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Experimental investigation of strength properties of concrete with partial replacement of cement with glass powder and fine aggregate with foundry sand

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Abstract

Management of natural income and preservation of environment is necessary thing. Rapid growth of industrialization has resulted the production of huge volume of wastes, equally in solid and liquid in manufacturing zones. It's apparent that around 10-15% of wastes formed are hazardous and creation of hazardous wastes is increasing at the rate of 2-5% per year. These generated waste were dumped on land or discharged in to water bodies and thus becomes a large source of environment pollution and wellbeing threats. This study grants the evidence about use of industrial wastes as a suitable material for construction purposes, by which cost of construction can be condensed and also a safe disposal of waste materials can be achieved. In the present study cement will be partly replaced by glass fine particles (5%, 10%, 15%, and 20%) and fine aggregates will be partially replaced by foundry sand (5%, 10%, 15%, and 20%). The strength factors such as compressive strength, split tensile strength will be conducted for both 7 days and 28 days of curing period. Based on the test results suitable proportion of substitution will be decided.

Keywords: Glass powder, Foundry sand, Compression test & split tensile strength.

1. Introduction

Concrete is one of the nearly everyone widely used material throughout the world in the various field, which basically contains ingredient such as cement, sand and crushed quarry gravel and water for the hydration of cement. Sand and compressed quarry gravel are available locally and naturally, these are used as a filler material in the concrete and cement is used for binding and strength parameter of the concrete. Even though concrete is used enormously, it has many draw backs such as for the production of one tone of concrete nearly one tone of CO_2 is released which effect the environment. The face up to for the civil engineering community in the near hope is to realize projects in harmony with the perception of sustainable development and this involves the use of high presentation materials and products affected at reasonable cost with the lowly possible environmental impact.

Basically, concrete is inexpensive, physically powerful, and lifelong. Although concrete technology diagonally, the industry continue to rise to the pressure of a change in the market. The construction area finds that considerable improvements are essential in production, product performance, energy competence and environmental results. The industry wants to face and get rid of over a number of institutional, competitive and scientific challenges. One of the chief challenges with the environmental awareness and scarcity of space for land-filling is the waste byproducts utilization as an alternative to discarding. All the way through the engineering sector, including the concrete production, the cost of environmental fulfillment is high. Use of industrial by-product such as foundry sand, fly ash, bottom ash and slag can answer in significant improvement largely in industry energy efficiency and environmental appearance.

1.1 Foundry Sand

Foundry sand is high quality silica sand with consistent physical characteristics. It is a by-product of ferrous and non-ferrous metal casting productions, where sand has been used for eras as a molding material because of its high thermal conductivity. The physical and chemical indicating of foundry sand will depend on the type of casting procedure and the industry area from which it begin. In recent foundry practice, sand is typically recycled and reused through many manufacture cycles. Foundries purchase high quality size exact silica sand for use in their molding and casting operations. The raw sand is in general of higher quality than the

typical bank run or natural sand used in fill building sites. These sands usually rely upon a small amount of betonies clay to act as the folder material. Chemical binders are also used to create sand cores and for molds for nonferrous castings. The quality of foundry sand can be quantify by its durability and soundness, chemical composition, and variability,. Durability of foundry sand depends on the strength of the sand. The sand can be weakened by successive molding but chemical composition of the foundry sand relates directly to the metal molded at the foundry. While the sand is typically used manifold times within the foundry before it becomes a by-product and only 10% of the foundry sand was reuse, the sand from the brass, bronze and copper foundries are generally not reused. In foundry process, sand distorted molds or cores can be domestic and reused.

1.2 Glass Powder

Glass is amorphous material with high silica content, thus creation it potentially pozzolanic when particle size is less than 75µm (Federio.L.M and Chidiac S.E, 2001, Jin.W, Meyer.C, and Baxter.S, 2000). Studies have shown that finely ground glass does not donate to alkali – silica reaction. In the recent, various attempts and investigate have been made to use ground glass as a substitute in conventional ingredients in concrete making as a part of green house organization. A major concern about the use of glass in concrete is the chemical reaction that takes place between the silca – rich glass particle and the alkali in pore solution of concrete, which is called Alkali – Silicate reaction can be very damaging to the stability of concrete, unless appropriate safety measures are taken to minimize its effects. ASR can be prevented or reduced by adding mineral admixtures in the concrete mixture, common mineral admixtures used to minimize ASR are pulverized fuel ash (PFA), silica fume(SF) and met kaolin (MK).A number of studies have proven the suppressing ability of these materials on ASR. A high amount of waste glass as aggregate is known to decrease the concrete unit weight (Christopher cheeseman, 2011, Mageswari.L.M and B.Vidivelli,2010). The fact that glass has high silica content has led to laboratory studies on its possibility as a raw material in cement manufacture. The use of finely divided glass powder as a cement replacement material has yielded positive results (Malek Batayneh, Iqbal Marie, Ibrahim ASI, 2007), Optimal dosage range of this glass powder is chosen based on cement paste studies.

