International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

Enhancement of Concrete Compressive Strength by the Synergy of Blocks, Bricks, and Glass Powder as Mineral Admixtures in the Production of Concrete

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Abstract**—** *This article presents the outcome of the enhancement of concrete compressive strength by the synergy of blocks, bricks, and glass powder as mineral admixtures in the production of concrete. To achieve the study aims, four different construction waste materials, viz; waste brick tiles, waste brick blocks, sandcrete hollow blocks, and waste glass were sourced and crushed to powder form as fine as cement and synergy with a ratio of 1:1. Then, the synergized sample was used as a mineral admixture in casting concrete cubes of 150mm x 150mm x 150mm at different percentage levels (5%, 10%, 15%, and 20%) by weight of cement. A mix ratio of 1:2:4 with a water/cement ratio of 0.5 by weight was used. A total number of sixty cubes were produced for this research, twelve were reference (0%) and twelve cubes for each percentage addition (5%, 10%,15%, and 20%) of the synergy of waste brick tiles, waste brick blocks, sandcrete hollow blocks and waste glass powder. Cube samples were cured and investigated for their compressive strength performance at 7, 14, 21, and 28 days. The study results revealed that the specimen with 0% addition of supplement had an overall increase of 20.7% in strength all through the course of the curing period with an initial value of 16.7MPa and an end value of 20.3MPa. the specimen with a 5% addition of supplement exhibited an overall increase in strength by 6.74% through the course of the curing period. Although had an early increase of 8.7% at the second interval i.e. day 14 but decreased by 1.96% at the fourth interval i.e. day 28. The specimen with 10%,15%, and 20% addition of supplement had a general increase in strength by 13.5%,10.3%, and 7.3%. Among all specimen with supplement addition (5%, 10%, 15%, and 20%), the specimen with 10% supplement addition had the highest increase in strength by 13.5% and an approximate increase in strength by 7.61% in all, above that of the specimen with 0% supplement addition. it is recommended that the 10% addition of the synergy of waste brick tiles, waste brick blocks, sandcrete hollow blocks, and waste glass powder with a ratio of 1:1 should be used in the production of concrete.*

Keywords—*Synergy, Mineral Admixture, Compressive Strength, Construction Waste, Synergy Ratio.*

I. INTRODUCTION

The inevitable surge in the production of waste materials in the construction industry and deficiency in the management of construction waste materials is a result of the advancement in infrastructural development in the world today. Industrial waste like broken bricks, glass, and blocks constitute a nuisance to both health and environment when poorly disposed of, and as such, an enormous amount of generated waste by-product must be conveyed and hoarded in landfills. However, a hike in the price of conventional building materials in most developing and underdeveloped countries is due to high inflation. In consideration to reduce the overall cost of materials and construction, many research works geared towards the utilization of inexpensive and accessible by-products of industrial waste as a substitute of aggregate or binder in infrastructural development, [1]. In most places, there is a strong interest to upgrade the properties of either new or hardened concrete or both for specific purposes hence, the adoption of admixtures in concrete is imperative. The perception of upgrading in most situations is only achieved more promptly with the use of appropriate admixtures that are cost-effective. The wide selection of delving into the use of broken waste bricks, glass, and blocks as an admixture in concrete could potentially complement the profit-making ventures of construction workers by harnessing the waste materials to translate into assets and will also suffice as a cheap complementary to conventional admixtures, with a reasonable cutback in the cost of construction and at the same time solving ecological contamination brought about by the amassment of unmanageable waste.

