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EXPERIMENTAL INVESTIGATION ON SELF CURING RECYCLED AGGREGATE CONCRETE MEMBERS

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Self-curing concrete is an important aspect in strength development, which is neglected due to various reasons such as shortage of water, inaccessibility of structures during curing. Self-curing agents play important role in heat of hydration and strength development. The present study involves the use of self-curing agent polyethylene glycol (PEG 6000). In this investigation, M20 to M50 grade concrete has been considered to evaluate strength characteristics and flexural behavior using natural and recycled aggregate concrete. The various percentages of PEG 6000 have been used. The test result indicates self-curing concrete has indicated strength enhancement compared to conventional curing concrete. The strength for normal coarse aggregate concrete with a self-curing agent (PEG 6000) at 2% with 10% GGBS is decreased when compared with recycled coarse aggregate concrete with 1% (PEG 6000) with addition 10% GGBS. Mechanical properties are 7% to 20% higher for self-curing concrete when compared to natural concrete. Similarly, the flexural strength of normal coarse aggregate concrete was found to be varying from 4% to 16% more than with recycled coarse aggregate concrete at 28 days. Ultimate deflection of RC beams is 10% greater than the NC beams and ultimate moments of RC beams were 1% to 3% less than the corresponding NC beams. The moment-curvature relationship and load-deflection characteristics of the NC beams and RC beams show a similar trend.

Keywords: PEG 6000, GGBS, Recycled coarse aggregate, Moment-curvature, Deflection.

1 INTRODUCTION

Curing is the process of controlling the rate and extent of moisture transport from concrete during cement hydration. It may be either or after it has been placed in position thereby providing time for the hydration of the cement to occur. Since the hydration of cement does take time in days and even weeks thus curing must be undertaken for a reasonable period of time in order to concrete achieve potential strength and durability. Curing may also encompass the control of temperature since this affects the rate at which cement hydrates. The curing period may depend on the properties concrete, the purpose for which it is used and ambient conditions, i.e. the temperature and relative humidity of the surrounding atmosphere. Curing is designed primarily to keep the concrete moist, by preventing the loss of internal moisture during the period in which it gains strength. Curing of concrete shall be maintained satisfactorily during its early stages in order to develop the desired properties.

2 NEED FOR THE PRESENT STUDY

A self-curing concrete is provided to absorb water from the atmosphere to achieve better hydration of cement in concrete. It solves the problem that the degree of cement hydration is lowered due to no curing or improper curing. It is now widely accepted that there is a significant potential for reclaiming and recycling demolished debris for use in value-added applications to maximize economic and environmental benefits.

3 OBJECTIVES

- To determine the mechanical properties of natural coarse aggregate and recycled coarse aggregate with self-curing concrete
- To study the flexural behavior of self-curing concrete of RC beams and comparing with NC beams.

4 LITERATURE REVIEW

El Dieb (2007) has investigated to find out the water retention capacity and degree of hydration and moisture transport by using a self-curing agent and compared to conventional curing concrete. El Dieb *et al.* (2012) carried out a research on synthesized water-soluble polymers viz., polyethylene glycol (PEG) and polyacrylamide (PAM) as self-curing agents and its effect on the degree of hydration, water absorption, permeable pores and microstructural characteristics of Portland cement mixtures without and with 8% silica fume replacement. Kumar *et al*. (2012) carried out of a research on the mechanical characteristics of concrete such as compressive strength, splitting tensile strength and modulus of rupture by varying the percentage of PEG from 0% to 2% by weight of cement for both M20 and M40 grades of concrete. Kholia *et al. (*2013) carried out a research on the working and efficiency of curing methods, which are generally adopted in the construction industry and compared with the conventional water curing method. Laboratory tests show that concrete in a dry environment can lose as much as 50 percent of its potential strength compared to moist cured. Evangeline (2014) carried out a research on specific water-soluble chemicals such as Polyvinyl alcohol added during the mixing which can reduce water evaporation from and within the set concrete, making it "self-curing‟.

5 EXPERIMENTAL WORK

The materials used in the investigation are cement, fine and coarse aggregate, recycled coarse aggregate, Polyethylene glycol (PEG 6000), Ground granulated blast furnace slag (GGBS). Polyethylene glycol is a condensation polymer of ethylene oxide and water with the general formula H(OCH2CH2)n OH. For obtaining mechanical properties, cubes of 150 mm x 150 mm x 150 mm, cylinders 150 mm diameter x 300 mm length and prisms 100 mm x 100 mm x 500 mm were cast. For flexural behavior reinforced concrete beams 150 mm x 230mm x 1500 mm size has been adopted. The properties of recycled aggregate and PEG 6000 are presented in Table 1 and Table 2 respectively. Properties of GGBS are presented in Table 3 and Table 4. The reinforcement details of beams used for flexural analysis shown in Table 5. The compressive and tensile strains are recorded and these strains are used to plot strain diagram, which is used to find the depth of neutral axis, which is further used for calculation of curvature.

Table 1. Physical properties of recycled coarse aggregate.

S.No.	Specification	Value
1	Fineness modulus	1.37
2	Bulk density (kg/ m^3)	1325
3	Specific gravity	2.3

Table 2. Properties of PEG 6000.

S.No.	Specification	Value
1	Molecular weight	5500-6500
2	Appearance	white flake
3	Colour, Boha	10 max
4	Moisture	0.5% max
5	Hydroxyl Value	16-23 (mg KOH/g)
6	PH	5 – 7
7	Specific Gravity	1.08 - 1.09
8	Dioxane	1ppm max

Table 3. Physical properties of ground granulated blast furnace slag (GGBS).

