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Innovative Construction Reinforcement Medium Using Crushed Glass: An Experimental Risk-Waste Reduction Research

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Research Article

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ABSTRACT

Several places in the Philippines have been considered as major contributors in producing by-product waste materials; one of these materials is waste glass. Traditional glass is manufactured for different functions such as container of foods, liquor bottles, and broken glassware or also known as “post-consumer material”. It has been found that large amount of waste glass is produced daily wherein it became a problem in disposal and control of landfill; therefore, promoting a way wherein it can be both beneficial to our environment and different engineering aspects is essential. Since there is limited resources for fine aggregates, having crushed waste glass as an alternative will somehow enhance the productivity of concrete making it more economical. Thus, crushed glass still possessed interfacing problems when mixed in concrete such as the alkali-silica reaction, flexural and compressive strength of the glascrete, and crushed glass being full replacement to fine aggregates. The main objective of this research is to promote risk-waste reduction while developing an innovative construction medium with the used of crushed glass; giving benefit to both environment and engineering aspects. From the conventional concrete mix, the sand is used as one of components then fully replaced this into crushed glass for the glascrete mix. During the testing, the highest compressive and flexural strength were acquired during the 28th day for both mixes but higher results were obtained for the concrete containg crushed glass as compared to conventional mix.

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INTRODUCTION

In construction, concrete is the most commonly used medium for different engineering propositions which plays a big role in establishing columns, foundations, road pavements, retaining walls, and dams. It is a mixture composed of essential particles such as the water, cement, aggregates, and some may even include admixtures. Understanding the properties of each particle helps the Civil Engineers to provide a well-mixed concrete. Different variations of debris have been recycled in the construction such as steel, bricks, woods, and some recyclable cement. So, developing an innovative construction material in combination for promoting risk-waste reduction is considered as a promising approach and highly in-demand; establishing waste crushed glass for engineering functions specifically [1].

Nowadays, one of the problems encountered is having by-product waste materials considered as harmful in our environment; this includes the problems when waste glass is sent to the landfill. The Local Government Units (LGU) conducted many seminars, outreach and studies on how to reduce the growing waste production due to the ignorance of the people towards proper recycling and segregation of wastes especially glass bottles. The Department of Labor and Employment (DOLE) and the Department of Environment and Natural Resources (DENR) have teamed up to promote environmental waste risk reduction by creating jobs for the unemployed that recycles and turns the wastes products into more useful product known as “Upcycling” or upgrading of what’s being recycled .

Traditional glass is a rigid, brittle and often transparent material made from molten sand, limestone and sodium carbonate. There are two types of glass: glass cullet and industrial glass. Glass cullet defined as “postconsumer material” which are manufactured for different functions. This partially includes containers of food, beer, juices, liquor bottles; excluding glass debris from different electronic applications because of their coating and composition [2]. On the other hand, industrial glass pertains to materials which are from rubbish of different glassware; usually broken and outdated. It has been found that large amount of waste glass is produced, promoting a way wherein it can be both beneficial to our environment and different engineering aspects is essential. Since there are only limited resources of fine aggregates, having crushed waste glass as an alternative will somehow enhance the productivity of concrete making it more economical. Some past researchers termed it as “glascrete” probably because of waste glass being mixed with the concrete. Glass is the only material which can be recycled continually without sacrificing its properties; making it an ideal material for enhancing concrete [3].

An ordinary concrete includes fine aggregates which basically serve as a filler of voids for sustainability, durability and workability. Hence, this research investigates if crushed glass will sustain and improve such properties as compared to the typical mixture of concrete.