Glass waste disposal as a landfill has environmental repercussions and also could be very expensive and difficult to manage being that glass in its mature is bio-degradable. The estimated production of glass waste as of 2005 was 130Mt with the European Union, China, and USA as major producers, having a precise production rate of 33Mt, 32Mt, and 20Mt respectively [2]. Hence the integration of responsible management and creation of a healthy environment with consideration to resource efficiency in construction is nothing short of sound construction practice. With concrete becoming the foremost material in construction because of its flexibility and industrial use is not without a consequence on the environment. The major source of greenhouse gas emission emanates from the formulation of cement which is an essential constituent in the production of concrete. Reducing the quantity of cement in concrete by using supplementary cementitious materials holds a promise in reducing the environmental impact from the construction industry. Ground granulated blast furnace slag (GGBS) including silica fume (SF) and fly ash among other several industrial by-products have been used successfully as SCMs [3]. The workability, early and long-term strength, durability, and economy of concrete are generally improved when these materials are used to create a blended cement [4]. However, glass waste which has equal potential as SCMs has not achieved the same commercial success [5]. Investigations on the glass as a material have proved that it possesses a chemical composition and phase comparable to the traditional SMCs [6, 7], and with a high rate of availability could pose to be of great economic value [8]. The enhanced reaction between glass waste and cement hydrates by milling glass waste into micro-meter scale particle size can be of major economic environmental and energy benefits as cement is partially replaced with milled waste glass in the production of concrete [5]. Hemraj and Kumavat, (2013) researched on brick waste as a construction material to serve as a supplement to cement and sand in cement mortar as it performs as a pozzolana. This has a remarkable influence on the decrease of the adverse effect of brick waste on the environment with regards to construction and disposal. His findings indicated that richer mixes give a lower value of bulk density and higher values of compressive strength for sand replacement with brick waste up to 40%. It also presents valuable data for the brick manufacturing industry, builders, and mortar manufacturing companies in terms of minimizing the impact of brick waste and using eco-efficient resources [9].

Rogers, (2011) researched on the most favorable method for resolving the possibilities for given brick dust-producing a pozzolanic reaction when combined with sand. This peculiarity is referred to as pozzolanic. The research required an assessment of the properties of a pozzolanic material, the nature of the pozzolanic reaction, and the review of the existing procedures for determining pozzolanic. At the Architectural Conservation Laboratory of the University of Pennsylvania, a preliminary test program was developed and executed to effectively evaluate the approaches for testing pozzolanic of brick dust to decide their usefulness [10]. Hasanpour, (2013) Investigated the potentiality of using waste bricks powder of Gachsaran Company in the production of concrete. A major consideration was given to the pozzolanic property of the brick waste and the compressive strength of concrete, and as such, cement was replaced by brick waste up to 40 percent by weight in different quantities. Given that concrete with partial replacement of cement by waste brick powder experienced a little reduction in strength, according to findings. The result of the research also consolidates on the potentials of producing pozzolanic concrete with the cement supplement brick waste [11]. John et al (2020) researched milled sandcrete hollow blocks as an additive in limestone cement concrete, the research results established that there was indeed a significant increase in compressive strength of concrete with an addition of 5 – 20 percent of pulverized sandcrete broken blocks powder. With the addition of 5%,10%,15% and 20% respectively, an increase in compressive strength of 10%,17%,12.5, and 7.5% was achieved. According to the author, the highest value of compressive strength from the results was realized at 0% and 20% addition of ground sandcrete broken blocks powder at 28 days, followed by 15% addition of ground sandcrete broken blocks powders at 28 days [12]. Also, John et al (2020) examined waste brick tiles as an admixture in concrete. Study results revealed that the incorporation of waste brick tiles powder produced greater compressive strength than 0%, (control specimens) at 28 days. However, there was a reduction in strength with the 5% addition of waste brick tiles powder at 21 days, while there were increases in the compressive strength at 7 and 14 days with 5-15% addition of waste Brick Tiles powder [13]. The authors intend to know whether the synergy of blocks, bricks and glass powder as a mineral admixture in the production of concrete can improve the performance of the compressive strength

II. Materials and Methods

The materials used in the production of the experimental test specimen of 150mm x150mm x 150mm concrete cubes are Portland limestone cement (PLC) of grade 42.5 according to [14], river sand as fine aggregate conformed to [15], crushed stone as coarse aggregate conformed to [15] and portable mixing water according to [16]. Crushed powdered supplementary materials of waste brick tiles, waste brick blocks, sandcrete hollow blocks, and waste glass were also used in the production of the test specimen of concrete cubes. To achieve the study aim, four different construction waste materials, viz; waste brick tiles, waste brick blocks, sandcrete hollow blocks, and waste glass were sourced and crushed to powder form as fine as cement and synergy with a ratio of 1;1, given in Figure 1.0. Then, the synergized sample was used as a mineral admixture in casting concrete cubes of 150mm x 150mm x 150mm at different percentage levels (5%, 10%, 15%, and 20%) by weight of cement. A mix ratio of 1:2:4 with a water/cement ratio of 0.5 by weight was used. A total number of sixty cubes were produced for this research, twelve were reference (0%) and twelve cubes for each percentage addition (5%, 10%,15%, and 20%) of the synergy of waste brick tiles, waste brick blocks, sandcrete hollow blocks and waste glass powder. Concrete cube samples were cured and investigated for their compressive strength performance at 7, 14, 21, and 28 days.