Fig. 1 – Glass Powder

2. EXPERIMENTAL INFORMATION AND METHODOLOGY

2.1 Objective of Testing

The main objective testing is to know the properties of the materials used in the concrete, and the performance of concrete when the waste product and industrial by-product (foundry sand) used as a substitute for cement and fine aggregate respectively.

2.2 Test Results of Materials used; The force of the concrete mainly depends upon the property of the ingredient that is used in the concrete.

Ingredient Materials of Concrete:

- OPC 53 Grade Ultratech cement
- River Sand as Fine Aggregates
- Quarried and compressed rock as Coarse Aggregates
- Foundry Sand the same as a replacement for Fine Aggregate
- Glass Powder since a replacement for Cement

2.2.1 Cement: Ultratech Ordinary Portland cement (OPC) Of 53 grades meeting the requirements to IS 12600: 1989 was used in this project. Its physical properties were tested in harmony with B.I.S specification and revealed in Table 1

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Table 1. Physical Properties of Cement

Sl. No.	Particulars	Tests Conducted On	Test Results found
1	Specific Gravity	Specific Gravity Bottle	3.10
2	Normal Consistency (%)	Vicat Apparatus	29.5
3	Initial Setting Time (min)	Vicat Apparatus	110
4	Final Setting Time (min)	Vicat Apparatus	270

2.2.2 Fine Aggregate; The close by available river sand in compliance to grading of Zone II of IS: 383 - 1970 was worn as fine aggregate in this project work. The physical properties and sieve analysis data are revealed in Table 2

Table 2. Physical Properties of fine aggregates

Sl. No.	Particulars	Test Results found
1	Specific Gravity	2.56
2	Bulk Density	1319.68 kg/m^3
3	Water Absorption	0.9%
4	Fineness Modulus	2.80

2.2.3 Coarse Aggregate; The nearby available crushed granite material has been used as coarse aggregate. Coarse aggregate of 20 mm nominal size are used in this project work. The physical properties and sieve analysis data of 20 mm nominal size aggregates are tabulated in Table 3.

Table 3. Physical Properties of course aggregates

Sl. No.	Particulars	Test Results found
1	Specific Gravity	2.71
2	Fineness Modulus	6.99
3	Water Absorption	0.45

2.2.4 Foundry Sand; Foundry sand which is procured since Lamina Foundry Ltd. Nitte, Karkala. The test results are shown below

Table 4. Physical Properties of Foundry sand

Sl. No.	Particulars	Test Results found
1	Specific Gravity	2.27
2	Fineness Modulus	1.95
3	Moisture content	0.41%

2.2.5 Glass Powder; Glass Powder was procured from Enviro Safety Glass, Mysore. Its physical properties are shown in Tables 5

Table 5. Physical Properties of Glass powder

Sl. No.	Particulars	Test Results found
1	Specific Gravity	3.00
2	Fineness Modulus	600µm
3	Colour	White

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2.2.6 Water; Clean filtered fresh water, which is free from deliberation of acid and unrefined substance, has been used for combination the concrete. Water has two main reasons in a concrete mixture. Firstly, it reacts chemically with the cement to form a cement paste in which the inert aggregates are held in delay until the cement paste has hardened. Secondly, it serves as a vehicle or oil in the mixture of fine aggregates and cement.

2.3 Mix Proportion

Mix design of a concrete is prepared as per IS 10262: 2009. As shown below

Table 6. Physical Properties of Glass powder

Grade	Cement (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	Water (ltr/m^3)
M25	444.55	748.67	1080.99	177.82

