Assessment of Properties of Concrete with Partial Replacement of Various Constituents

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Abstract:- Preservation of environment and conservation of natural resources is the essence of any development. Also the present R and D continuously are dealing with technological and industrial development on waste management. In order to address environmental effects associated with cement manufacturing, it is crucial to advance alternative binders to compose concrete. Consequently extensive delving is continuing, on substitution of cement by differing waste materials and industrial offshoot. As partial replacement of cement and/or aggregate attempts on fly ash, demolished concrete, waste glass, rice husk etc. have already been accomplished in concrete industries. If few waste materials found convenient and economical for concrete manufacturing, a major gain will be achieved in disposal of waste management and depression in construction cost. The work audits the feasibility of fly ash, glass powder and demolished concrete as partial substitute of cement and natural coarse aggregate respectively. For this intent, procedure is partitioned into two stages. The initial stage proceeds with replacing 25% cement content by variant proportions of fly ash (FA) and glass powder (GP). Further tested for compressive and flexural strength, at 7 days, 14 days & 28 days and correlated with conventional concrete. The adequate results were attained with the combination of cement 75% and fly ash 25% in ratio, w.r.t properties tested. In second stage, same optimum ratio of cement and fly ash is added with partly replaced natural coarse aggregate (NCA) with recycled concrete aggregate (RCA) in concrete. For test intent, recycled aggregates were accessed from crushed concrete cubes of grade M25 in laboratory. Variant composition of natural coarse aggregate and recycled aggregate adopted and test samples from this matrix were prepared for the same test as mentioned above. Observations reveal, combination of 90% NCA and 10% RCA in ratio, leads to adequate results.

Keywords:- Compressive Strength, Flexural Strength, Fly Ash (FA), Glass Powder (GP), Natural Coarse Aggregates (NCA), Recycled Concrete Aggregates (RCA)

I. INTRODUCTION

During recent years the consciousness regarding environmental atrocity has increased as a result the interest of 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 seen as opportunities. The waste glass pieces from the shops are disposed off as waste material but glass being an inert substance can be recycled without any chemical reaction. The fly ash is produced in abundance in the thermal power plants as abate product which is not easy to be disposed off and is dangerous to the environment. Recycled concrete aggregate is produced by crushing concrete to reclaim the aggregate. Recycled aggregate can be used for many purposes. The primary market is road base for information on recycling asphalt pavement into new asphalt pavement. Aggregate resulting from the processing of inorganic material previously used in construction and principally comprising crushed concrete washed and graded for use as an aggregate in the production of further concrete. The project includes utilization of cement which may be partially replaced by fly ash and Glass Powder. In the 1st phase of work in 7 batches of different proportions of binders have been readied and cubes and beams have been casted. Outcomes acquired were analyzed and proportions that provide optimum values have been taken for the next stage. In second stage of work, Natural Aggregates have been partially replaced by Recycled Concrete Aggregates. Furthermore 5 batches have been prepared and results will be investigated.

II. EXPERIMENTAL WORK

2.1 Material Used:

The materials used for this work is cement (C), sand (S), fly ash (FA), glass powder (GP), natural coarse aggregates (NCA) & recycled concrete aggregates (RCA). Potable water was used for getting concrete mix. FA was collected from thermal plant near Khandwa, MP. Broken glass pieces were collected from local source and

then were crushed to get powder. Sieve analysis was conducted on GP to obtain particle size equivalent to cement. Demolished concrete was collected from laboratory and then broken into small pieces to get 20 mm to 25 mm size aggregates (RCA). Some of the physical properties were obtained in the laboratory of the materials are given in table 1.

Table 1: Properties of material

Properties	Value
Cement	
Initial Setting Time	35 Min
Final Setting Time	585 Min
Sand	
Silt Content	7.2 %
Aggregates	
Impact value	15.15
Flakiness Index	37.83
Elongation Index	30.86

2.2 Problem Formulation

Stage-1 of work:

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. (refer Table 2)

Table 2: Formulation of work (Stage-1)

Batch Mix	***Cement (%)***	***FA (%)***	***GP (%)***	***Sand (%)***	***Natural Coarse Aggregates (%)***
1	100	--	--	100	100
2	75	25	00	100	100
3	75	20	05	100	100
4	75	15	10	100	100
5	75	10	15	100	100
6	75	05	20	100	100
7	75	00	25	100	100

Stage-2 of work:

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.