Fig. 1. Ground Construction Waste Materials (a) Waste glass Powder (b) Waste Brick Block Powder (c) Waste Brick Tile Powder (d) Waste Sandcrete Hollow Block Powder (e) Synergy of (a), (b), (c), and (d)

III. Result

The research result of the enhancement of concrete compressive strength by the synergy of blocks, bricks, and glass powder as mineral admixtures in the production of concrete is presented in this section. The test specimen of different percentage addition of the supplementary material (0%,5%,10%,15%, and 20%), were tested for compressive strength at seven days interval of curing period (7,14,21 and, 28) and the results recorded and presented in Table 1.0. Figure 2,3,4 and 5 shows the graphical representation of the plotted data for 7,14,21 and 28 day respectively as clearly specified in Table 1.

TABLE 1. Compressive Strength of Concrete at 7, 14, 21 and 28days

0% Addition	7 Days (MPa)	14 Days (MPa)	21 Days (MPa)	28 Days (MPa)
0%	16.1	19.4	20.2	20.3
5%	16.6	18.2	18.2	17.8
10%	19.2	19.8	21.0	22.2
15%	19.2	19.8	20.6	21.4

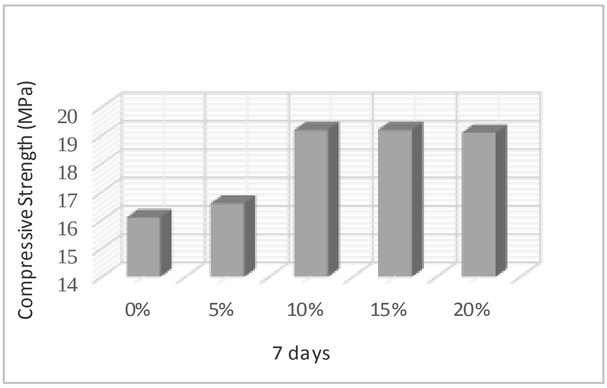

Fig. 2. Compressive Strengths of concrete at 7 days

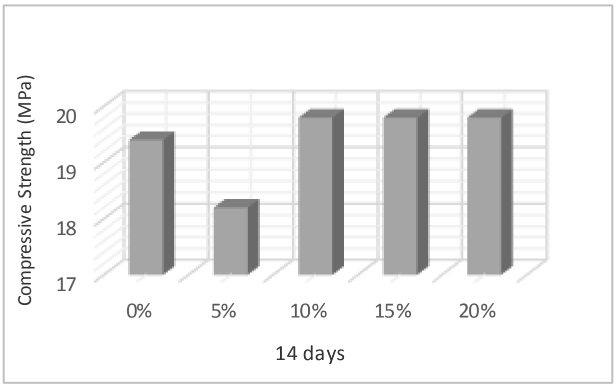

Fig. 3. Compressive Strengths of concrete at 14 days

IV. Discussion

Figure 2-4 shows the various compressive strength of the test specimen with different percentage addition of the supplementary material i.e. waste brick tiles, waste brick blocks, sandcrete hollow blocks, and waste glass. The compressive strength test result at the first interval of the seven days i.e. day 7 is presented in Figure 2 and in direct correlation with Table 1, the specimen with 0% addition of supplement had 16.1 MPa, and specimen with 5% addition of supplement had 16.6MPa, exhibiting a slight increase of 0.6% in strength relative to the 0% supplement addition. Nevertheless, the specimen with 10%, 15% and 20% addition of supplement attained a higher compressive strength of 19.2MPa, 19.2MPa and 19.1MPa respectively, with an increase in strength of 16.14% for 10% and 15% dose and 15.7% for 20% addition, relative to that of the reference specimen.

