ISSN No:-2456-2165

The Effect of Eggshell Powder as Partial Supplement of Ordinary Portland Cement on the Compressive Strength of Sand Crete Blocks

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Abstract:- The demand of cement in the building industry is on the rise since cement is a major component of mortar. The production of cement however, has been one of the major causes of global warming due to the release of greenhouse gases during its production. Various experiments have been conducted to partially replace cement in the production of concrete or sandcrete blocks using waste materials such as fly ash, cement kiln dust and many others. In this work, the effect of using egg shell powder as partial supplement of ordinary Portland cement on the compressive strength of sandcrete blocks has been investigated. Cement was replaced by egg shell powder at 5%, 10%, 15%, 20%, 25% and 30% with 0% egg shell powder as the control. The sandcrete blocks were tested for compressive strength at 7 days, 14 days and 21 days of curing. Results from the compressive strength test revealed that 15% cement replacement by egg shell powder was found to have the highest compressive strength.

Keywords:- *Compressive Strength, Eggshell Powder, Global Warming, Greenhouse Gases.*

I. INTRODUCTION

The rate of infrastructure development in the world especially in the developed countries is on the increase and to meet out this demand large quantities of sandcrete blocks and concrete are required (Shu, D *et al.*, 2014). Hence, concretes and sandcrete blocks have been properly labeled as the backbone to the infrastructure development of a nation.

Sustainable construction has become an interest in the engineering community and several standards have been developed to assess the environmental impact of new construction projects. (Isler, 2012). A major component of sandcrete block is cement and it is one of the three primary producers of carbon dioxide, a major greenhouse (Karthick, J and Jeyanthi, R., 2014). As of 2001, the production of Portland cement contributed 7% to global CO_2 emission, largely due to the sintering of limestone and clay at 1500°C.

Cement manufacture contributes greenhouse gases both directly through the production of carbon dioxide when calcium carbonate is thermally decomposed, producing lime and carbon dioxide and also through the use of energy, particularly from the combustion of fossil fuels (Walton, H.V *et al.*, 1973). There is a growing interest in reducing carbon emission related to cement production from both academic and industrial sectors.

Recycling of waste components contributes to energy savings in cement production, to conservation of natural resources and to protection of the environment (Kuma, S., 2014). Researches have shown that it is possible to use recycled materials to replace some of the traditional mixture components in concrete products and produce a more sustainable building material (Amarnath Yerramala., 2014). One of these materials that can be recycled and have the possibility of use in the sandcrete block production is waste eggshell.

➢ *Eggshell Powder*

Generally eggshell is thrown as waste. Eggshell waste falls within the category of food waste, which is materials from the preparation of foods and drinks, if subjected to adequate scrutiny, and they could can be suitable alternative material for construction (Gowsika, D *et al.*, 2014). The eggshell creates some allergies when kept for a longer time in garbage (Phil, G 2011).

Disposal is a problem since it creates undesirable smell which can cause irritation. Eggshell consists of several mutually growing layers of $CaCO_3$, the innermost layer maxillary 3 layer grows on the outermost egg membrane and creates the base on which palisade layer constitutes the thickest part of the eggshell (Amu, O., 2005).

The shell itself is about 95% $CaCO_3$ (which is also the main ingredient in sea shells). The remaining 5% includes Magnesium, Aluminum, Phosphorous, Sodium, Potassium, Zinc, Iron, Copper, Ironic acid and Silica acid. Eggshell has a cellulosic structure and contains amino acids; thus, it is expected to be a good bio-sorbent (Walton, H.V *et al.*, 1973). In many other countries, it is the accepted practice for eggshell to be dried and use as a source of calcium in animal feeds.

➢ *Chemical properties of ESP*

component	Cement (%)	Eggshell powder (%)
SiO_2	21.8	0.08
Al_2O_3	6.6	0.03
Fe_2O_3	4.1	0.02
CaO	60.1	52.1
MgO	2.1	0.01
Na_2O	0.4	0.15
K_2O	0.4	-
SO_3	2.2	0.62
Others	-	0.62
LOI	2.4	45.42

Table 1:- Chemical characteristics between cement and eggshell powder

II. MATERIALS AND METHODS USED

➢ *Sample Collection and Preparation*

The materials used were eggshell, ordinary Portland cement, water and sand. The eggshells used were locally obtained at the canteen of the University of Mines and technology. The eggshells were thoroughly washed with water and sun dried for a day after which it was manually broken into pieces in a container using a metal. The broken eggshells were further subjected to milling for 1 hour to obtain eggshell powder in a ball mill in the minerals laboratory of university of mines and technology.

