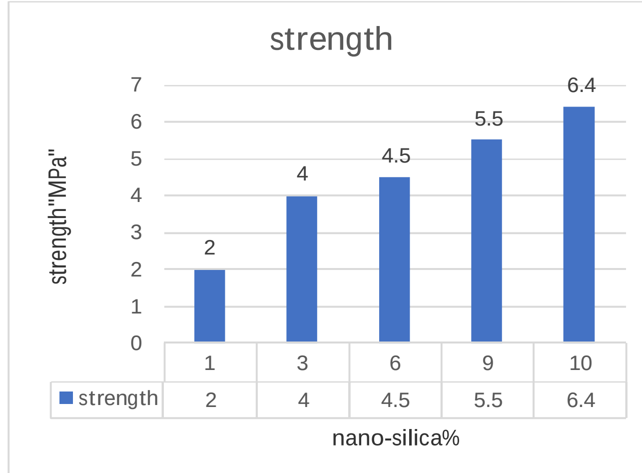

Figure 4 strength based on cement, sand, and aggregates with different Nano-silica percentage

For the durability properties, durability which include the pore structure of the bricks, its particle size, the permeability, the ability to resist chloride ion absorption. the presence of Nano silicon dioxide divides the bulk porosity of the cement bricks into smaller pores which enhance the cement bricks permeability. The pore structure size decreases in the all cement bricks and blocks type as the curing time of the cement bricks and blocks increase, pores decrease by the time. Even small amount of Nano silicon dioxide could enhance the permeability of the cement bricks and it is also easier to disperse which reduce the amount of chlorine ions present in the structure or prevent the cement bricks from absorbing it

6.3. Thermal conductivity

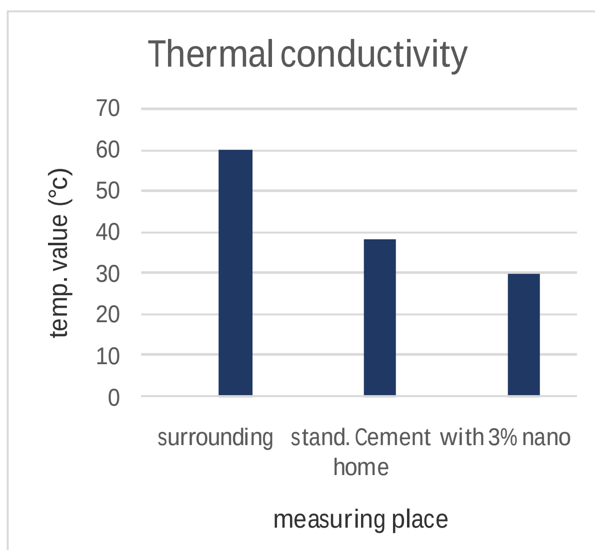

Figure 5: Thermal conductivity compression

The thermal conductivity is measured in a cement house twice, one in a cement house based on the standard samples, and another time in cement house based on the addition of 3% by weight Nano silicon dioxide using the "EXtech" device for measuring the surrounding temperature and the temperature inside the house, and as showed in the results the standard cement bricks had resisted the heat by about 63% than the surrounding the temperature reduced from 60 ºc to 38 ºc. After that at 3% Nano silicon dioxide by weight of the total brick, the heat conductivity had been reduced by about 55% than the surrounding from 60 ºc to 33 ºc, and by about 87% than the cement bricks without Nano silicon dioxide from 38 ºc to 33 ºc.

7. CONCLUSION

The research is done in several stages. First, studying and preparing the raw materials required to obtain the practical work, and studying the time required for the sample to be cured and workable. Then, start to be specific with the ratios which was "1:02,1:04, 1:06", "1:04:04, 1:04:06, 1:04:08", and "1:02:02, 1:02:04, 1:02:06" to continue the work with based on its compressive strength and its raw materials ratios, all the samples was prepared in a cubic wooden mould with 4*4 cm in dimension .The obtained samples was 1;04:06 which gives a compressive strength with 2 MPa, and 1;02:06 which it's compressive strength was 3.9 MPa. After that started to apply the modification in the most economical sample with good compressive strength which finally was "1: 02 :06" by the addition of Nano silica with different percentage "1,3,6,9, and 10%" of the total samples' weight. After applying the compressive strength on the samples, it obtained that, as the percentage of the Nano silica increase the strength of the concrete bricks increase, the final sample was a cement bricks with 10% Nano silica and obtained a strength of 6.4 MPa which achieve the target of the research. Also as an additional test, is testing the ability of the Nano silicon dioxide to reduce the thermal conductivity, and the results showed that at only 3% of the Nano silicon dioxide the heat conductivity is reduced from 60 ºc to 33 ºc which represent a 55% less than the surrounding, and from 38 ºc to 33 ºc which represent about 87% less than the cement bricks without Nano silicon dioxide, and expected to achieve more improvement at higher percentage.

ACKNOWLEDGEMENT

We express our deep gratitude to British University in Egypt (BUE). This work was partially performed using the facilities at the Nanotechnology Research Centre (NTRC) at the British University in Egypt (BUE). The authors also declares that there is no conflict of interest.

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