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Effect Of Glass Powder As Partial Replacement Of Cement In Recycled Concrete

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Abstract - *This study consists of the activities performed in order to evaluate the performance of fresh and hardened concrete containing Glass Powder as partial replacements of cement respectively. An IScode proportioned control concrete mix design was achieved for testing the compressive and split tensile strength of concrete. Other concrete mixes with replacements of cement by 5%, 15% and 25% by weightwith glass powder respectively were also prepared. These mixes were tested in their fresh and hardened state and the results were compared with the control mix. The compressive and split tensile strength of concrete were found to be maximum at 15% partial replacements of glass powder with cement respectively.*

Key Words *- Cement, glass powder, fine aggregate, partial replacement, concrete.*

1. INTRODUCTION

In construction field concrete is a material which consists of mixing of cement, aggregates, water and admixtures. Now-a-days a lot of researches are going around the world, by the usage of many waste materials like fly ash, silica fume, rice husk ash, rubber tires, etc. These waste materials are also called as filler materials in concrete. Glass is used many ways in our day to day life and it has limited span and after use it been sent to landfills. Irrespective of the nature of their products, almost all industries produce waste. In that only 5% of waste materials are recycled every year around globe. Building construction materials that are energy efficient must be updated with local materials and technology at a reasonable price to meet the ever-increasing demand.

1.1 Glass Powder

Crushed glass or cullet, if properly sized and processed, can exhibit characteristics similar to that of gravel or sand. When used in construction applications, waste glass must be crushed and screened to produce an appropriate design gradation. Glass crushing equipment normally used to produce a cullet is similar to rock crushing equipment. Because glass crushing equipment in glass sector has been primarily designed to reduce the size or density of the cullet for transportation purposes and for use as a glass production feedstock material, the crushing equipment used is typically smaller and uses less energy than conventional aggregate or rock crushing equipment (Egosi, 1992). Waste glasses are used as aggregates for concrete (Johnson, 1998, Masaki, 1995; Park, 2000), However, the applications are limited due to the damaging expansion in the concrete caused by ASR between high-alkali pore water in cement paste and reactive silica in the waste glasses. The chemical reaction between the alkali in Portland cement and the silica in aggregates forms silica gel that not only causes crack upon expansion but also weakens the concrete and shortens its life (Swamy, 2003). Ground waste glass was used as aggregate for mortars and no reaction was detected with fine particle size, thus indicating the feasibility of the waste glass reuse as fine aggregate in mortars and concrete. The estimated cost for housing is more and some construction materials like natural sand are also becoming rare. Waste glasses are used as aggregates for concrete.

1.2 GLASS

Glass is a transparent material produced by melting a mixture of materials such as silica, soda ash, and Calcium Carbonate ($CaCO_3$) at high temperature followed by cooling where solidification occurs without crystallization. Glass is widely used in our lives through manufactured products such as sheet glass, bottles, glassware, and vacuum tubing Glass is an ideal material for recycling. Whether plain, clear, or tinted, glass is one of the most versatile substances on Earth, being used in a variety of applications and forms. The use of waste glass in Construction companies is increasing because of the emphasis placed on sustainable construction.

In this study, I have made an effort to replace partial cement with Glass Powder to study the strength characteristics of concrete and compare it with that of conventional concrete.

2.0 OBJECTIVES OF THE STUDY

1. Accessibility of cement is plummeting day by day and becomes more expensive. Waste glass can be option for concrete industry.

2. Glass is used many ways in our day to day life and it

has limited span and after use it been sent to landfills. Since the glass is non-biodegradable, landfills do not provide eco-friendly, so there is a strong reason to utilize waste glass as partial replacement of cement or fine aggregates or coarse aggregates.

3. Waste glass powder provide high strength when replaced with cement rather replacing it with fine or coarse aggregates.

4. In olden days solid wastes were used as landfills in low-lying areas. Industrial wastes like fly ash, silica fume, blast furnace slag, etc and other wastes of plastics, glass, tiles and agriculture are causing environmental pollution.

5. Recycling of wastes is therefore emerging as an important component of technology for making contribution towards sustainability.

3.0 EXPERIMENTAL PROGRAM

3.1 Materials Used:

3.1.1 Cement: Ordinary Portland cement of grade 53(Birla Super) has been used.

3.1.2 Fine aggregate: The material of size below (4.75mm) is termed fine aggregate. Natural sand is used as a fine aggregate. If natural sand is not available, it is replaced by crushed stone. In our study, fine aggregate extracted from the bed of the Cauvery River was used, confirming IS 383 1970 and comes under zone II.

