SUITABILITY OF PULVERIZED WASTE GLASS SOURCED FROM BAYELSA AS ADMIXTURE IN CONCRETE WORKS

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Abstract:
Truckloads of waste or discarded glass are abundant in Bayelsa State, Nigeria. Waste glass is not appropriate for landfill as this does not decay in the environment. Glass is mostly made up of silica. Using grinded discarded or waste glass in concrete works as admixture could be an essential measure toward growth of sustainable infrastructure systems. When waste glass in grinded into a powder form, it is thought to go through pozzolanic reactions with OPC hydrates, yielding Calcium Silicate Hydrate.
Suitability of pulverized waste glass powder as admixture in concrete works was studied in this work. Concrete made by replacing cement with waste glass were studied. The effect of partial replacements of 5 to 20 percent of cement, by weight, with waste glass in concrete production was investigated.
Results gotten from the study showed that compressive strength of concrete samples with the addition of 5-10% weight of cement pulverized waste glass powder evidently illustrates the positive outcome of admixture on compressive strength of concrete.
Keywords: *Pulverized, glass, concrete, strength and mix ratio*

Introduction

Glass is considered as a non-biodegradable in natural history, using it as a landfill material could have ecological effects. Though concrete is a universal building material, cement, which is its major constituent results in carbon-dioxide emission, producing about 5% of universal artificial emissions of this greenhouse gas (Imbabi et al., 2012 and Naik, 2008).). The use of pulverized waste glass to replace a portion of the cement or use as admixture in concrete works is an encouraging technique for decreasing the environmental effect from the cement industry.
Quite a lot of industrial waste-products have been used effectively as complementary cementitious materials, such as silica fume, blast furnace slag and fly ash (Islam et al., 2011 and Imbabi et al., 2012). These materials are pulverized and calcined to produced blended cements which can enhance concrete properties and produce cost-effective concrete (Detwiler et al., 1996). Waste glass, if pulverized, has potential some cementitious properties (Rashed, 2014).

Research shows that glass has a chemical composition comparable to conventional cementitious materials (Nassar and Soroushian, 2012). Waste glass is everywhere, can be of no or low economic benefit and is often used as landfilled (Byars et al., 2003). Grinding of waste glass into a powdery form could yield economic benefits when cement is partially replaced with grinded waste glass for concrete works (Rashed, 2014). Some Researchers have worked on the use of waste glass as partially and full replacement for aggregates in concrete works (Taha and Nounu,

2009).

Shi et al., (2005) reported that the pozzolanic properties of glass were first observed at particle sizes below 300 *lm*. They reported that below 100 *lm*, glass can have a pozzolanic reactivity at low cement replacement levels after 90 days of curing. Numerous investigations show that, at the advanced age waste glass concrete (15% to 20% of cement replaced) with pulverized waste glass gives compressive strengths beyond those of control concrete (Nassar and Soroushian, 2011). Conversely, review research by Rashed (2014) reported that earlier investigations with glass addition were not conclusive in view of workability and strength while the chloride resistance of glass powder added concrete was realized to be alike with control condition. Sadiqul et al., (2017) reported that pulverized waste glass powder replaced material in concrete can lessen cost of cement production up to 14%.

This study examined the suitability of pulverized waste glass as admixture in concrete works. Experimental investigation was performed on the performance of pulverized waste glass in concrete works.

Materials and Methods

Materials

The materials employed for this research comprised: Ordinary Portland Cement, fine aggregate (river sand), waste glass, coarse aggregate (crushed stone), water. The waste glasses were crushed and milled to powder form. The fine aggregate, which conforms to BS 882:1992, used in this study was gotten from Amassoma river, Bayelsa State. Also, Ordinary Portland Cement used, which conforms with BS 12:1996, was manufactured by Dangote Cement Nigeria. Clean potable water free from all harmful matter was used for all the experiments as specified in BS 3148:1980.

Collection of Sample

The fine and coarse aggregates sourced in bags were transported to the civil laboratory in Niger Delta University where they were sun dried for 12hrs to lessen the moisture content after which the sieve analysis and specific gravity test were examined. The coarse aggregate was properly washed and rinsed in order to lessen the clay content. Figure 1 shows the crushed waste glass in powder form.