The eggshell powder was sieved using 90µm sieve size and all particles that passed through the sieve size was used for the project. The ordinary Portland cement and sand used were obtained from the construction site of the University of Mines and technology whereas water used was obtained from the minerals laboratory of university of mines and technology.

Fig. 1:- Eggshell powder

➢ *Mixed proportions*

The mixing ratio of sand to cement was 3:1 for each block molded. Moreover, the water-cement ratio for each block was 0.5. Table 2 shows the mixing proportions.

SN	Definition	Mass of ESP per unit block (g)	Mass of OPC per unit block (g)	mass of sand per unit block (g)	vol of water per unit block (ml)
M0	0% ESP	0	150	450	75
M1	5% ESP	7.5	142.5	427.5	71.25
M2	10% ESP	15	135	405	67.5
M3	15% ESP	22.5	127.5	382.5	63.75
M4	20% ESP	30	120	360	60
M5	25% ESP	37.5	112.5	337.5	56.25
M6	30% ESP	45	105	315	52.5

Table 2:- Mixed proportion of materials

- *Casting of blocks*

A mould of dimension 100mm x 50mm x 70mm (length, breath and height) was used for casting all blocks. A ratio of 3:1 sand to cement was used throughout the casting of blocks. The particle size of sand used was -150µm whereas that of eggshell powder was -90 µm. The percentage replacement of cement used were 5%, 10% and 15%. 20%, 25%, 30% and 0% replacement of cement was used as a control. The quantities of materials obtained from the mix design were measured in each case with the aid of electronic balance. The mixture was mixed thoroughly by the aid of a trowel in a pan to obtain a homogenous mixture. Water was added gradually and thoroughly mixed until uniform appearance in colour and consistency. For the other experiments, the procedure was repeated where the required dosage of each blend of cement, glass waste powder, sand and water was added and the composites mixed thoroughly. A total of 21 blocks were formed. Small amount of water was sprinkled into the metal mould to avoid the blocks from sticking to the walls. Curing was done 24 hours after the casting of blocks. The blocks were cured for 7 days and 14 days and 21 days.

Fig.2:- casted blocks

- *Compressive Strength Test*

Compressive strength tests were carried out to determine the effect of the admixture (glass waste powder) of the blocks. The compressive strength was determined with CONTEST compressive strength testing machine (Type GDIOA, Serial Number 3688) with maximum capacity of 2000kN at the Geological Engineering Department Laboratory of University of Mines and Technology (UMaT), Tarkwa. The test was carried out after the samples were cured for 7, 14 and 21 days.

Fig 3a: compressive test machine in use

Fig 3b: compressive strength test

III. RESULTS AND DISCUSSION

REPLACEMENT %	Compressive strength(N/mm^2)		
	7days	14 days	21 days
0	1.512	2.557	3.415
5	1.633	2.715	3.612
10	1.678	2.817	3.824
15	1.832	2.858	4.323
20	1.432	2.342	3.405
25	1.387	2.094	3.132
30	0.987	1.723	2.974

Table 3:- Compressive Strength of Sandcrete Blocks for 14-days, 21 days and 30 days of curing.

