Comparative Study in Fly Ash, Glass Powder and Recycled Concrete Aggregates as a Partial Replacement of Materials in Conventional Concrete

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Abstract— During recent years, the consciousness regarding environmental atrocity has increased as a result the interest of the construction community in using waste or recycled materials in concrete has also aggravated. If we see around us, we can see so many materials we consider waste which rather must be opportunities. The fly ash is produced in abundance in the thermal power plants as abate product which is not easy to be disposed of and is dangerous to the environment. Recycled aggregate can be used for many purposes. To address the environmental effects associated with cement manufacturing, it is crucial to advance alternative binders to compose concrete. If a few waste materials found convenient and economic for concrete manufacturing, a major gain will be achieved in the disposal of waste management and depression in construction cost. The work audits the feasibility of fly ash, glass powder, and demolished concrete as a partial substitute of cement and natural coarse aggregate, respectively. For this intent, the procedure is partitioned into two stages. In first stage replacing 25% cement content with different proportions of fly ash and glass powder. Further tested for compressive and flexural strength, at 7 days, 14 days & 28 days and correlated with conventional concrete.

Keywords: Fly Ash, Recycled Aggregate Compressive Strength Test

I. INTRODUCTION

Recycled coarse aggregate is granular material fabricated by evacuating, smashing, and preparing hydraulic cement concrete, asphalt for reuse with a pressure-driven solidifying medium to deliver fresh paving concrete.

Fly ash, otherwise called flue-ash, maybe a standout amongst the residues created under combustion and comprises those fine particles that rise with flue gases. Fly ash is by and large caught by electrostatic precipitators or other molecule filtration gear before those pipe gasses arrive at the chimneys of coal-fired power plants. Depending upon the source and makeup of the coal continuously burned, the contents for fly ash change considerably, in any case, all fly ash incorporates significant sums of silicon dioxide (SiO2) (both amorphous and crystalline) and calcium oxide (CaO), both being endemic parts in many coal-bearing rock strata.

Glass is generally utilized in our lives through fabricated items, for example, sheet glass, bottles, glassware, Also vacuum tubing. The measure of waste glass may be increased bit by bit over the recent years due to the ever-growing utilization of glass items. Most waste glasses have been dumped under landfill destinations.

II. OBJECTIVES OF STUDY

The following are the objectives of the current study"

- Comparative study of fly ash, glass powder and recycled concrete aggregates with conventional concrete.
- Review the properties of fly ash, glass powder and recycled aggregate in strength enhancement.

III. METHODOLOGY

In stage 1, I have partially replaced cement with FA (Fly Ash) and GP (Glass powder), varying from 0-25% in different proportions. 9 cubes and 6 beams with conventional concrete i.e. concrete having Cement (C), Sand (S) and Natural Coarse Aggregate (NCA) have been cast and then % of cement is reduced to 75%, and the remaining 25% binder (Cement) is replaced by a different proportion of FA and GP. In stage 1, a total no. of 63 cubes and 42 beams are cast in a total of 7 batch mixes.

In stage 2, Natural Coarse Aggregate (NCA) is partially replaced by Recycled Concrete Aggregates (RCA) varying from10% to 40%. For stage 2 results of compressive and flexural strength have been considered on working in stage 1, batch mix giving optimum values of compressive strength, and flexural strength was adopted for further research work in stages 2

As stage 1, 9 cubes and 6 beams of conventional concrete i.e. having Cement (C), Sand (S), and Natural Coarse Aggregates (NCA) are casted.

Then a proportion giving optimum values of strengths in stage stage-1 are taken for further research work in stage-2 and taking that proportion, NCA is replaced 10%, 20%, 30%, 40% by weight, by RCA. Hence a total of 6 batches are prepared and a total of 54 cubes and 36 beams are cast in stages 2.

A. Tests on aggregates

The following tests on aggregates were performed:

1) Impact Test

The aggregate impact test is carried out to evaluate the resistance to impact of aggregates. Aggregates passing 12.5 mm sieve and retained on 10 mm sieve is filled in a cylindrical steel cup of internal diameter 10.2 mm and depth 5 cm which is attached to a metal base of impact testing machine. The material is filled in 3 layers where each layer is tamped for 25 number of blows. Metal hammer of weight 13.5 to 14 Kg is arranged to drop with a free fall of 38.0 cm by vertical guides and the test specimen is subjected to 15 number of blows. The crushed aggregate can pass through 2.36 mm IS sieve. And the impact value is measured as

percentage of aggregates passing sieve to the total weight of the sample.

2) Shape Test

Flakiness Index: The flakiness index of aggregate is the percentage of the mass of the aggregates whose least dimension is less than 0.6 times the mean dimension. The flakiness test is applicable to aggregates of size larger than 6.3 mm.