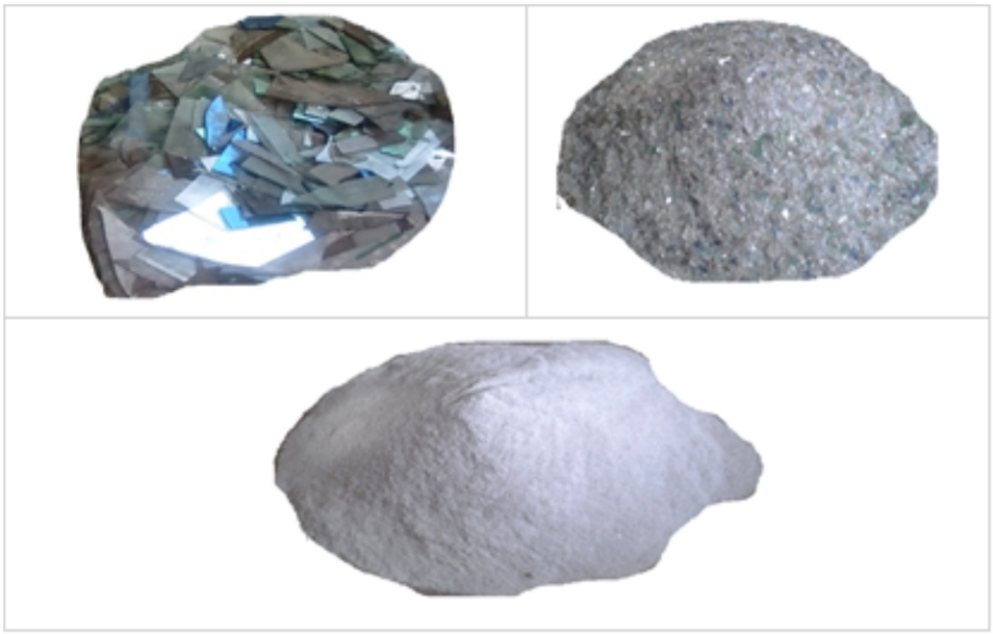

Figure 1: Crushed waste glass in powder form

Laboratory Test
Quite a lot of test and experiments were performed at the civil engineering structural laboratory in Niger Delta University. In general, Ordinary Portland Cement manufactured by Dangote Cement Company was stored in airtight bags in the structural laboratory.

Laboratory tests on Fine and Coarse Aggregates
The laboratory test on fine and coarse aggregates encompassed the bulk densities, particle size distribution, specific gravity. Test on particle size distribution was carried out for both fine and coarse aggregates with sieve size 4.75mm to pan. The particle size distribution was done in accordance with BS 410: 1986 and BS 812 -103: 1985. The sample was poured into the arranged sieves and placed on a mechanical shaker for 10mins. The stacks were removed from the shaker and the weight of each sieve with its retained aggregates were recorded. Percentages retained and cumulative percentages passing were evaluated.

Concrete Preparation
Trial mix design were carried to achieve the target strength of 28N at 28 days with a workability of 50– 75 mm. The pulverized waste glass powder addition in concrete was varied (0–20% weight of cement). A weighed amount of fine and coarse aggregates was dry mixed. Also, a weighed quantity of pulverized glass powder was mixed with weighed amount of cement separately then combined into the fine and coarse aggregates mixed. Weighed amount of clean water was added to the mixture and properly mixed for few minutes. After mixing the concrete, workability of the concrete was examined using slump test. It was verified that the slump measured values of concrete at different pulverized waste glass addition level hang around within the target slump range of 50 –75mm without varying the water content. The concrete was placed a standard mould of 150mm x 150mm x 150mm, tamped the required times on each layer, compacted and surface finished with a trowel in cube mold. The Test specimens were kept within the mold for a day before demolding. After demolding, the samples were cured for required period before testing. A total of 150 cubes were cast.

Compressive Strength Test
The compressive strength of a concrete is the uniaxial compressive stress reached when the concrete fails completely. For each percentage of addition and curing age, three cubes were made and tasted in each instance and the mean value of these three was stated. Cubes were positioned in compressive testing machine and load applied gradually until the sample fails in accordance with the specifications in BS1881-116:1983. Concrete specimens were tested for compressive strength at 7, 14, 21 and 28 days.

