MANUFACTURING A LIGHTWEIGHT CONCRETE BY USING FOOD WASTE

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ABSTRACT

Lightweight concrete in building construction is important hence according to this research, egg and walnut shells and nano-cellulose were selected as hardening and lightening materials in cement substitutes. Walnut shell has cellulose structure in its cell wall and egg shell has sustainability, high level of renewable and environmentally friendly raw materials which show some new features in nano dimensions.

1 Introduction

Today, the use of lightweight concrete in building construction is becoming increasingly important[1][2]. Furthermore, the use of environmentally friendly materials is one of the new approach applied by engineers[3]. Hence, our research team used natural wastes in concrete construction[4]. According to studies, egg shell, walnut shell and nano-cellulose were selected as hardening and lightening materials and separately tested as cement substitutes[5].

As is unfortunately the case, the earthquake does cause thousands of deaths worldwide every year. Since the earthquake damages are mostly originated from building destructions, the use of lighter but stronger materials appears to reduce the rate of fatality and injuries caused by building disintegration [6][7].To this end, the concrete materials and components are appreciated as the most widely used constituents in the construction industries. In general, the concrete is referred to as any substance or composition which is composed of a cementitious adhesive. It may be made of various types of cement, as well as Pozzolans, Slag, Furnaces' Dusts, Sulfur, Polymers, Fibers, and so on. Furthermore, to modify and obtain the required properties, some specific additives are also added [8].

Lightening any of the aforementioned crucial parts and materials without sacrificing the strength has been the subject of tremendous previous studies[9]. Accordingly, researchers have attempted to utilize the resulting waste materials such as oil palm shell, palm oil clinker, and coconut shell as lightweight aggregate to produce structural lightweight concrete grade. In this respect, the wood wastes, as coarse aggregates, were also used in producing a special concrete grade holding higher compressive strength. In similar attempt, Hwang et al. developed a light weight concrete by using sewage sludge and glass waste. In 2016, Srivastava *et al.*, studied the suitability of ceramic and plastic wastes as possible substitutes for conventional coarse aggregates in producing the lightweight concrete. To generate lightweight concrete by adding the waste expanded polypropylene-based aggregates was also explored by Martina Záleská *et al*., in 2018. As the approach to produce the lightweight concretes is an endless process, the present work was conducted to examine some new additives to concrete in order to assist the construction industries in reducing the cost but still boasting a high enough strength.

2 Materials and Methods

2-1 Materials

In the present work, different materials such as gravel (sand of Zagros mountain ,Nemati brothers production factory, size 06), cement (Saruj company ,type1.425), two different sizes of egg shell (under and on mesh 200), walnut shell, Nano-cellulose, tap water, Lubricants (Kimiya Plast 101), lightweight P1, P2 (two natural gums) and E600 (lightweight filler) were examined. In addition, 5*5 molds, metal tray, track, scales (with 0.1g accuracy), graded cylinder, metal spoon, knuckle, concrete breaker (EG & G Chandler's 4207 compacting density tester is an automatic electric hydraulic press which includes a 5-inch diameter cylinder, that applies a force of about 40,000 pounds to a welded steel plate) water bath, 3 different sizes of sieves (3.8 ,4,16), micrometer, and wooden rod were utilized to prepare the samples.

2-2 Experiments and procedures

In order to make the desired samples, the raw materials were accurately measured by a precise scale for each sample separately in 270C(table 2). In the next step, tap water was added gradually to achieve a homogeneous mixture. Then, the mixture was poured in the molds in a uniform shape with 5 cm side during three stages. After each stage, 25 beats were hit until the mixture was completely compressed. After three days, the samples were dried and taken out of the molds. In the last step, they were placed in a water bath for one week to dissolve the sample lime in water. After taking the samples out of the water bath, they were sent to the laboratory for pressure test and density calculation.

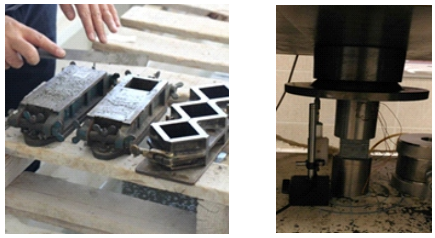

Fig. 1: samples and procedures

3 Results and Discussion

After comparing the compressive strength of the samples with each other and with the reference sample, it can be concluded that the addition of egg shells to the concrete components makes the concrete lighter and stronger by decreasing the amount of concrete cement. This can be related to the mineral structure of egg shell. Nano cellulose was used because this material showed some new features in nano dimensions. Walnut shell was used because it has cellulose structure in its cell wall. The egg shell possessed silica, as well as sand and calcium carbonate, which had a calcareous effect. The reason for the obtained concrete strengthening is related to the bonding produced from the combination of calcium carbonate and silica. This in fact produces a substance called calcium silicate (CaSiO3). This is the same material that strengthens the glasses.

According to the results obtained from the second steps, the smaller size of the egg shells led to the samples with higher strength and higher density. Besides, employing more egg shells reduced the density. The size of utilized sand was also an important factor. The smaller sand size resulted in lower density. Water consumption was another factor affecting the strength of concrete. According to the results of this work, as the amount of consumed water was increased, the sample compressive strength was raised but the density was decreased .Furthermore, two natural gums (P1 and P2) and E600 lightweight filler were used. P1 and P2 could condense the mixture and capture the air bubbles from the samples. These additives greatly reduced the density, but the samples strength were reduced due to the formation of air bubble. The results are summarized in table (1).