Table 3: Formulation of work (Stage-1)

Batch Mix	*Cement (%)*	*Fly Ash (%)*	*Glass Powder (%)*	*Sand (%)*	*Natural Coarse Aggregate (%)*	*Recycle Concrete Aggregate (%)*
Batch Mix -1	100	0	0	100	100	0
Batch Mix -2	75	25	0	100	100	0
Batch Mix -3	75	25	0	100	90	10
Batch Mix -4	75	25	0	100	80	20
Batch Mix -5	75	25	0	100	70	30
Batch Mix -6	75	25	0	100	60	40

III. TEST CONDUCTED & RESULTS

Compressive Strength

Nine cubes are casted in each batch mix for determining compressive strength. Tests are performed at the age of 7 days, 14 days and 28 days of the specimens. Specimens are placed in the test machine as per IS: 516-1959 clause no 5.5.1 page no 11, also loading is applied on the specimen as per the same IS code.

Calculation are made by dividing the maximum applied load by the cross sectional area of the specimen. As there are three specimens for each batch mix, the average of the three values is taken.

Table 4: Compressive Strength Result (Stage 1)

S.N.	Combination	Compressive Strength (N/mm^2) at		
		7 Days	14 Days	28 days
Mix-01	C+S+NCA	18.17	20.63	24.13
Mix-02	75%C+S+NCA+ 25%FA+0%GP	23.20	26.40	30.61
Mix-03	75%C+S+NCA+ 20%FA+5%GP	21.74	24.72	28.67
Mix-04	75%C+S+NCA+ 15%FA+10%GP	21.08	24.03	27.36
Mix-05	75%C+S+NCA+ 10%FA+15%GP	18.91	21.75	25.16
Mix-06	75%C+S+NCA+ 5%FA+20%GP	17.23	19.87	22.86
Mix-07	75%C+S+NCA+ 0%FA+25%GP	15.36	17.71	20.32

Table 5: Compressive Strength Result (Stage 2)

S.N.	Combination	Compressive Strength (N/mm^2) at		
		7 Days	14 Days	28 days
Mix-01	C+S+NCA	18.17	20.63	24.13
Mix-02	75%C+S+25%FA+ 0%GP+100%NCA	23.20	26.40	30.61
Mix-03	75%C+S+25%FA+ 0%GP+90%NCA+10 %RCA	23.49	27.36	31.02
Mix-04	75%C+S+25%FA+ 0%GP+80%NCA+20 %RCA	20.58	24.51	27.36

Mix-05	75%C+S+25%FA+ 0%GP+70%NCA+30 %RCA	19.91	23.02	26.52
Mix-06	75%C+S+25%FA+ 0%GP+60%NCA+40 %RCA	19.68	22.74	26.24

Flexural Strength

Beams of size 10cm × 10cm × 50cm are casted for determining flexural strength. Test on beams are performed at the age of 7 days, 14 days & 28 days of the specimen. Placement of specimen in machine is done as per IS: 516-1959 in the clause no 8.3.1 page no 17. Load is applied at increasing rate of 1.8KN/min. Load is applied until specimen fails and load at which specimen fails is recorded. As specified in the IS code flexural strength is calculated and tabulated below:-

Table 6: Flexural Strength Result (Stage 1)

S.N.	Combination	Flexural Strength (N/mm^2) at		
		7 Days	14 Days	28 days
Mix-01	C+S+NCA	3.88	4.45	5.14
Mix-02	75%C+S+NCA+ 25%FA+0%GP	4.85	5.58	6.46
Mix-03	75%C+S+NCA+ 20%FA+5%GP	4.53	5.34	6.02
Mix-04	75%C+S+NCA+ 15%FA+10%GP	4.46	5.19	5.98
Mix-05	75%C+S+NCA+ 10%FA+15%GP	4.21	4.89	5.57
Mix-06	75%C+S+NCA+ 5%FA+20%GP	3.88	4.41	5.13
Mix-07	75%C+S+NCA+ 0%FA+25%GP	3.62	4.23	4.75