Result and Discussions
Figures 2 to 6 show the effect of replacing cement with various quantities of waste glass. The strengths of waste glass-cement concrete were obtained at 7, 14 and 28 days.

Compressive strengths of concrete with the addition of 0-20% weight of cement pulverized or milled waste glass powder as admixture in concrete at various days are given in Figures 2 to 6. At 7 days compressive strength of concrete samples with the addition of 5-10% weight of cement pulverized or milled waste glass powder evidently illustrates the positive outcome of admixture on compressive strength of concrete. At 14, and 21 days compressive strength of concrete samples with the addition of 5-15% weight of cement pulverized or milled waste glass powder gave average compressive strengths beyond the control concrete (0% weight of cement pulverized or milled with waste glass powder). Figure 2-6 above showed that with the addition of weight of cement pulverized or milled waste glass powder with 12% and above, offered considerably lower concrete compressive strength than control concrete strength at 7, 14, 21- and 28-days age. Concretes with 2 - 10% weight of cement pulverized or milled waste glass powder addition as admixture provided average compressive strengths beyond the control concrete. A 10% replacement of cement with waste glass gave the optimum compressive strength at 7 days, while a 5% replacement of cement with glass powder gave an optimum compressive strength at 14 days.

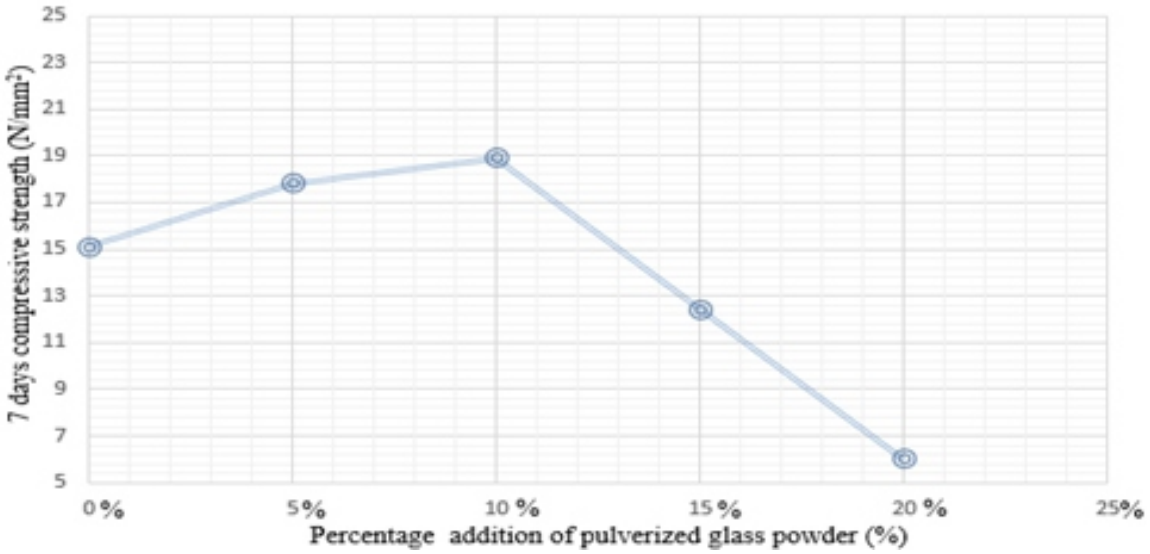

Figure 2: Graph of 7-day compressive strength of concrete against percentage cement replacement with waste