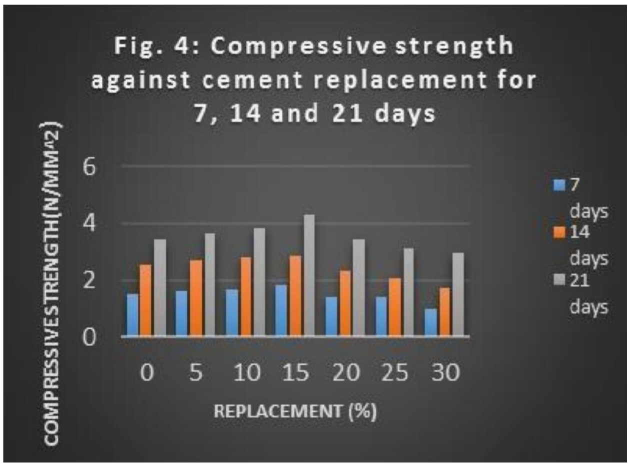

Fig 4

From Fig. 4 and table 3, it can be seen that as the number of days for curing increases, compressive strength also increases. The result also reveals that as the percentage of replacement of cement with eggshell powder increases, strength increases up to 15% and beyond that it decreases. The compressive strengths for 15% cement replacement represent 21.16%, 11.77% and 26.59% increase when compared to the compressive strengths of the control (0%) for 7 days, 14 days and 21 days respectively. The increase in strength is due to percentage of calcium carbonate in the eggshell powder which acts as a filler to fill the various pores in the mortar mixture thus making the mortar more compact and dense (Dhanalakshmi, M. 2015). Moreover, the calcium carbonate in the eggshell powder reacts with the aluminate minerals in the cement to form carboaluminate hydration products which compensate for the loss of cement (Jayasankar. R, 2010).

IV. CONCLUSIONS AND RECOMMENDATIONS

An experiment to investigate the effect of eggshell powder on the compressive strength of sandcrete blocks has been conducted. The following conclusion has been reached;

- There is a general increase in the compressive strength with increase in the curing ages of 7, 14, and 21 days.
- The optimum replacement level of Ordinary Portland cement with eggshell powder is 15%.
- The maximum compressive strength of 4.323 N/mm^2 was achieved at 15% replacement at 21 days of curing.
- There is percentage increase in compressive strength of 21.16%, 11.77% and 26.59% when compared to the compressive strengths of the control (0% cement replacement).

REFERENCES

[1]. Shu, D *et al.*, (2014), "Eggshell Powder: Potential Filler in Concrete", Malaysian Technical Universities Conference on Engineering and Technology. Kuma, S., (2014), "Experimental analysis on effective utilization of industrial waste materials of egg shell, GGBS and saw dust ash", *International Journal of Management, Information Technology and*

[2]. *Engineering (BEST: IJMITE),* Vol. 2, Issue 1, pp. 1926.

[3]. Jayasankar. R (2010), "Studies on concrete using

[4]. Fly ash, rice husk ash and Egg shell powder", *International Journal of Civil and Structural*

[5]. *Engineering*, Vol.1, No.3, pp. 30-35

[6]. Amarnath Yerramala., (2014), "Properties of Concrete with Eggshell Powder as Cement Replacement", *the Indian Concrete Journal*, pp. 94-102.

[7]. Dhanalakshmi, M. (2015), "Comparative Study on Egg Shell Concrete with Partial Replacement of Cement by Fly Ash", *International Journal for Research in Applied Science & Engineering Technology (IJRASET),* Volume 3, Special Issue-I1, pp. 10211027.

[8]. Gowsika D *et al.*, (2014), "Experimental investigation of eggshell powder as partial replacement with cement in concrete." *International journal of Engineering Trends and Technology (IJETI),* Volume 14, No 2. Isler J.W. (2012), "Assessment of Concrete Masonry Units Containing Aggregate replacements of Waste Glass and Rubber tire particles", thesis submitted to the University of Colorado Denver, pp. 11-18.

[9]. Karthick, J and Jeyanthi, R., (2014), "Experimental Study on Usage of Egg Shell as Partial Replacement for Sand in Concrete" *International Journal of Advanced Research in Education Technology*

[10]. *(IJARET),* Vol. 1, Issue 1 pp. 7-10. Phil, G (2011), "Handling and Treatment of Poultry Hatchery Waste: A Review", Vol 3.

[11]. Amu, O., (2005), "Effect of Eggshell Powder on the Stabilizing Potential of Lime on an Expansive Clay Soil", *Research Journal of Agriculture and Biological Sciences,* Vol 1 pp. 80-84.

[12]. Walton, H.V *et al.*, (1973). "Composition of eggshell waste from egg breaking plants". *Journal of Poultry Science*, Vol 52, pp. 18361841.