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Experimental Investigation of Concrete with glass powder as Partial replacement in cement

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Abstract: *Glass powder can be used to substitute cement to some level in concrete, which helps to increase strength, according to research on the impacts of doing so. Glass powder was used to substitute cement in various amounts, such as 10%, 20%, and 30%, and multiple concrete cylinders were made beside specimens of plain concrete. At ages 7, 14, and 28 days, the cylinders were evaluated for compressive strength and split tensile strength, and the findings were contrasted with those of ordinary concrete. The overall test results showed that waste glass powder could be used as a good cement substitute in concrete up to 75 microns or less in particle size.*

Key Word: *Concrete, Glass Powder, Compressive Strength, Split Tensile Strength*

I.INTRODUCTION

Due to its many benefits in terms of accessibility, availability, and affordability, concrete is very well-liked throughout the building business. It is created by combining water with fine aggregate, coarse aggregate, and typically cement as the binding agent. With the aid of water, cement, one of the key ingredients in concrete, acts as a binder between coarse and fine material. It contributes significantly to concrete and has its own environmental effects. However, a sizable amount of CO2, a greenhouse gas, is released during cement manufacture. The sustainable growth of the cement and concrete industries is heavily influenced by environmental concerns. Glass recycling reduces CO2 emissions by one tone for every six tone of container glass, saving more than one tone of natural resources [1]. The concrete industry has made numerous attempts to employ waste glass (WG) in place of natural aggregates or regular Portland cement (OPC) in concrete [2].

Rahman[3] discovered a creative logical coincidence. Concrete's plastic qualities might be enhanced by the use of pozzolanic glass powder. The durability of concrete was also found to be increased by milled waste glass, which inhibits alkali-silica interactions. An essential step in creating long-lasting concrete-based infrastructure systems is the use of milled waste glass in concrete as a partial replacement for cement.

1.1. Chemical Properties of Cement and Glass Powder

Chemical properties of cement and glass powder are quiet similar, but the percentages are different. Chemical properties of glass powder and cement are given in Table 1 [4].

Table1.Chemicalpropertiesofcementandglasspowder

Properties	Waste glass powder	Cement
SiO_2(%)	70.22	23.71
CaO(%)	11.13	57.27
MgO(%)	-	3.85
Al_2O_3(%)	1.64	4.51
Fe_2O_3(%)	0.52	4.83
SO_3(%)	-	2.73
Na_2O(%)	15.29	-
K_2O(%)	-	0.37
Cl(%)	-	0.0068
Losson ignition (%)	0.80	7.24

II.MATERIALS AND METHODS

2.1. Materials Used

2.1.1 Cement

Ordinary Portland Cement (OPC) was used for casting of concrete. Specific gravity test was done as given the result is given in Table 2.

Table2.Testoncement

Name of test	Code Followed	Found value
Specific gravity	ASTMC188-16[5]	3.13

2.1.2. Coarse aggregate (CA)

Stone chips were used to make the plain concrete and glass powder concrete. The size of the aggregate was maintained 1 inch passing, ¾ inches retained and ¾ inches passing, ½ inches retained. The conducted test results on coarse aggregate are given in the Table3.

Table3.TestsonCA

Name of tests	Code followed	Found value
Specific gravity	ASTMC127-15[6]	2.42
Absorption capacity	ASTMC127-15	1.2%
Dry rodded unit weight	ASTM C29-C29M-17[7]	1412.5kg/m^3 (102.95lb/ft^3)
Gradation	ASTM C33-C33M-16e1	Fineness Modulus 3.1

Specific Gravity and Absorption Capacity test of CA

Gradation of CA

Dry Rodded Unit Weight test of CA

Illustrates the experimental works done for the specific gravity and absorption capacity, gradation and dry rodded unit weight tests respectively. Again, the gradation curve of coarse aggregate.

2.1.3. Fine Aggregate (FA)

Sand collected from Sylhet, Bangladesh was used. The conducted test results on fine aggregate are given in the Table 4showing the experimental works of specific gravity and absorption capacity and gradation tests of fine aggregates respectively.

