Assessment of mechanical properties by using powder waste glass with cement in concrete mix

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Abstract: The normal concrete is vital and economical but the maintenance cost of normal concrete is large on the other hand if the concrete is replaced with waste material which is useful in concrete production then maintenance cost is less and also workability, durability, and strength is very precious as compared to normal concrete. C&D waste materials replace with raw materials in concrete improves the compressive strength and workability at less to moderate grade and proportions as compared to normal concrete. Production of cement is a highly affect the environment by its energy-intensive property, the production rate of cement is increasing day by day due to construction and development hence it is important to look out for materials which can replace the cement for promoting sustainability and green technology based construction. A promising C&D material like waste glass can replace as cement and it is to prevent essential materials. The powder glass waste in concrete manufacturing makes it economical in construction site. In this study the powder waste glass in various % ratio so that the property of hardened strength of concrete is find higher as the concrete control mix. PWG was replacing with cement in multiple percentages such as 5 to 40 % in variable of 5 %. Control mix is also made for relative reasons Test of hardened strength outcomes indicated that on 30% PWG was Replacement with cement for M30 mix of concrete the workability was good and Mechanical strength noted were maximum than the strength of normal M30 mix.

1. INTRODUCTION

Now a day in all countries, the problem of disposal of solid waste materials has become one of the important environmental and social concerns. In our country, solid C&D waste generated from concrete and other materials are not properly recycled but dumped in an open area. Also, naturally available materials are speedily minimized as the use of fast construction activity particularly river sand as aggregate. So, therefore an alternate way to sort out this type of problem the use of C&D waste as recycled materials in conventional concrete is useful. In this research work recycled coarse aggregate, glass powder and plywood dust which are produced totally from building construction and demolition waste are used as a material which replaced from naturally available materials. Waste glass in concrete has better results in the study of long term chloride permeability but they have concern about ASR effect. Harmful chemical constituents such as sulfates, and alkalis which create the risk of ASR in concrete, Better pozzolanic material can be mitigate ASR and reduce to efflorescence by using lime content [3][5]. In year 2005, the total waste glass production approximately calculate was 0.132 billion ton, in which the EU, USA & China produced nearby 33 Million ton, 32 Million ton and 20 Million ton, respectively. Due to non-bio-degradable in behavior, glass discarding as landfill has flora and fauna impacts and also can be inclusive for sustainable concrete production means creative and ideal management of a good built
environmentally, ecology and prescription resource. Waste glass also used for replacing the course aggregate [4]. Manufacturing process of cement is a important source of green house gas emissions in environment [7]. The basic use of supplement cementitious material (SCM) to balance a cement part in concrete for making effective and smaller the environmental impact from the construction site. By product of all around construction industrial has been utilized successfully as SCMs [7]. Below 75µm particle size of glass has a pozzolanic activity and glass has amorphous materials which have high content of silica. The pore solution, fineness and chemical composition influence the property of concrete and also waste glass act as pozzolanic behavior [7]. Particle size of glass waste is small then it enhancing the reactions between cement and glass, it can be beneficial for environmental and economic when different milled waste glass replaced with cement for manufacturing of concrete [2]. Waste glass used in tiles and brick work in construction industry [1]. Waste glass powder has not contributed to ASR effect in concrete. The research has be use fine glass powder as a partially replacement in main ingredients which is use in concrete production as a provide sustainable environment. Glass is basically use for chemical reaction which happen between the silica present in glass and concrete alkali (Alkali – Silicate reaction) minimize its effects appropriate precautions have taken.

2. EXPERIMENTAL INVESTIGATION

In this work different types of mixes were produced by changing the percentage replacement of cement with powder glass waste respectively. Total of 7 types of mixes is produced in this experiment. The size of the formwork used to produce the samples was the cubical size of 150mm x 150mm x 150mm. All specimens were operated for 7 and 28 days curing time. Cement was replaced by 5%, 10%, 15%, 20%, 25%, 30%, 35% and 40% of powder waste glass. The Sample was prepared for fresh and hardened concrete. These samples were used for two types of testing which are slump test and compressive strength test.

2.1 Required Materials

**Cement:** OPC 43 grade cement, 8112-2003 IS code specified for preparing the concrete different grades. Water which pH value 6.5 the ratio of w/c was prepared to 0.45 according to IS 10262:2009 for mix design and for achieve the good workability Shaliplast SP-431 superplastizer was used 0.8% by cement weight. The cement setting time was observed 30 (initial) and 595 (final) minutes respectively by Vicat apparatus. 4 mm soundness was found by Le-Chetelier of OPC cement.

**Aggregates:**

**Fine:** Gradation of fine aggregate in the range b/w 4.75mm to 150mc. In this work Banas River sand, Rajasthan was used with SG 2.67 and % finer 99.4.

**Coarse:** Gradation of course aggregate greater than 4.75mm, generally CA range in between 9 mm to 22.5mm dia. In this work course aggregate range 10mm and 20 mm particles size was used which specific gravity 2.76.