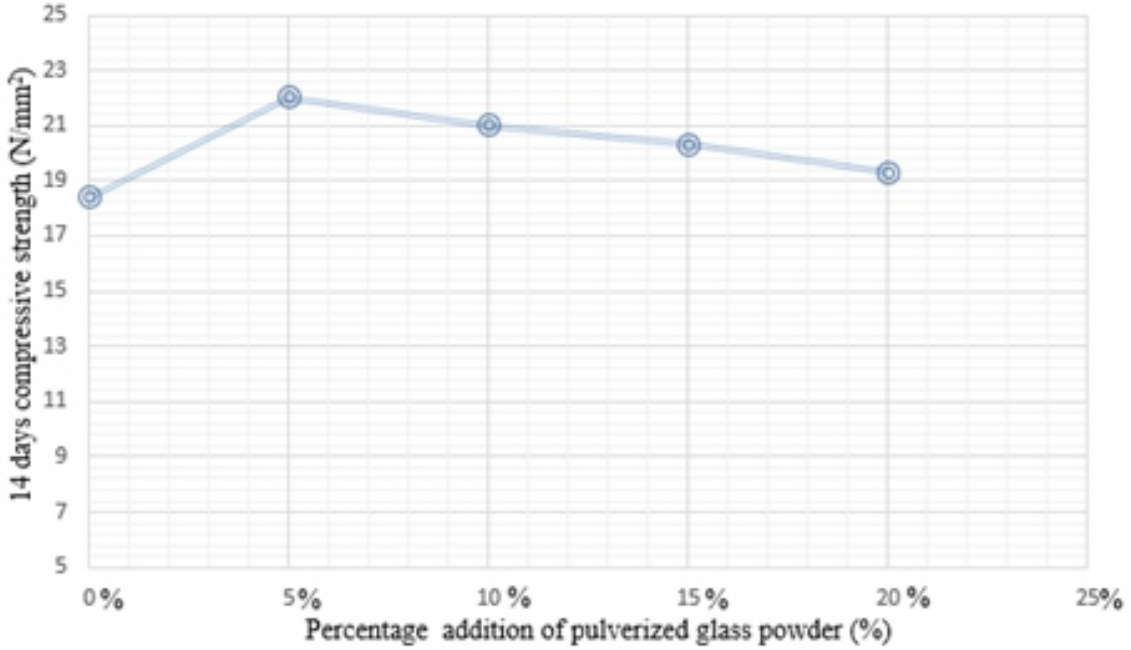

Figure 3: Graph of 14-day compressive strength of concrete against percentage cement replacement with waste

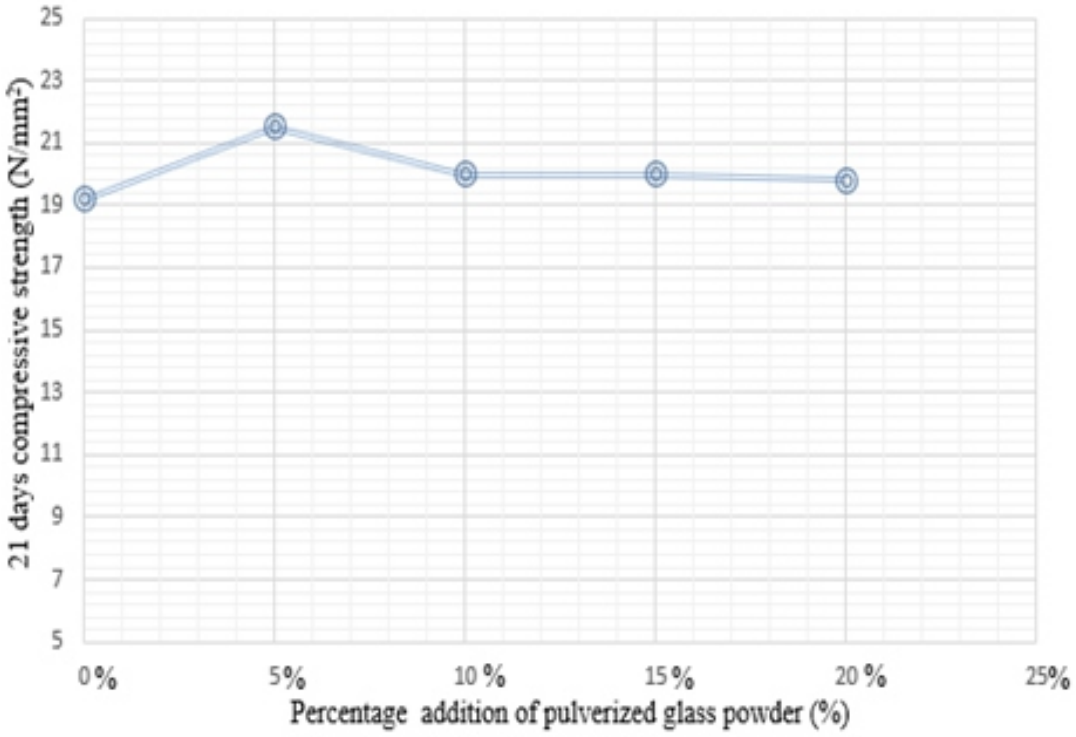

Figure 4: Graph of 28-day compressive strength of concrete against percentage cement