Table4.TestsonFA

Name of tests	Code followed	Found value
Specific gravity	ASTMC128-15[8]	2
Absorption capacity	ASTMC128-15	21.95%
Gradation	ASTMC778-13[9]	Fineness Modulus2. 1

2.1.4. Glass Powder

Waste glass bottles collected from local source were grinded manually and the size was maintained less than 0.075 mm.

2.2 ACI Mix Design of Concrete

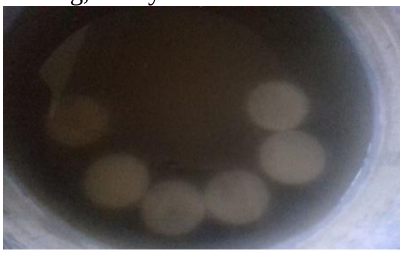
From the results of materials tests, ACI mix design was conducted and the ratio among cement (c), fine aggregate (FA) and coarse aggregate (CA) and water-cement ratio(W/C) were found as given in Table 5. The slump valuewasfoundas25mm.

Table5.Mixdesign ratio

Name	Value
C:FA:CA	1:2.57:3.39
W/C	0.61

2.3 Casting and Curing

Total 24 cylinders were casted as shown in Fig. 10.Among them, 6 cylinders was of cement replaced by 10%of glass powder, 6 of 20% and 6 of 30%. In addition, control cylinder was also casted with 0% glass powder to compare the strength with respect to replacement. After 24hours of casting, the cylinders were demolded and submerged.



Concrete cylinder under water for curing

2.4 Compressive and Split Tensile Strength Test

Compression Testing Machine (CTM) of capacity 2000KN was used for both compressive strength test according to ASTM C39-C39M-17 [10] and split tensile strength testaccordingtoASTMC496-C496M-11[11]of concrete cylinder. Load values were measured from the load cell of CTM.

III.RESULT AND DISCUSSION

3.1. Compressive Strength

Using 10% of GLP, the compressive strength at 7 days was nearly about of plain concrete butat14daysand28days,thestrengthswerenotmuchincreased and were remained almost stagnant. Using 20%of GLP, the compressive strength at 7 days and 14 dayswere much lower than of plain concrete but at 28 days, the strengths was increased marginally and the compressive strength was more than that of plain concrete. lower than of plain concrete but at 14 days, the strength was nearly about of plain concrete and at 28 days, thestrengthwas15%lower than plain concrete.

3.2. Split Tensile Strength

Using 10% of GLP, the splitting tensile strength at 7days and14days were nearly about of plain concrete but at 28 days, the splitting tensile strength was slightly lowerthanthatofplainconcrete.Using20%ofGLP,splittensile strength at 7 days was slightly lower than that of plain concrete but at 14 days, the strength was increased marginally and the split tensile strength was more than that of plain concrete. At 28 days, the split tensile strength was slightly lower than that of plain concrete. Using 30%of GLP, split tensile strength at 7 days was much lower than of plain concrete but at 14 days and 28 days, the strength was significantly increased and the strengths were more than plain concrete.

IV.CONCLUSIONS

The following conclusions were drawn from the above investigation:

- Compared to plain concrete, the concrete with cement replaced by glass powder has shown better result for compressive strength when the percentages of glass powder was 20, but has shown improved result for split tensile strength for 30% glass powder. By changing or modifying the various parameters, it is possible to improve the performance of the senatorial, which plays an important role for eco- friendly construction.
- The addition of recycled green building materials such as glass powder can increase the slump of concrete, but an excessive addition may result in surplus mixing water that could result in slight segregation that can reduce the overall strengths.
- Furthermore, these concrete with glass powder utilize the locally available materials for producing the binding material. So it can be considered as a sustainable material for green construction.
- In general, considering the similar performance with replaced material glass addition can reduce significant cost of cement production and CO_2 emission and save the environment by reducing green house gas and particulate production.

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