Table 1: The components in our samples

Component	Sand (gram)	Cement (gram)	Distilled Water (gram)	Egg shell (gram)	Walnut shell (gram)	Nano Cellulose (gram)	Compressiv pressure(KN
Index (W)	70	10	20	-	-	-	4.0
X	70	5	20	5			4.50
Y	70	5	20	-	5	-	0.5
Z	70	5	20	-	-	5	2.15

The best combination in this project was sample B with 7% egg shell replacement instead of cement by passing 200mesh.

The optimum properties were achieved in the sample which had 7% lower cement than the reference one, tits egg shells were passed from 200 mesh, and 12% water in its total mass. This sample could show the stability of 8500 kg, which was 1400 kg more than the reference sample and therefore could tolerate the weight of 6 cars. Its density was 2.22 g / cm3, which was 0.15 g/ cm3 lower than the reference sample. It is worth considering that the results obtained from the compressive strength are related to 6-days concrete, but usually the concrete used in constructions is 28-day concrete. There are many ways to convert this number which differs based on the temperature conditions and ingredients.

By placing the strength of the sample B in the formula, the strength of the concrete will be 499.9 kg/cm2 due to increasing the strong over time. The density and the compressive strength of samples has been shown in figures (2a-d).

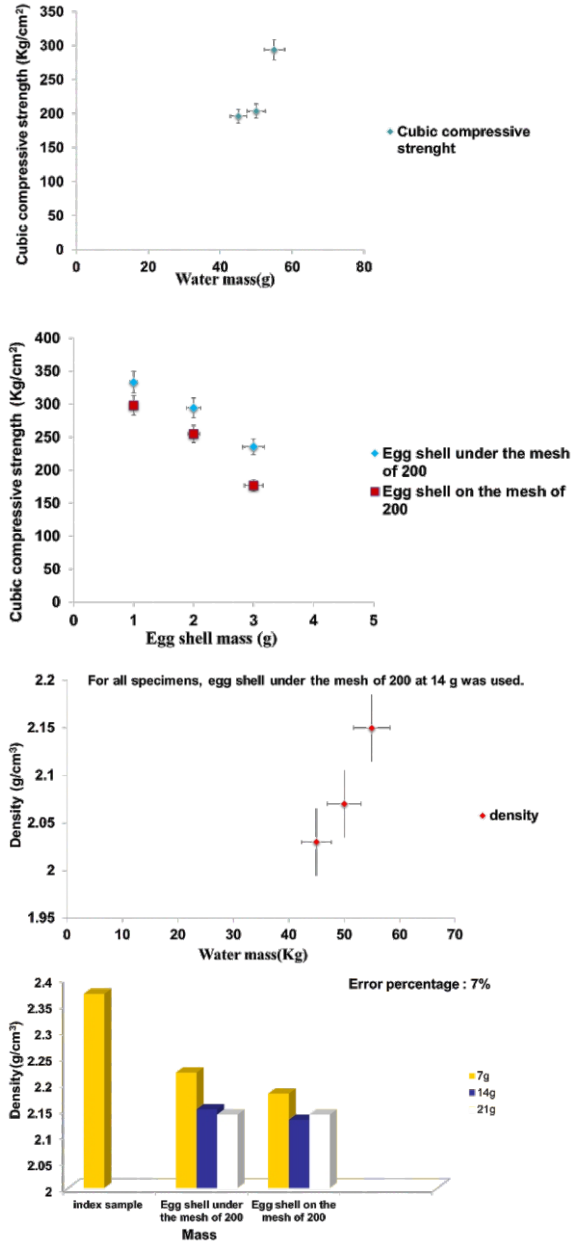

Fig. 2:compress strength and density of samples

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References

[1] Chai L.J. , Shafigh P. , Bin Mahmud H., 2017. "Production of high-strength lightweight concrete using waste lightweight oil-palm-boiler-clinker and limestone powder", European Journal of Environmental and Civil Engineering,

[2] Mo K.H. , Alengaram U.J , Jumaat M.Z. , 2014. “A Review on the Use of Agriculture Waste Material as Lightweight Aggregate for Reinforced Concrete Structural Members”, Materials Science and Engineering , Article ID 365197, 9 pages.

[3] Tuan B . A., Hwang C., Lin K., Chen y., Young M. ,2013. "Development of lightweight aggregate from sewage sludge and waste glass powder for concrete" , construction and building materials.

[4] Agrawal A., Srivastava V., Harison A., Suryavanshi S., “Use of ceramic and plastic waste in concrete: A review”, Sam Higginbottom Institute of Agriculture Technology and Sciences, Allahabad, India

[5] Thandavamoorthy T.S., 2015. " Wood waste as coarse aggregate in the production of concrete", European Journal of Environmental and Civil Engineering

[6] Muthusamy K., Zamri N.,Zubir M.A., Kusbiantoro A. , Ahmad S. W.,2015. "Effect of Mixing Ingredient on Compressive Strength of Oil Palm Shell Lightweight Aggregate Concrete Containing Palm Oil Fuel Ash", Procedia Engineering, vol.125,pages 804- 810.

[7] Siddique R.,Khatib J., Kaur I.,2008. "Use of recycled plastic in concrete: A review", Elsevier , Vol. 28, Issue 10, Pages 1835-1852 .

[8] Industrial Resources Council (2008). "Portland Cement concrete". www.industrialresourcescouncil.org. Retrieved 2018-06-15.

[9] Záleská M., Pavlíková M. , Jancovskyý O., Pokorný J., Z. Pavlík, 2018. “ Lightweight concrete made with waste expanded polyporopylene-based aggregate and synthetic coagulated amorphous silica”.