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MATERIALS AND METHODS

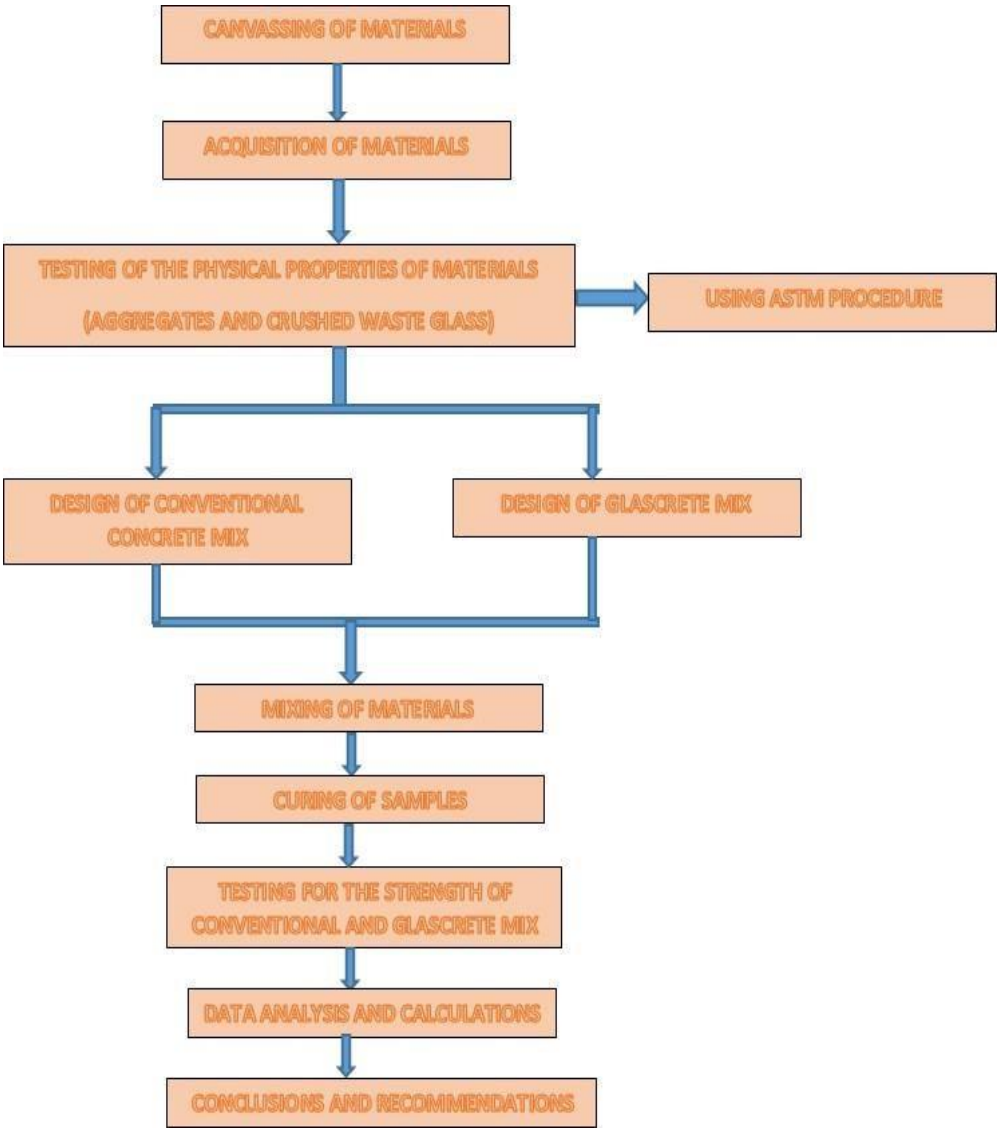

Figure 1: Flow chart

Canvassing of materials will be the first priority. Getting the availability of waste glass which is commonly acquired from the process of local industries. While the main materials like cement, sand and gravel will be purchased from the local hardware.

After canvassing and acquisition of the materials, the physical properties of crushed waste glass and aggregates will be obtained using ASTM procedures[4].

The mixture is composed of conventional concrete mix and the glascrete mix. The conventional concrete mix will be obtained by weight. And the glascrete mix will have fully replacement of waste crushed glass to the fine aggregates and it will be mix to the cement and coarse aggregates. Both mixes is based on ASTM standards procedures.

After curing the modified and conventional concrete, it shall be tested using the UTM (Universal Testing Machine)

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and the results will be recorded. Acquiring all the necessary data for both concrete mix, then analyzing and comparing with each other.

Data for the flexural, compressive, and specific strength were derived from a total of 36 samples containing 9 rectangular and 9 cylindrical samples for both mixes. There are important parameters that will be evaluated for this research which may affect the inconsistency of results the dimension of molds, design criteria and curing time under the 7th, 14th, and 28th day of testing.

The volume-weight method will be used in order to compute for the strength of each sample. To determine the maximum compressive strength of cylinder, the recorded force was converted to Newton and divided it into the cross-sectional area of the container (Force/ Area). On the other hand, for the beam, flexural strength will be the determining factor in attaining the compressive strength. It is expressed in bending equation comprising the maximum moment, centroid, and moment of inertia Also, the specific strength will be evaluated for both mixes which is observable during the testing because glascrete specimens appear to have lighter weight; it is also a factor in determining the ability of concrete to carry a load until failure within its measured weight [5].

RESULTS

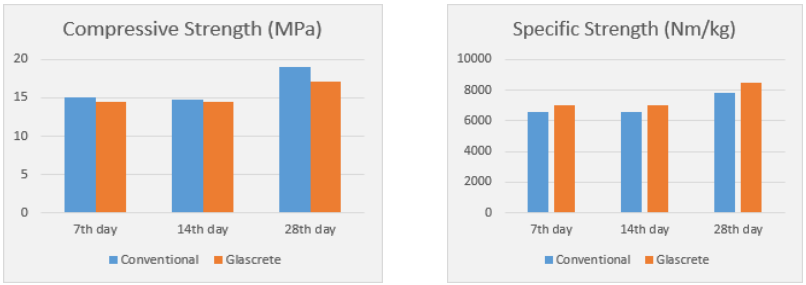

Figure 2: Compressive strength and specific strength of the cylindrical samples.