**Powder waste glass (PWG):** Before adding PWG in the cement for making concrete decide the desired size (<75 mc). Specific gravity of powder waste glass is 2.55

The above data of all materials has been tabulated in the following table 1.

| Material                  | Fine aggregate | Coarse aggregate | Powder waste glass (PWG) | Water |
|---------------------------|----------------|------------------|--------------------------|-------|
| Specific Gravity          | 2.67           | 2.76             | 2.55                     | -     |
| Color                     | Light brown    | Grayish white    | Dark grey                | Colorless |
| pH                        | -              | -                | -                        | 7-6.5 |
3. EXPERIMENTAL PROGRAM:

3.1 Mix Proportioning

For this experimentation grade of concrete is chosen M30 at 0.45 fixed w/c ratio confirming BIS 10262:2009. Admixture is used in 0.8% by the weight of cement to achieve the desirable workability. PWG is used as replacement with cement at interval of 5% from 5 to 40% level as shown is Table No.2.

| Mix designation | Binder (Kg/m³) | % of PWG | Aggregate (kg/m³) | Water, (Kg/m³) | Admixture, (Kg/m³) |
|-----------------|----------------|----------|-------------------|----------------|-------------------|
|                 | Cement OPC43   | PWG      | Coarse 10mm       | Fine 20mm      |                   |
| G0              | 385.00         | 0%       | 0                 | 645.81         | 780.80            |
| G1              | 365.48         | 5%       | 19.25             | 645.81         | 780.80            |
| G2              | 346.50         | 10%      | 38.5              | 645.81         | 780.80            |
| G3              | 327.25         | 15%      | 57.75             | 645.81         | 780.80            |
| G4              | 308.00         | 20%      | 77                | 645.81         | 780.80            |
| G5              | 288.75         | 25%      | 96.25             | 645.81         | 780.80            |
| G6              | 269.50         | 30%      | 115.50            | 645.81         | 780.80            |
| G7              | 250.25         | 35%      | 134.75            | 645.81         | 780.80            |
| G8              | 231.00         | 40%      | 154               | 645.81         | 780.80            |

4. RESULTS AND ANALYSIS

4.1 Workability Test (Slump test)

In this work workability indentify by slump test in fresh concrete mix. Outcomes of test for Mixes G0 to G8 are respectively. Graph in figure 1 shows that slump value for workability test of concrete mix increased upto 20% replacement of PWG with cement. Increae in workailty reperesent pozolonic behavior of PWG.

![Figure 1. Slump (In mm) effect of PWG replacement on cement](image)

4.2 Density of concrete test Result

The density of cubes were measured before testing the cubes. To measur the density of cubes first external surface of the cube is cleaned and swept with the help of any cotton cloth.

Graph in Figure 2 shows that Hardend Density of concrete mix decreases with replacement of PWG with cement.
4.3 Compressive Strength
In this work as per BIS: 516- 1959 Compressive strength of the cubical mould of size 150X 150 X 150mm were determined. The specimen was tested after 7 days and 28 days period of curing fully underwater. Graph in figure 3 shows that compressive strength (7 Days and 28 Days) of concrete mix increase upto 30% replacement of PWG with cement. Percentage variation achieved as 21.76% at 7Days and 8.44% at 28 days.

4.4 Flexural Strength
In this experiment (figure 4) prepared the beam specimen of size 700*150*150mm to analysis the flexural strength as per BIS 516:1959 for concrete mix. Outcomes of test for Mixes G0 to G8 are respectively 4.3, 4.35, 4.56, 4.7, 4.85, 4.95, 5.05, 4.8 and 4.52 N/mm². Graph in figure 5 shows that its increased upto 30% replacement of PWG with cement.
4.5 Splitting Tensile Strength

For tensile strength test prepared Cylindrical specimen (figure 6) of size 150mm(diameter) x 300mm(length) was used of all the mixes. The cylindrical specimen were tested as per BIS 5816:1999. Outcomes of test for Mixes G0 to G8 are respectively 3.3, 3.32, 3.35, 3.45, 3.48, 3.5, 3.55, 3.35 and 3.3 N/mm². Figure 7 shows that Split tensile strength of cylindrical specimen of concrete mix increased upto 30% replacement of PWG with cement.
5. CONCLUSION

The workability which is analysis by slump test of concrete shows that it is increases up to 20% replacement of PWG due to its pozzolanic behavior after a certain percentage of mix its decreases due to its fineness but it remains within the target value of slump(100-125mm) for every mix.

1. Super plasticizer was used to make a more workable concrete specimen dose up to 0.8% for each mix by % weight of cement.
2. In mix specimen compressive strength was detected to rise in strength up to 30% replacement. The percentage variation achieved as 21.76% at 7 days and 8.44% at 28 days but further increasing the PWG, the compressive strength goes to decreasing.
3. Concrete density of mix decreasing in replacement of cement with increased WG dose due to low specific gravity of WG compares to OPC cement.
4. Flexural strength in mix concrete was detected to increase in strength up to 30% replacement. The percentage variation achieved as 17.44% at 28 days but further increasing the PWG, the flexural strength of beam goes to decreasing.
5. Split tensile strength in mix concrete was detected to increase in strength up to 30% replacement in. The percentage variation achieved as 7.57% at 28 days but further increasing PWG split tensile strength goes to decreasing.
6. Adding glass waste in cement concrete reduces the demand of manufacturing cement and also reduces land filling problem.

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