Table 7: Flexural Strength Result (Stage 2)

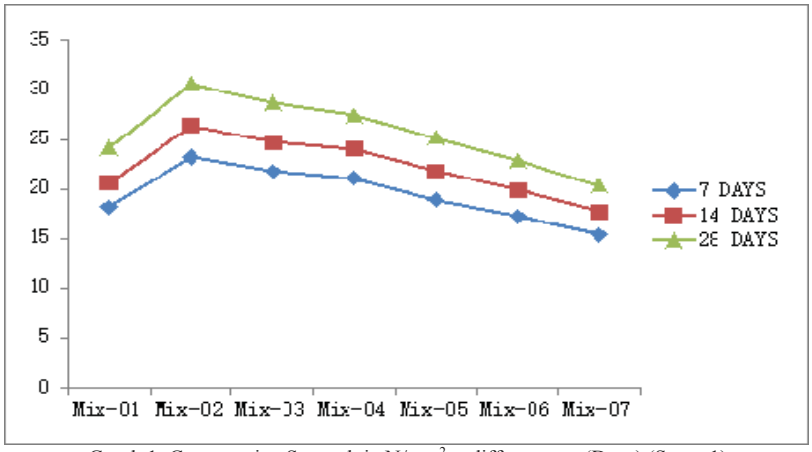
S.N.	Combination	Flexural Strength (N/mm^2) at		
		7 Days	14 Days	28 days
Mix-01	C+S+NCA	3.88	4.45	5.14
Mix-02	75%C+S+25%FA+ 0%GP+100%NCA	4.85	5.58	6.43
Mix-03	75%C+S+25%FA+ 0%GP+90%NCA+10 %RCA	5.17	6.03	6.93
Mix-04	75%C+S+25%FA+ 0%GP+80%NCA+20 %RCA	4.22	4.92	5.65
Mix-05	75%C+S+25%FA+ 0%GP+70%NCA+30 %RCA	4.18	4.83	5.57
Mix-06	75%C+S+25%FA+ 0%GP+60%NCA+40 %RCA	4.12	4.74	5.32

IV. DISCUSSION

Compressive Strength:

Stage 1: Partial replacement of cement by FA & GP

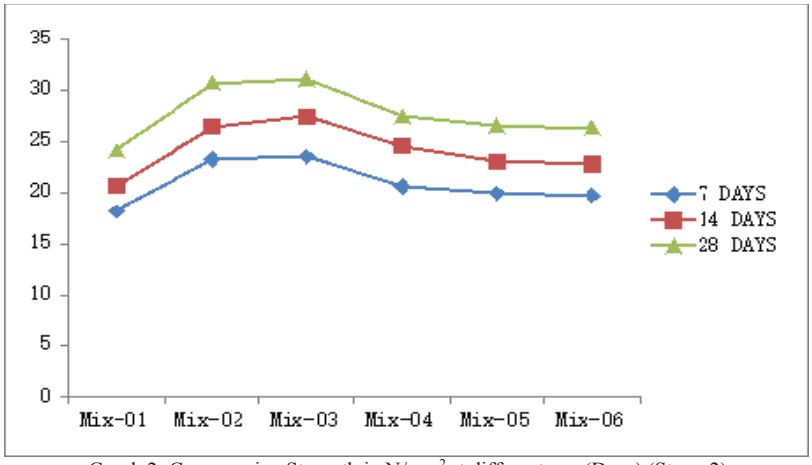
Graph 1 shows compressive strength for stage 1 at 7, 14 & 28 days curing period. It shows, compressive strength of Mix-02 when 25% cement is replaced by FA, a maximum value is achieved at all the three ages of concrete i.e. for 7, 14 & 28 days. An increment of about 27% was found when compared with conventional concrete. On further replacement of cement by increasing percentage of GP and decreasing FA, a decreased strength was observed.