Results shown were tabulated after the testing under the 7th, 14 and 28th day. The compressive strength of 18.966 MPa for conventional mix and 17.10 MPa for glascrete mix. Comparing the results, slight discrepancies were made in terms of compressive strength but note that both mixes still attained the desirable safe strength design for columns.

Results of specific strength are undeniably higher in glass concrete since it possesses lighter weight which resulted to higher specific strength, having a specific weight of 7,793.86 Nm/kg for Conventional concrete and 8,511.73 Nm/kg for Glascrete[6].

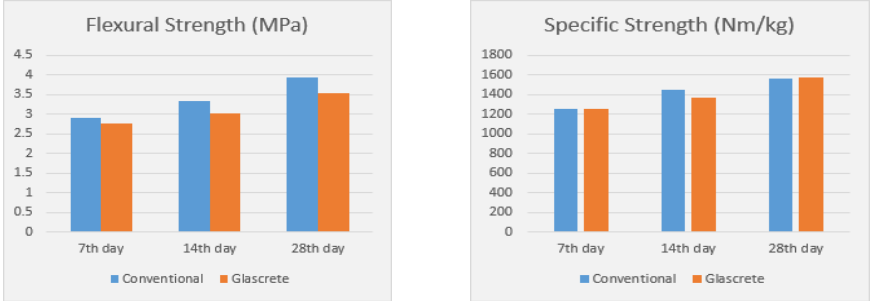

Figure 3: Flexural strength and specific strength of the rectangular samples.

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Results shown the flexural strength and specific strength of the rectangular samples having a strength of 3.94 Mpa for Conventional and 3.548 Mpa for Glascrete. When comparing the flexural strength of the two mixes, both met the acceptable criteria for beams therefore, using crushed glass in concrete for beams is acceptable.

Specific strength of beams surpasses the conventional but its strength is more consistent in cylinders**,** having a strength of 1569.49 Nm/kg for conventional concrete and 1573.75 Nm/kg for Glascrete.

Figure 4: Weight of Conventional Concrete sample and Glascrete sample

The weight of conventional concrete sample is 29.82 kgs. and for the glascrete sample is 27.75 kgs. The glascrete appeared to have lighter weight than the conventional mix [7].

CONCLUSION

After the conducted experiment, the researchers had successfully evaluated the important parameters which led to the attainment of objectives stated in chapter 1 as well as the comparison between the conventional and glascrete mix. The properties for both samples undergoing different curing days were tested and were compared whether the crushed glass can be a full replacement for fine aggregates or not. It is concluded that a correct computation for the weight of water, cement and aggregates is essential to attain the acceptable requirements for concrete using a water-cement ratio equivalent to 0.463; details of computation was shown in the appendices section. Note that this test is more prone to errors because any excess in adding of each component greatly affects the concrete mix especially when it comes to adding crushed glass for it does not have the same properties with fine aggregates; for instance, having too much water will increase the moisture content but may continually decrease the compressive strength. Maintaining the advisable requirements is difficult to sustain in a field, tests often lead to unreliable and inaccurate outcome.

The crushed glass can be a full replacement to fine aggregates because of the results shown in Figures 2 and 3. As this research promotes not only enhancing the strength of concrete, the use of waste glass in concrete was also concluded to be a factor in waste reduction as well. The performance of concrete mixed with crushed glass was proven to be satisfactory because test results were comparable to conventional mix; most glascrete samples even surpass the specific strength of conventional. So, this experiment inferred that it is more ideal to use glass concrete in terms of having a goal of reinforcing the construction as well as managing the continuous increase of waste; this is considered as promising approach since it is sustainable and low cost. The glascrete appeared to have lighter weight than the traditional mix which can be concluded that the specific strength

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(Nm/kg) or the strength- to-weight ratio of crushed glass concrete is stronger for both beams and cylinders. Determining the material's specific strength is an important index for comprehending its ability to sustain heavy loads in a lighter weight. With this concept, it was concluded this should be a factor when it comes to advancing technologies and building high rise infrastructures because when heavy materials were all mixed in a building, it is more prone to failure especially as years passed. Infrastructures can experience force majeure any time of the year and its quality may be sacrificed so having a component with higher specific strength but lighter in weight is very important .

The concrete with crushed glass tend to gain its strength slower than the traditional mix because there's only a minor increase in strength for glascrete mix between 7th and 14th day as well as in 14th and 28th day than the conventional; this statement was proven by past researchers Shayan & Xu (2006). In this case, it is concluded that the glascrete will still gain strength even after the 28th day which is one of the explanations stating concrete with crushed glass have longer life span than the traditional mix.

Generally, the proposed innovative construction reinforcement medium had successfully proved to be an auspicious study in terms of enhancing the construction industry while promoting risk-waste reduction with the use of crushed waste glass as a full replacement for fine aggregates. Glascrete can be used for future studies and visibly economical as the student researchers were able to conclude its advantageous effect on both the concrete and environment.

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