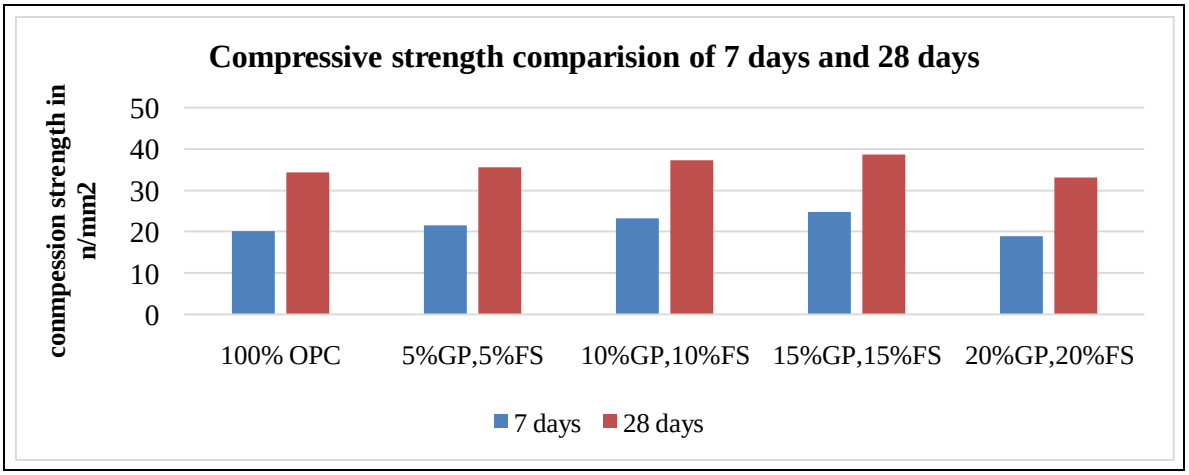
3. TESTS & RESULTS

3.1 Compressive strength

The compressive strength of various control mixes was determined at the age of 7-days and 28-days for various replacements of Glass powder and foundry sand as a partial substitution for cement and fine aggregates at the end of 7-day and 28-dayscuring. As per IS: 516-1959, loading rate of 2.5 kN/s was applied. 2000 KN power compression testing machine was used. Results for 7-days compression strength of test specimen are given in below table.

Table 7 - Compression Strength of 7 & 28 days

% of Glass powder & Foundry sand replacement	7-days	28-days
0%	20.15	34.36
5%GP & 5%FS	21.47	35.55
10%GP & 10%FS	23.25	37.17
15%GP & 15%FS	24.73	38.66
20%GP & 20%FS	18.96	33.03



Graph 1: Comparison of compressive strength for 7 & 28 – day's results

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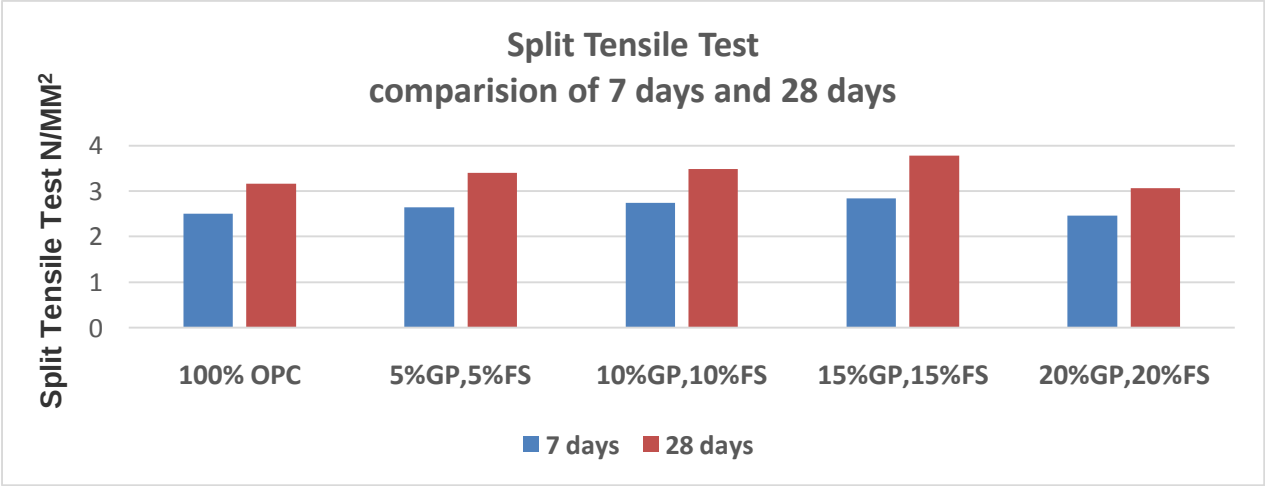
3.2 Split Tensile Strength

This test was passed out on a universal testing machine (UTM) of ability 2000KN. As per IS: 516-1959 loading charge of 2.5kN/s was applied. Cylinder specimens (size 150 mm dia X 300 mm long) are used for this test. Tensile strength was measured at 7 & 28 days.

Table 8 – Split tensile Strength of 7 & 28 days

% of Glass powder & Foundry sand replacement	7-days	28-days
0%	2.499	3.16
5%GP & 5%FS	2.640	3.39
10%GP & 10%FS	2.734	3.48
15%GP & 15%FS	2.828	3.77
20%GP & 20%FS	2.452	3.06



Graph 2: Comparison of Split tensile strength for 7 & 28 – day's results

4. Conclusions

1. The compressive strength of concrete with partial substitute of sand by Foundry sand& cement by GP can be replaced by 15% & 15% has achieved 38.66 higher strength for 28-days when compared with control mix.
2. The split tensile strength of concrete with partial substitute of sand by Foundry sand & cement by GP can be replaced by 15% & 15% has achieved 3.76 higher strength for 28-days when compared with control mix.
3. The Maximum compressive strength of concrete for partial replacement of fine aggregate with Foundry sand by 15%& cement with GP by 15% has increased by 12.5% when compared with conventional concrete.
4. The Maximum split tensile strength of concrete for partial replacement of fine aggregate with Foundry sand by 15% & cement with GP by 15% has increased by 19.36% when compared with conventional concrete.
5. Hence for optimal mix (15%GP & 15%FS) is 6.53% lesser than our conventional concrete. It's observed from the cost analysis results that it's economical.

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