Graph 1: Compressive Strength in N/mm^2 at different age (Days) (Stage-1)

Stage 2: Partial replacement of NCA by RCA

Here, graph 2 is showing compressive strength for stage 2 at same 7, 14 & 28 days of curing. When analyzed, strength of Mix-03 when 10% NCA was replaced by RCA an approximately 29% of strength increased when compared with conventional mix, which is more(2%) than optimum results of stage 1. Also, on further increment of RCA, strength decrement was observed.

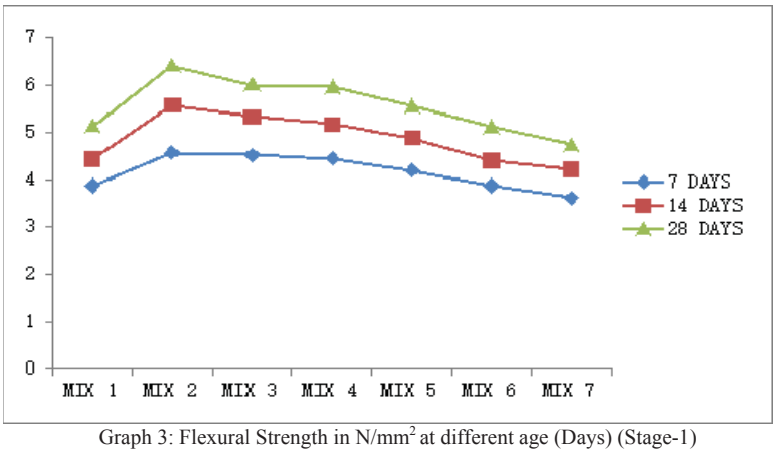


Graph 2: Compressive Strength in N/mm^2 at different age (Days) (Stage-2)

Flexural Strength:

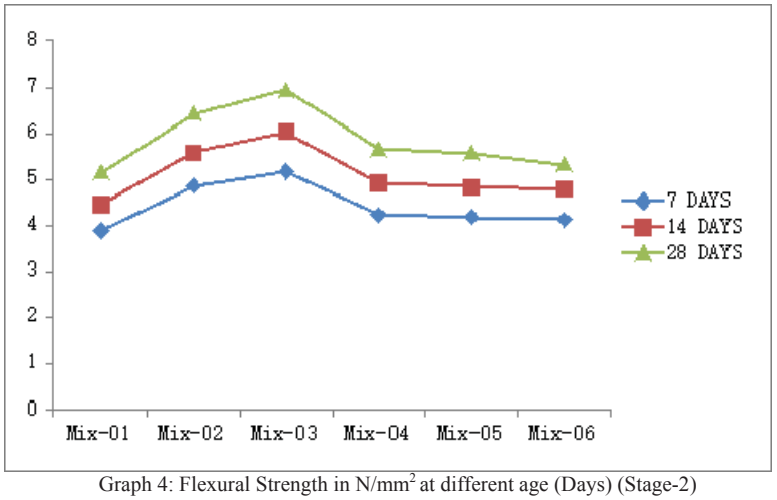
Stage 1: Partial replacement of cement by FA & GP

In graph 3 flexural strength is shown for stage 1 at all three curing ages i.e. 7, 14 & 28 days. In stage 1 when cement is 25% replaced by FA, a maximum flexural strength was achieved for mix-02. The increment that was observed was 25% as compared to conventional concrete mix. For flexural too, on increasing percentage of GP by decreasing FA, a decreased strength was observed.



Graph 3: Flexural Strength in N/mm^2 at different age (Days) (Stage-1)

For stage 2 flexural strength, graph 4 is plotted which shows, there is an improved flexural strength is obtained. For mix-03 when 10% NCA was replaced by RCA, optimum strength was achieved. It was even more than maximum strength of stage 1. On further replacement of NCA by RCA decreased strength significantly.