Elongation Index: The elongation index of aggregates is the percentage by weight of the particles whose longest dimension (i.e. length) is greater than 1.8 times the mean dimension

3) Specific gravity and water absorption test

The specific gravity and water absorption of aggregates are important properties that are required for the design of concrete and bituminous mixes. The specific gravity of a solid is the ratio of its mass to that of an equal volume of distilled water at a specified temperature.

4) Sieve Analysis

Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregates. This is done by sieving the aggregates as per IS: 2386 (Part I) – 1963. In this we use different sieves as standardized by the IS code and then pass aggregates through them and thus collect different sized particles left over different sieves.

B. Tests on cement

The following tests on cement were performed:

1) Fineness Test

Fineness is nothing but the mean size of grains of cement. It is performed to measure the average size of cement grain. The finer the cement the more will be the surface area for hydration and hence more will be the strength of cement.

2) Consistency Test

Consistency test is performed to estimate the amount of water required to form a cement paste of normal consistency.

3) Setting Time Test

Cement has two types of setting time; one is initial setting time, and another is final setting.

Initial setting time of the cement is that state of cement when it starts to become stiff. Final setting time of the cement is that state when cement becomes fully non - workable.

4) Soundness Test

Soundness of cement is performed to check the volume change in cement after setting. Higher the changes in volume higher will be the cracks and other failure.

5) Strength Test

Compressive strength test of cement is performed on size 70.6*70.6*70.6 mm3 mold. Cement with higher compressive strength is better.

C. Construction of Concrete Mix

1) First Stage

Batch Mix Details for first stage test					
Batch	Cement (Kg)	Sand (Kg)	Aggregate (Kg)	Fly Ash (Kg)	Glass Powder (Kg)
Mix 01	16.7	16.7	33.42	***	***
Mix 02	12.5	16.7	33.42	4.18	***
Mix 03	12.5	16.7	33.42	3.34	0.84
Mix 04	12.5	16.7	33.42	2.5	1.68
Mix 05	12.5	16.7	33.42	1.68	2.5
Mix 06	12.5	16.7	33.42	0.84	3.34
Mix 07	12.5	16.7	33.42	***	4.18

2) Second Stage

Batch Mix Details for first stage test					
Batch	Cement (Kg)	Sand (Kg)	Aggregate (Kg)	Fly Ash (Kg)	Recycled aggregate
Mix 01	16.7	16.7	33.42	***	***
Mix 02	12.5	16.7	33.42	4.18	***
Mix 03	12.5	16.7	30.08	4.18	3.34
Mix 04	12.5	16.7	26.74	4.18	6.68
Mix 05	12.5	16.7	23.4	4.18	10.02
Mix 06	12.5	16.7	20.06	4.18	13.36

In this stage of work cement is partially replaced by FA & GP in different percentages as shown in the table below. 7 batches are prepared in different proportions including conventional concrete mix (Cement as binder, Sand as fine aggregates & Natural Coarse Aggregates). Cubes and beams are casted for determining compressive and flexural strengths respectively at 7, 14 and 28 days.

Results obtained from stage 1 are considered for stage 2. Proportions of the batch giving optimum values of Compressive Strength and Flexural Strength are taken for this stage of work. In the table below x, y & z are showing % of cement, FA & GP in stage 1 which is giving optimum results. In this stage NCA is partially replaced by RCA in different proportion as shown here. As stage-1, cubes and beams are casted for different proportions to determine compressive and flexural strengths respectively at 7, 14 and 28 days.

D. Tests on concrete

The following tests on aggregates were performed:

1) Slump Cone Test:

Concrete slump test or slump cone test is to determine the workability or consistency of concrete mix prepared at the laboratory or the construction site during the progress of the work. Concrete slump test is carried out from batch to batch to check the uniform quality of concrete during construction.

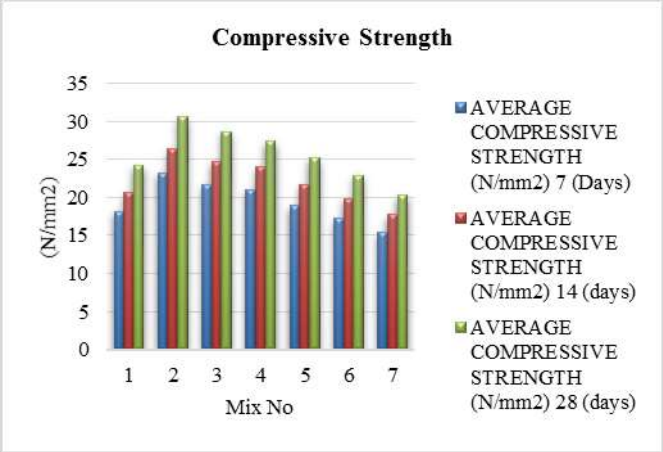
2) Compressive Strength Test:

- To determine the compressive strength and durability effects of concrete, 150 mm× 150 mm × 150 mm size concrete cubes were cast and tested in accordance with IS: 516-1959.
- All strength tests were conducted using 2000 kN compression testing machine. Cube moulds of size 150x150x150 mm were used

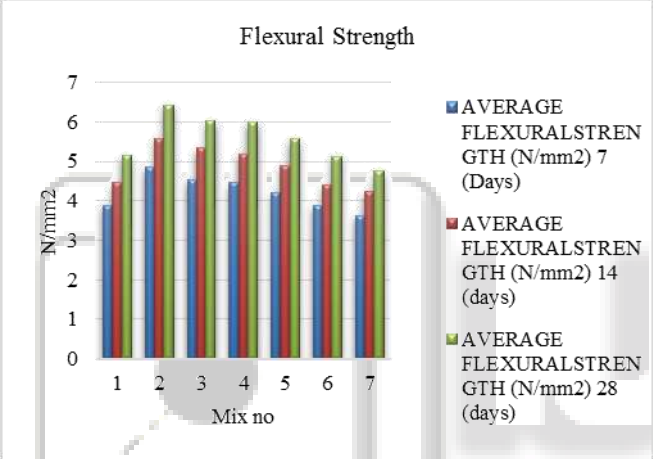
IV. TEST RESULTS

A. First Stage

1) Compressive Strength

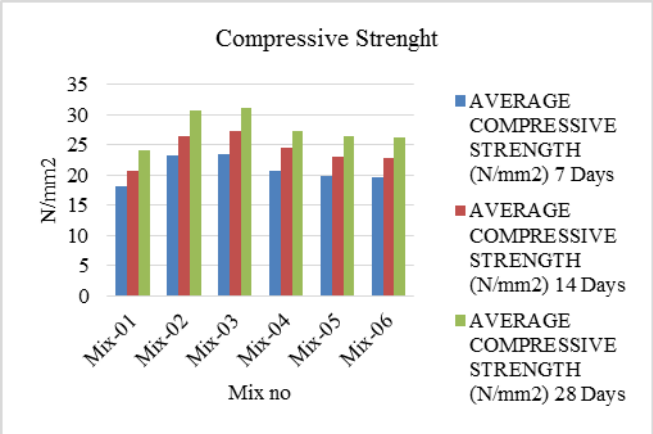


2) Flexural Strength

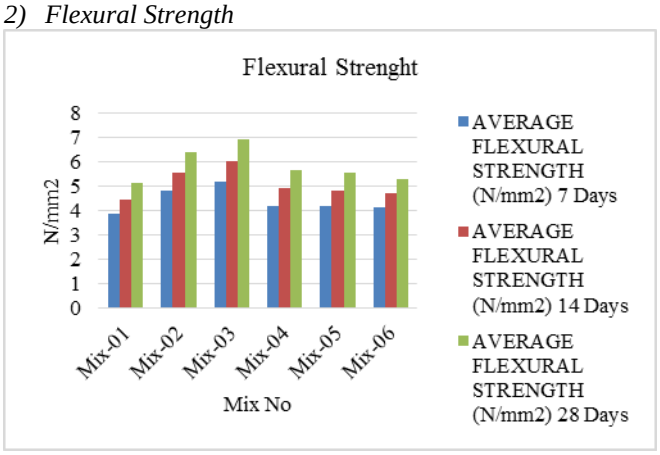


B. Second Stage

1) Compressive Strength



2) Flexural Strength



V. CONCLUSION

From the above graphs and previous discussion, the following conclusion is drawn: -

- The replacement of cement at an optimum percentage by Fly ash (25%), improved compressive and flexural strengths as compared to conventional concrete in stage 1.
- In stage 1, on decreasing percentage replacement of FA (25% to 0%) by increasing percentage replacement of glass powder (0% to 25%), a decreased strength is determined, i.e. When Glass Powder is used as a replacement material, strength of concrete gets reduced.
- When mixed proportion giving optimum strengths in stage-1 is considered for stage-2, 10% NCA replacement by RCA gives a higher strength value for both compressive and flexural.
- On increasing percentage replacement of RCA by replacing NCA, a continuous decrease in strength is investigated. It is shown, only 10% replacement of NCA by RCA gives increased strength properties.
- A maximum compressive and flexural strength is noted when 25% of cement is replaced by FA & 10% NCA are replaced by RCA for all 7 days, 14 days and 28 days curing period.
- The increase in flexural strength is more when compared with compressive strength with the replacement of conventional materials.
- It can be concluded from this dissertation work that FA can be used as a partial replacement of cement and RCA can be used as a partial replacement of NCA up to an optimum value. Glass Powder is not that useful as far as the replacement of cement is concerned. A more detailed study can be carried out to discuss the use of concrete having such materials in the future.

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