3.1.3 Coarse aggregate: The material of a size greater than (4.75mm) is termed as coarse aggregate. Broken stone is used as a stone aggregate. Coarse aggregate used is a locally available crushed angular aggregate of sizes 20mm and 4.75mm.

3.1.4 Waste glass powder: Glass is produced by melting a mixture of materials such as silica, soda ash, and Calcium Carbonate ($CaCO_3$) at high temperatures followed by cooling where solidification occurs without crystallization. The waste glass used in this work was brought from a local Glass vendor in Jalandhar, Punjab, India.

4.0 METHODOLOGY

1. Material collection and study.
2. Mix design.
3. Curing of specimen
4. Casting of specimen
5. Testing of specimen
6. Result
7. Conclusion

4.1 CONCRETE MIX DESIGN– M25 Grade Concrete

4.2 MIX PROPORTION

The concrete mix design was proposed by using IS 10262 [10]. Concrete grade M-25 with a water to cement ratio of 0.45 was taken.

4.3 STIPULATIONS FOR PROPORTIONING M30

a) Type of cement: OPC 53 grade conforming to IS 12269

b) Maximum cement content: 450 Kg/m^3 (as per IS 456:2000)

c) Max. Nominal Size of aggregate: 20 mm

d) Grade designation: M25

e) Maximum W/C ratio: 0.55

f) Degree of supervision: Good

g) Exposure condition: Mild

h) Workability: 100 mm (slump)

i) Type of aggregate: Crushed angular aggregate

j) Minimum cement content: 340 Kg/m3

4.4 TEST DATA FOR MATERIALS

a) Specific Gravity of Coarse aggregate: 2.70 Fine aggregate:2.70

b) Specific Gravity of cement: 3.15

c) Water Absorption of; Coarse aggregate: 0.13% Fine aggregate: NIL

d) Cement used: OPC 53 grade (ACC)

e) Sieve Analysis of Coarse aggregate: Graded Fine aggregate: conforming to grading zone I

f) Free (surface) moisture of; Fine aggregate: Nil Coarseaggregate: Nil

4.5 TARGET STRENGTH FOR MIX PROPORTIONING

F'ck = Fck+ 1.65 S

where, F'ck =Target average compressive strength @ 28 days

Fck = Characteristic compressive strength @ 28 days

S-Standard deviation,

Standard deviation S= 5 N/mm^2

Target strength=40+ 1.65 x 5=48.25 N/mm^2

4.6 SELECTION OF WATER-CEMENT RATIO

From table-5 of 1S 456:2000,

Maximum W/C ratio – 0.55

4.7 SELECTION OF WATER CONTENT

From table -2, for 20 mm aggregate, Maximum Water content is 186 litre (for 25mm to 50mm slump).

So, we would take the estimated water content of 186 lt (Hence OK).

4.8 CALCULATION OF CEMENT CONTENT

Cement content-186/0.55-338.18 kg/m^3-340 kg/m^3 [because W/C ratio-0.55]

From table-5 of IS 456:2000,

Minimum cement content for mild exposure condition – 300 kg/m^3

Therefore, 340 kg/m^3 > 300 kg/m^3, hence OK.

4.9 PROPORTION OF VOLUME OF COARSE AND FINE AGGREGATE CONTENT

From table -3,

The volume of coarse aggregate corresponding to 20 mm size of coarse aggregate & fine aggregate (Zone II) for W/C ratio of 0.50 = 0.62

In the present case, the W/C ratio is lower by 0.55.

Therefore, the volume of coarse aggregate is required to be increased to decrease the fine aggregate content.

As the W/C ratio is lower by 0.05, the proportion of the volume of coarse aggregate is increased by 0.01 (at the rateof +0.01 for every +0.05 change in the W/C ratio).

