DURABILITY STUDIES OF SELF- COMPACTING CONCRETE WITH RECYCLED COARSE AGGREGATE AND WASTE GLASS POWDER

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Abstract - *Incorporating waste and recycled materials in concrete provides not only a long-term benefit, but also increased resistance to special circumstances that concrete structures face, such as fire. The crushed concrete aggregate has been used as a replacement to natural aggregate in SCC. Waste glass powder can be utilized as partial replacement of cement. If some of the waste materials can be suitable for concrete making it can reduce the cost of construction. The current study investigated the performance of incorporating recycled coarse aggregate (RCA) and two unprocessed waste powder materials on the residual mechanical properties of self-compacting concrete (SCC). SCC mixtures have been created by adding to cement mass with up to 25% waste fly ash (WFA) and replacing cement 10%, 20%, 30% using waste glass powder, as well as replacing the coarse natural aggregate (NA) with up to 50% RCA. Replacing cement by 10% waste glass powder and 50% RCA gives more strength. The durability properties were investigated, such as water absorption tests, and carbonation tests, and were compared with conventional SCC. Results indicated durability of concrete mix.*

Key Words: Self Compacting Concrete, Recycled Concrete, Waste Glass Powder, Waste Fly Ash, Natural Aggregate

1.INTRODUCTION

The availability of skilled-labor in the construction sector decreased throughout the 1980s. The desire for concrete that could address issues with poor craftsmanship was sparked by this circumstance. As a result, self-compacting concrete was created. The following are the major causes of concrete deterioration today, reinforcing steel corrosion, frost action in cold climates, and physico-chemical effects in aggressive environments. The permeability of concrete, rather than normal variations in the composition of port land cement, is widely accepted as the key to all durability issues. Despite having superior fire resistance than the majority of construction materials, concrete loses strength and may even crack when exposed to high temperature. A potential solution for sustainable development is the partial substitution of coarse natural aggregate (NA) with coarse recycled concrete aggregate (RCA). The impact of using waste glass powder in place of cement in concrete has been the subject of numerous investigations. Milled glass with particles smaller than 75 microns has the pozzolanic qualities to function as a supplementary cementitious material (SCM) and can be sufficiently compared to other proven SCMs like fly ash and silica fumes.

2. MATERIALS

2.1 Cement

Use of Ordinary Portland Cement (OPC) of Grade 53 according to IS specifications is made in this investigation.

Table-1: Properties of OPC 53 grade cement

Properties	Test results	Technical reference
Specific gravity	3.12	IS4031(PART 11): 1988
Consistency (%)	30	IS4031(PART 4): 1988
Fineness of cement (%)	4.7	IS4031(PART 2): 1996
Initial setting time (minutes)	78	IS4031(PART 5): 1988

2.2 Fine Aggregate

With the exception of grading requirements, fine aggregates should meet the requirements of ASTM C33. Variations in fine aggregate quality will have a significant impact on overall quality of SCC. M-Sand is less than 4.75mm in size. M-sand is used in this study as fine aggregate. Table 2 gives properties of fine aggregates.

Table-3: Properties of Fine Aggregate

Properties	Test results
Specific gravity	2.52
Fineness modulus	3.84
Free surface moisture	Nil

2.3 Coarse Aggregate

Coarse aggregates particle sizes ranges between 10 and 40 mm in size. The coarse aggregate used for SCC is round in shape, well graded, and smaller in maximum size than that used for conventional concrete because round smaller aggregate provides flowability, deformability, and segregation. The experimental study's coarse aggregate was 12.5mm in size and conformed to IS 383:1970. Table 4 lists the characteristics of coarse aggregate.