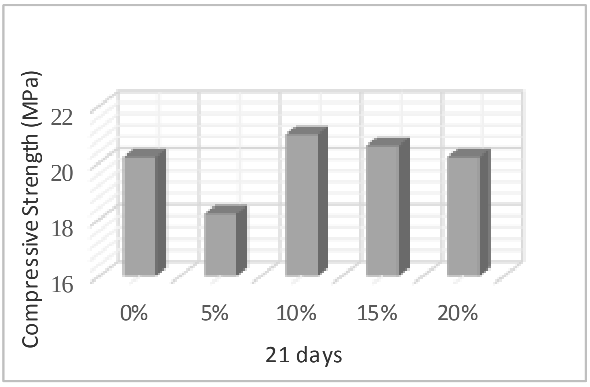

Fig. 4. Compressive Strengths of concrete at 21 days

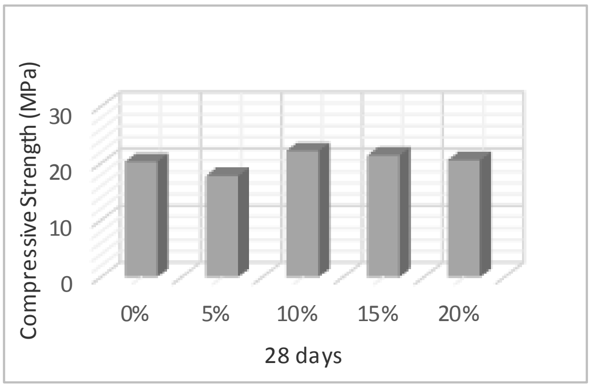

Fig. 5. Compressive Strengths of concrete at 28 days

The compressive strength results for the second interval of the seven days i.e. day 14, are shown in Figure 3. Specimen with 0% addition of supplement had 19.4 MPa, the specimen with 5% dose of the supplement had 18.2MPa, the specimen with 10%, 15% and 20% of supplement addition attained a compressive strength of 19.8MPa respectively. Specimen with 5% supplement addition exhibited 6.18% decrease in strength relative to 0% addition, while specimen with 10%,15% and 20% had an increase in strength of 2% relative to 0% supplement addition.

The graph in Figure 4 indicates the compressive strength for the third interval of the seven days i.e. day 21. Specimen with 0% addition of supplement had 20.2 MPa, the specimen with 5% addition of supplement had 18.2MPa. Specimen with 10%, 15%, and 20% addition attained compressive strengths of 21.0MPa, 20.6MPa, and 20.2MPa respectively. Specimen with 5% supplement addition exhibited a 9.9% decrease in strength relative to 0% addition, while specimen with 10% and 15% addition of supplement had an increase in strength of 3.8% and 1.94%, relative to 0% supplement addition.

Also, the graph in figure 5 shows the compressive strength for the fourth interval of the seven days i.e. day 28. Specimen

Amadise S. Ogboin, John A. TrustGod, and Enyeru U. Divine, "Enhancement of Concrete Compressive Strength by The Synergy of Blocks, Bricks, and Glass Powder as Mineral Admixtures in The Production of Concrete,'' *International Research Journal of Advanced Engineering and Science*, Volume 5, Issue 3, pp. 218-221, 2020.

with 0% addition of supplement had 20.3 MPa, the specimen with 5% addition of supplement had 17.8MPa. Specimen with 10%, 15%, and 20% addition attained compressive strengths of 22.20MPa, 21.4MPa, and 20.6MPa respectively. Specimen with 5% supplement addition exhibited 12.32% decrease in strength relative to 0% addition, while specimen with 10% 15% and 20% addition of supplement had an increase in strength of 8.56%, 5.14% and 1.46%, respectively, relative to 0% supplement addition.

The specimen with 0% addition of supplement had an overall increase of 20.7% in strength all through the course of the curing period with an initial value of 16.7MPa and an end value of 20.3MPa. the specimen with a 5% addition of supplement exhibited an overall increase strength by 6.74% through the course of the curing period. Although had an early increase of 8.7% at the second interval i.e. day 14 but decreased by 1.96% at the fourth interval i.e. day 28. The specimen with 10%,15%, and 20% addition of supplement had a general increase in strength by 13.5%,10.3%, and 7.3%. among all specimen with supplement addition (5%, 10%, 15%, and 20%), the specimen with 10% supplement addition had the highest increase in strength by 13.5% and an approximate increase in strength by 7.61% in all, above that of the specimen with 0% supplement addition.

V. CONCLUSION

From the research study, aimed at enhancement of concrete compressive strength by the synergy of a block, bricks and glass powder as mineral admixtures in the production of concrete which result was evaluated by the comparison of compressive strength for different percentage addition of supplementary material, the following conclusion was made:

I. Specimen with 10%, 15%, and 20% supplement addition performed better than specimen with 0% addition of supplement through the course of the curing period.
II. Specimen with 5% supplement addition performed less than the specimen with 0% addition of supplement through the course of the curing period.
III. Specimen with 10% supplement addition had a better increment of the compressive strength of concrete through the course of the curing period (day 7,14,21 and 28)
IV. For specimen with percentage addition of a supplement, the specimen with 10% addition of supplement obtained a more favorable result.

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