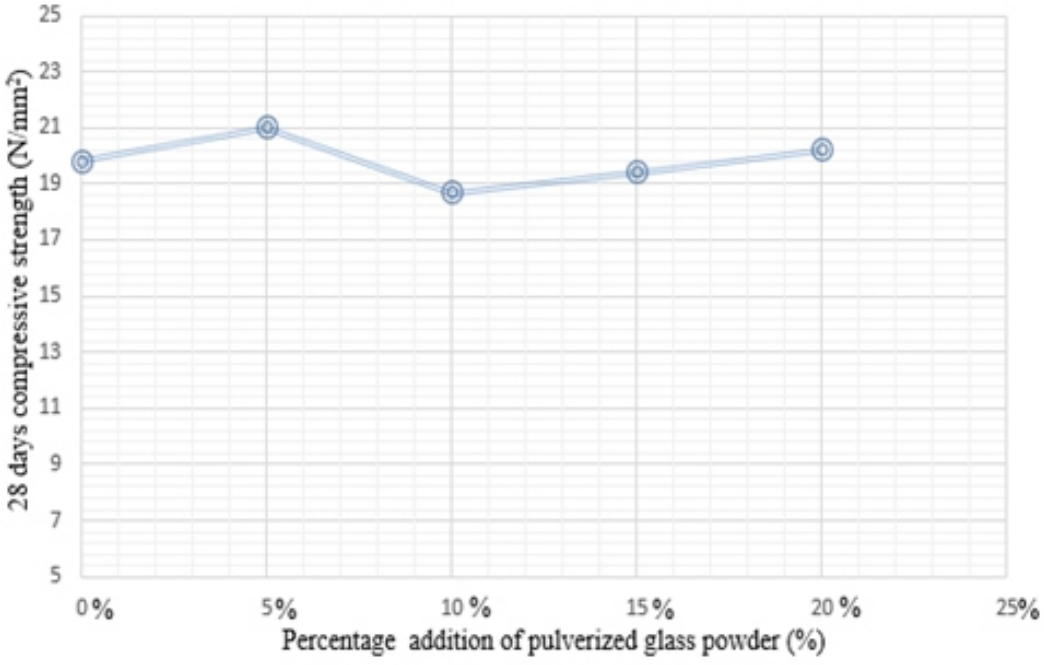

Figure 5: Graph of 28-day compressive strength of concrete against percentage cement replacement with waste glass