Table-4: Properties of Coarse Aggregate

Properties	Test results	Technical reference
Specific gravity	2.69	IS2386(PART 3): Clause 2.4.2
Free surface moisture	Nil	IS383(PART 3): 1970
Fineness modulus	4.25	IS383(PART 3): 1970 table 2

2.4 Recycled Coarse Aggregate

The aggregate represents 60 to 75% of concrete volume. Therefore, the complete or partial substitution of conventional aggregate by crushed concrete aggregate presents high economic and ecological advantages as it reduces the deposition of waste in landfills and the extraction of natural aggregates. It is now acknowledged that recycled concrete has less durable mechanical qualities due to the high water absorption coefficient and low density of the recycled concrete aggregates (RCA) as contrasted with concretes made with natural aggregate Recycled concretes seem to show better residual mechanical strength. Recycled coarse aggregate has a lower durability, but mixing it with special materials such as fly ash improves its durability.

Fig- 1 : Recycled Coarse Aggregate

Table 5 Properties of Recycled Coarse Aggregate

Physical Test	NA	RCA
Water absorption (%)	1.01	5.60
Los Angeles wear (%)	26.30	36.11
Density (kg/m^3)	2,640.11	2,612.29

2.5 Waste Glass Powder

Studies have also demonstrated that glass can be employed as a pozzolanic or cementitious component in concrete because of the chemical composition's high silica and calcium content and the glass's amorphous structure. In the primary bonding phase of concrete, the reaction between the glass powder and the $Ca(OH)_2$ in the concrete mix results in C-S-H gels. a gradual decrease in the strength properties of the concrete containing glass material as the temperature increase.

Fig-2: Waste Glass Powder

2.6 Fly Ash

Fly ash is a finely separated by product of pulverised coal combustion that is carried away from the combustion chamber by exhaust gases. It is a fine grey coloured powder having spherical glassy particles that rise with the flue gases. As fly ash contains pozzolanic materials components which reach with lime to form cementitious materials.

3. DURABILITY TESTS ON CONCRETE

There are certain methods for determining durability of concrete. Durability test includes water absorption test and carbonation test.

3.1 Water Absorption Test

The water absorption test determines both the outer and inner concrete surfaces' water absorption rate (sorptivity). The test involves measuring the increase in mass of concrete samples as a function of time due to water absorption when only one face of the specimen is exposed to water. A cube specimen measuring 150 mmx

150 mmx 150 mm was cast and submerged in water for 28 days as part of a water absorption test. The specimens are weighed again at room temperature after being oven-dried for 24 hours at a temperature of 150ºC to ensure that the mass is constant.

$$\%\text{Water absorption} = \frac{W_1 - W_2}{W_2} \times 100$$

W_1= oven dried weight of specimen

W_2 = final weight of specimen

3.2 Carbonation Test

Carbonation in concrete is main reason for corrosion of steel reinforcement. Carbonation testing provides clear information about carbon dioxide infiltration into the concrete. carbonation depth can be measured during this Test shall be performed on freshly exposed surface. Cylinder specimen of 300mm length and 150mm diameter was cast. Indicator solution was prepared by 1% Phenolphthalein solution in ethanol. if the specimen becomes pink, the specimen is considered to be un-carbonated; otherwise, it is assumed that specimen is carbonated. Depth of carbonation can be measured.

4. RESULT AND DISCUSSION

This section presents the findings of various experiments conducted to evaluate the concrete's durability characteristics.

4.1 Water Absorption Test

According to the findings of water absorption tests, the specimen of 10% cement replacement with waste glass powder in SCC absorbs less water than other control specimen.

4.2 Carbonation Test

Fig-:3 Carbonation Test

From figure 3 makes it very evident that the control specimen becomes colorless, showing that it is a carbonated specimen. Test specimen with 10 % replacement of cement with waste glass powder and 50% replacement of coarse aggregate with recycled coarse aggregate were still pink in colour, showing that it is an uncarbonated specimen but the carbonation depth is less.

5. CONCLUSIONS

The main findings of this investigation are given below.

- Concrete that has 10% replacement of cement with glass powder performs better in terms of durability than concrete made with the original mix.

Table 6 Water Absorption Test Results

MIX	OVEN D (kg)	Wet Weight ofspecimen (kg)	% Water absorption
CS	7.100	7.420	4.31
TS	7.240	7.430	2.55

The water absorption is higher in test specimen compared to control specimen.

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