Therefore, Volume of coarse aggregate = 0.62 +0.1 = 0.63

Volume of fine aggregate=1.0-0.63 = 0.37

4.10 MIX CALCULATIONS

The mix calculations per unit volume of concrete shall be asfollows:

a) Volume of concrete = 1 m^3

b) Volume of cement = mass of cement /specific gravity of cement x (1/1000) = 340/3.15 x (1/1000) = 0.108 m^3

c) Volume of water = mass of water /specific gravity of waterx (1/1000) = 186/1.0 x (1/1000) =0.186 m^3

d) Volume of All in Aggregate = [a-(b+c)] = [1-(0.108 +0.186] = 0.706 m^3

e) Mass of Coarse Aggregate = e x volume of CA x sp. Gr. Of CA x 1000 = 0.706 x 0.63 x 2.70 x 1000 = 1200.90 kg ≈ 1201kg

f) Mass of Fine Aggregate = e x volume of FA x sp. Gr. Of FA x1000 = 0.706 x 0.37x 2.7 x 1000 = 705.294 kg ≈ 706 kg

From Step 9 of mix design:

Equation 1; V = [W+(C/ Sc) +1/px (fa/Sfa)) x (1/1000)

Equation 2; V = [W+(C/Sc) + 1 (1-P) x (ca/sca)) x

(1/1000)Substituting the values in the above two

equations;

V = [W+(C/Sc) + 1/px (fa/Sfa)] x (1/1000 ……… (1)

= 0.98 [172+(430/3.15) +1/0.365 x (fa/2.61)) x (1/1000) 31

FA = 640 ~ 650 kg V = [W+(C/Sc)+1/(1-P) x (ca/sca)] x (1/1000) ……… (2)

= 0.98 [172+(430/3.15) + 1/(1-0.365) x (Ca/2.65)) x (1/1000)

CA = 1130.09 ~ 1130 kg

4.11 MIX PROPORTIONS

a) Coarse Aggregate = 1201 Kg//m^3

b) Water = 186 lts

c) Cement = 340 Kg/m^3

d) Fine Aggregate – 706 Kg//m^3

e) W/C Ratio = 0.55

Hence, Mix proportion: 1:2.07:3.53

5.0 TESTS ON FRESH CONCRETE

In accordance with IS CODE 456-2000, a workability test was conducted. An accurate filling of the form is determined by the workability of a fresh concrete mix. Workability depends on water content, aggregate (shape and size distribution), Cementitious content, and age (level of hydration and may be changed by adding chemical admixtures, like Superplasticizer).

1) Compressive Strength Machine Test

This test is performed to determine the workability of fresh concrete by compacting factor test as per IS: 1199 – 1959. Tests of this kind are primarily designed for laboratory use but are also useful for concrete that is compacted by vibration, as it is more precise and sensitive than slump tests and particularly useful for low workability concrete. The method applies to plain and air-entrained concrete, made with lightweight, normal weight, or heavy aggregates with a nominal maximum size of 38 mm or less but not to aerated concrete or no-fines concrete.

6.0 TESTS ON HARDENED CONCRETE

6.1 COMPRESSIVE STRENGTH RESULTS:

This test determines the hardness of cube specimens of concrete. The strength of a concrete specimen depends upon cement, aggregates, bond, w/c ratio, curing temperature & age, and size of the specimen. The major factor controlling the strength is the concrete mix design. Cubes of size 15cm x 15cm x15 cm are tested. Each specimen is given sufficient time for hardening (approx. 24 h) and then it is cured for 7, 14 & 28 days.

The type of concrete, age of concrete, the density of concreteand compressive strengths of the experiment are tabulated in the table given below. The compressive strength of concrete replaced with GGBS and glass has been seen to be significantly higher than that of plain concrete up to 20% replacement by GGBS and 35%

replacement by the waste glass as per the results obtained in the table below:

S. No.	M25 Concrete Mix (% of cement: % of glass powder) for 75 to 300 Microns	Compressive strength (MPa) at 7 Days	Compressive strength (MPa) at 28 days
1	M25 Normal	17.27	30.56
2	M25 (65.5)	19.26	31.25
3	M25 (85:15)	20.48	32.46
4	M25 (75:25)	18.62	31.49

7.0 CONCLUSIONS

- The initial gain of strength is low on starting but it meet's desired strength on 28th day on addition of waste glass powder as replacement of cement.
- At the replacement of 15% the glass powder meets the maximum strength as compared to that of with normal concrete and percentages like 5%, 25%. The particle size impact will be there in concrete.
- It is concluded that if the particle size of the glass powder decreases in concrete then the concrete strength increases.
- It is also concluded that particle size which is less than 75 microns has resulted high strength than the particle size ranged from 75 to 300 microns.

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