S.No	Description	Value
1	Color	Off white
2	Specific gravity	3.15
3	Fineness (m^2/kg)	420
4	Glass Content (%)	75

Table 4. Chemical Composition of GGBS.

S.No	Description	Mass (%)
1	Loss of Ignition	2.6
2	Calcium, CaO	42.5
3	Silica, SiO_2	34.4
4	Alumina, Al_2O_3	12.9
5	Iron, Fe_2O_3	1.12
6	Magnesium, MgO	4.87
7	Sodium, Na_2O	0.45
8	Sulphur, SO_3	3.10
9	Potassium, K_2O	0.66

Table 5. Reinforcement details of the test specimens.

S.No	Beam Designation	Grade of Concrete	Reinforcement Provided		Spacing of stirrups
			Tension zone	Compression zone	
1	NC-M20	M20	2No's -12ø	2No's-8ø	8mm @130mm c/c
2	RC-M20	M20	2No's -12ø	2No's-8ø	8mm @130mm c/c
3	NC-M30	M30	2No's-16ø	2No's-8ø	8mm @130mm c/c
4	RC-M30	M30	2No's-16ø	2No's-8ø	8mm @130mm c/c
5	NC-M40	M40	4No's-12ø	4No's-8ø	8mm @130mm c/c

6 RESULTS AND DISCUSSIONS

6.1 Workability

Series of tests were carried out on normal coarse aggregate (NC) and recycled coarse aggregate (RC) specimens of M20, M30, M40, and M50 concrete grade mixes. Slump values of recycled aggregate concrete are low compared to that of natural aggregate concrete due to high water absorption of recycled aggregate concrete. As per test result, the highest slump obtained was 140mm for NC mix and the lowest slump was 30mm for RC mix and the average slump for each batch of the mix was 84mm. Thus, target slump of 50mm to 120 mm has been achieved. It was found that M20, M30, M40 concrete grade with natural aggregate show medium workability and whereas M50 grade of concrete indicates low workability because of increase in water cement ratio. On the other hand, low workability has obtained for M20 and M30 grade concrete of recycled aggregate and for M40 and M50 even very low. This is because of the high water absorption capacity of recycled aggregate.

6.2 Mechanical properties

The test results of compressive strength for NC and RC are presented in Table 6. The compressive strength of the recycled aggregate concrete is 2.5% lesser than the normal aggregate concrete for all mixes. Further, it is found that for NC-M20, NC-M30, NC-M40 and NC-M50 grade concretes has an average splitting tensile strength of 2.25MPa, 3.5MPa, 3.78MPa, and 4.9MPa respectively. Average Flexural strengths for NC-M20, NC-M30, NC-M40 and NC-M50 grade concrete obtained as 4.24MPa, 4.84MPa, 5.58MPa, and 6.07MPa respectively. Similarly, for RC-M20, RC-M30, RC-M40 and RC-M50 grade concretes has an average flexural strength of 3.93MPa, 4.15MPa, 5.1MPa, and 5.8MPa respectively.

Table 6. Compressive strength (N/mm^2).

S.No.	Grade of concrete	Natural aggregate (NC)	Recycled aggregate (RC)
1	M20	34.33	32.79
2	M30	43.45	42.27
3	M40	52.27	51.33
4	M50	62.59	62.17

6.3 Flexural Behavior of Beams

The ultimate failure load and deflections were obtained and presented in Table 7 and Table 8. It was observed that the ultimate failure load of recycled aggregate beams were lesser than that of the natural aggregate beams. Also, the ultimate deflection of the recycled aggregate beams is more than the natural aggregate beams. Strain characteristics was found to be same for self-curing concrete of normal aggregate and recycled aggregate for all the mixes of grades M20, M30, M40 and M50 respectively and the moment resistance of beams of normal aggregate concrete is found to be 3% to 8% more than the recycled aggregate concrete for all the mixes.

Table 7. Ultimate carrying capacity (kN).

S.No.	Grade of concrete	Natural aggregate (NC)	Recycled aggregate (RC)
1	M20	167.64	162.56
2	M30	243.84	238.70
3	M40	269.24	248.92
4	M50	330.20	264.16

Table 8. Deflections (mm).

S.No.	Grade of concrete	Natural aggregate (NC)	Recycled aggregate (RC)
1	M20	6.70	7.20
2	M30	7.40	8.30
3	M40	7.45	8.40
4	M50	7.93	7.95

6.4 Moment Curvature Relation of Self-Curing Concrete of NC (Mix-A) and RC (Mix-B)

In the experimental investigation, the moment corresponding to every incremental load was computed using the solid mechanics principle, for all 8-mix cases. Deformations at the level of compression fibers and tension fibers were recorded through dial gauges corresponding to various load increments. These observations were recorded as mean values of the corresponding deformation measured for two beams. The data of strain measurements were then used to plot moment curvature graphs. With reference to these tables, the moment of resistance was found to be 3% more for NC-M20, 2% more for NC-M30, 8% more for NC-M40 and 25% more for NC-M50 respectively.

7 CONCLUSIONS

- The compressive strength was approximately 1% to 4% more for self-curing concrete of normal aggregate concrete compared to recycled aggregate concrete for mixes M20, M30, M40 and M50 respectively.
- The splitting tensile strength was approximately 7% to 20% more for self-curing concrete of normal aggregate concrete compared to recycled aggregate concrete for the mixes considered above.
- The flexural strength approximately observed to be 4% to 16% is more for self-curing concrete compared to recycled coarse aggregate for the mixes indicated above.
- The Ultimate deflections of RC-beams resulted 7% to 12% greater for self-curing concrete when compared normal coarse aggregate for the same mixes.
- The moment of resistance of beam for normal aggregate concrete is found to be 3% to 8% more than the recycled aggregate concrete for all the mixes.

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