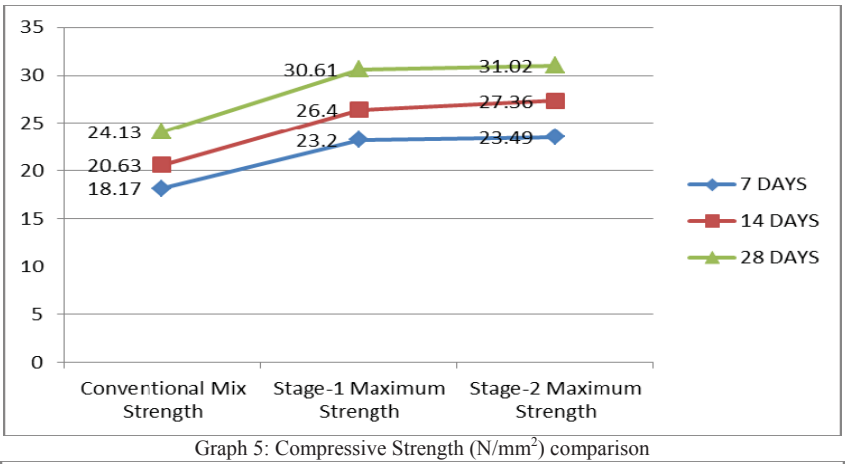


Graph 4: Flexural Strength in N/mm^2 at different age (Days) (Stage-2)

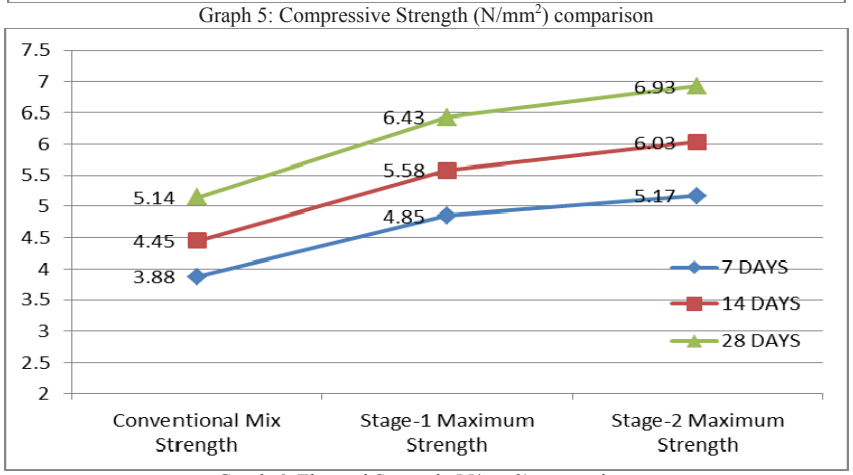
V. CONCLUSION

Based on the discussion and from graph 5 & graph 6, this research work can be concluded as:

- The replacement of cement at an optimum percentage by FA (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 GP (0% to 25%), a decreased strength is determined, i.e. When GP is used as a replacement material, the strength of concrete gets reduced.
- When mix proportion giving optimum strengths in stage-1 is considered for stage-2, 10% NCA replacement by RCA gives a higher strength values for both compressive and flexural.
- On increasing percentage replacement of RCA by replacing NCA, a continuous decrease in strength is investigated. It shown, only 10% replacement of NCA by RCA gives increased strength properties.
- A maximum compressive and flexural strength is noted when 25% 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 replacement of conventional materials.
- It was also observed that up to 10 % and 15 % replacement of cement by FA and GP respectively, investigated strengths were more than strengths of conventional concrete, hence depending upon availability of FA and GP, up to 10 % FA and 15 % GP can be used in place of cement without compromising strength.



Graph 5: Compressive Strength (N/mm^2) comparison



Graph 6: Flexural Strength (N/mm2) comparison

It can be concluded from this research work that FA can be used as a partial replacement of cement and RCA can be used as a partial replacement of NCA upto an optimum values. GP is not that useful as far as replacement of cement is concerned. A more detailed study can be carried out to discuss use of concrete having such materials in future.

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