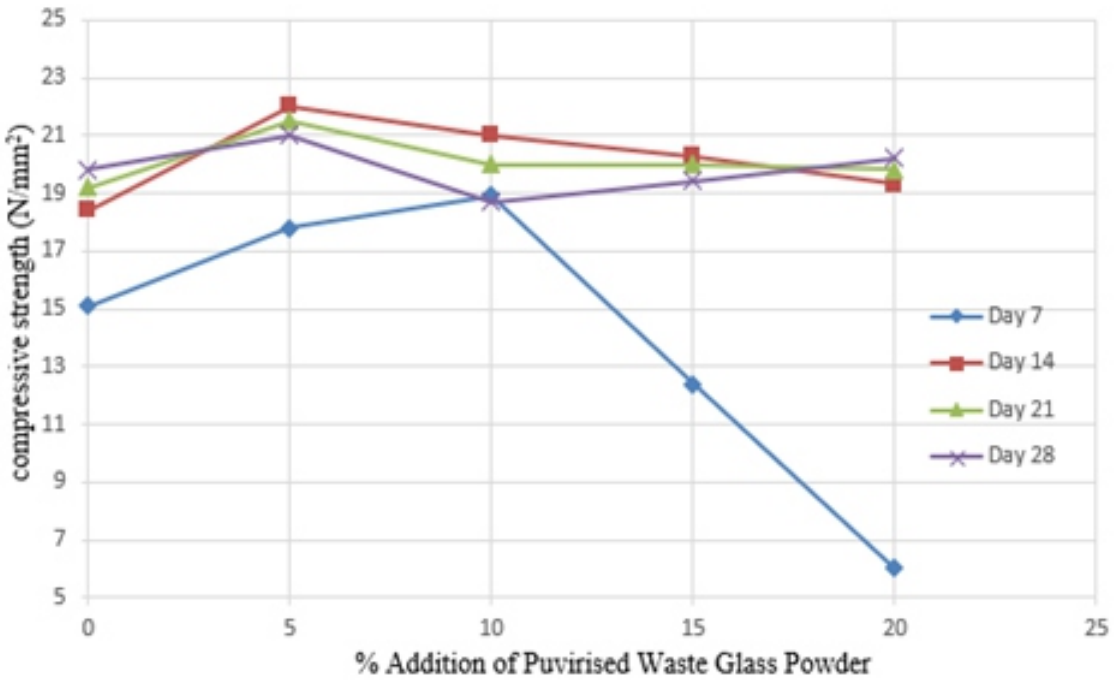

Figure 6: Comparison of compressive strength of concrete with different percentages of waste glass

Conclusion

Based on the outcome of the present investigation of suitability of pulverized waste glass, which were sourced from Bayelsa, as admixture in concrete works, the following conclusions have been drawn:

- **a)** Waste glass can be used as a pozzolanic material in concrete production
- **b)** From the test outcomes and evaluation, it was concluded that concretes with a 5% weight of cement replaced with waste glass powder could be beneficial and cost-effective, considering relative increase in compressive strength observed in from tests
- **c)** Concrete with 2 - 10% weight of cement replaced with milled waste glass powder admixture have relatively increased mechanical strength.

Further studies are recommended in order understand the micro structure of waste glass and concrete made with waste glass. Also, other properties such as the workability and durability of concrete made with waste glass need to be studied in order to gain proper insight into the behavior of this kind of concrete.

Reference

BS 12: (1978): Standard cement tests for Ordinary Portland Cement.

BS 3148: (1980): Test of water for making concrete.

BS 1881: Part 108, (1983): Method for making test cubes from fresh concrete.

BS 1881: Part 109, (1983): Method for making test beams from fresh concrete.

BS 1881 Part 116, (1983): Method for determining of compressive strength of concrete cubes.

BS 1881 Part 111, (1983): Method of normal curing of test specimens.

BS 882: (1992): Specification for aggregate from natural sources for concrete

Byars, E., Meyer, C., Zhu, H.Y., (2003). Use of waste glass for construction products: legislative and technical issues. In: Dhir, R.K., Newlands, M. D., Halliday,

J.E. (Eds.), Recycling and Reuse of Waste Materials. Thomas Telford Ltd., London, United Kingdom, pp. 827–838.

Detwiler, R., Bhatty, J.I., and Bhattacharja, S., (1996). Supplementary Cementing Materials for Use in Blended Cements. Research and Development Bulletin Rd112t, Portland Cement Association, Skokie, Illinois, USA.

Imbabi, M.S., Carrigan, C. and McKenna, S., (2012). Trends and developments in green cement and concrete technology. Int. J. Sustain. Built Environ. 1, 194–216.

Islam, G.M.S., Islam, M.M., Akter, A. and Islam, M.S., (2011). Green construction materials-Bangladesh perspective. In: Proceedings of the International Conference on Mechanical Engineering and Renewable Energy 2011, (ICMERE2011) 22–24 December 2011, Chittagong, Bangladesh (ID-063). Struct. Des. Constr. 13 (2), 98–103.

Nassar, R.U.D. and Soroushian, P., (2012). Strength and durability of recycled aggregate concrete containing milled glass as partial replacement for cement. Constr. Build. Mater. 29, 368–377.

Nassar, R.U.D. and Soroushian, P., (2011). Field investigation of concrete incorporating milled waste glass. J. Solid Waste Technol. Manage. 37 (4), 307–319.

Rashed, A.M., (2014). Recycled waste glass as fine aggregate replacement in cementitious materials based on Portland cement. Constr. Build. Mater. 72, 340–357.

Shi, C., Wu, Y., Riefler, C. and Wang, H., (2005). Characteristics and pozzolanic reactivity of glass powders. Cem. Concr. Res. 35 (5), 987–993.

Taha, B., and Nounu, G., (2009). Utilizing waste recycled glass as sand/cement replacement in concrete. J. Mater. Civ. Eng. 21 (12), 709–721.