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Performance Evaluation of Internally Cured High Performance Concrete

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Abstract: ***Internal curing has been rapidly emerging over the last decade as an effective way to improve the performance of concrete. Internal curing uses saturated lightweight aggregate to supply 'curing water' to low w/c pastes as they hydrate. These prewetted lightweight aggregates stores water in it and act as reservoirs which will be able to release the water whenever the concrete requires. In this research paper Fly ash based light weight aggregates has been used in partial replacement of coarse aggregates in 10%, 15%, 20%, 25%.The study was extended to prove that using prewetted lightweight aggregates can aid in reduction of curing periods .By using 20% of light weight aggregate as a partial replacement to natural coarse aggregates the compressive strength is promising. This study also deals with testing of internally cured concrete to meet standards that it would ever need to face.***

Keywords: Curing Periods, High Performance Concrete Internally Cured Concrete, Low W/C Pastes, Prewetted Lightweight Aggregates

1. Introduction

Internal curing refers to the process where increased hydration of cement occurs because of the availability of additional internal water that is not part of the mixing water. Typically concrete has been cured from the outside in; IC is curing from the inside out. Internal water is supplied via internal reservoirs found in prewetted lightweight aggregates. Time dependant improvement in the quality of containing fly ash based light weight aggregates is greater than with normal weight aggregates. The reason is better hydration of the cementious materials provided by moisture available from the slowly released reservoir of absorbed water within the pores of light weight aggregates.

The research investigated the impact of internal curing on service life of High performance concrete (HPC) by undergoing a comparative study of Normal concrete and internally cured HPC. The objective of study was to;

- To evaluate a baseline HPC
- The effect of variation in strength parameters i.e., Compressive strength, is studied for different dosage of self curing agent (10% –25% weight of coarse aggregates) and compared with that of conventional cured concrete.
- The compressive strength variation of internally cured as well as conventional concrete, on reducing the curing period.

2. Materials

- Cement: The Ordinary Portland Cement of 43 grades conforming to IS 8011:1989 is used. The various tests were performed for the cement. The specific gravity of cement was found to be 3.2.The percentage by weight of water with respect to cement to produce standard consistency is 33%.Initial Setting Time and final setting time was 1Hour and 6 Hour respectively.
- Fine Aggregate: The river sand conforming to the requirements of IS: 383 – 1970 is used as fine aggregate. A property of sand was specific gravity of 2.65, and water absorption of 1.14%.
- Coarse Aggregate (CA): The fractions from 20 mm to 4.75 mm are used as coarse aggregate, conforming to IS: 383 was used.
- Water: Ordinary potable water without acidity and alkaniety available in the laboratory is to be used.
- Lightweight aggregate (LA): supplied by Jindal powers, Gujarat conforming to IS:9142-1979, shown in figure 1.
- .Super Plasticizer: Suploflo PC 711, suppliers- Don chemicals, kochi .Technical properties as provided by the company are:
- Colour: yellowish liquid
- Specific gravity: 1.18
- Chloride content: nil
- Suploflo PC 711 complies with ASTM C 494 Type G and IS 9103: 1999.

Table 1: Comparative study of normal aggregate and light weight aggregates

	Properties	CA	LA
1	Shape	Angular	Spherical
2	Specific Gravity	2.89	1.3
3	Bulk Density(kg/m^3	1685	890
4	Crushing Value (%)	20%	48.5%

Table 2: Properties of normal aggregates with 10- 25% replacement with light weight aggregates

Material	Crushing Value (%)	Impact Factor (%)	Abrasion Value (%)
NORMAL	22.5	44.6	49.5
10:90	28.2	53.6	53.43
15:85	26	48.1	50.76
20:80	24.9	44.5	48.43
25:75	19.6	42.1	32.6

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From Table 1 it can be inferred that the shape and texture of aggregate affects the properties of fresh concrete more than hardened concrete. Concrete is more workable when smooth and rounded aggregate is used instead of rough angular or elongated aggregate. Low density of LCA helps in reduction of dead load lowers the handling cost. Table 2 indicates that

replacement of 25% doesn't comes under is code stipulation of crushing value not exceeding 30%, and impact value in between 30%-45%, and abrasion value within limit of 30%-50% range.

Figure 1: light weight aggregate

3. Mix Design

Using the properties of materials as listed above the mix design has been adopted from IS 10262:2009 to design for M40 grade of concrete**.**

As per the design, the mix proportion is 1:1.63:3.02, with super plasticizer added at 0.75% of cement content. Table 3 gives slump and compaction values on adding varying % of super plasticizers.

Table 3: Slump and Compaction Value

Mix Design	W/C Ratio	% of Plasticizer	Slump	Compaction Value
S1	0.36	0	29	0.87
S2	0.36	0.3	42	0.89
S3	0.36	0.6	71	0.92
S4	0.36	0.75	95	0.96
S5	0.36	0.9	120	1.03
S6	0.36	1	143	1.12

4. Casting of Specimens

The Concrete Cubes (control specimens) of size 15cm x 15cm x 15cm were cast by using conventional fine. Aggregate (FA) and conventional coarse aggregate (CA). The specimens were demoulded after 1 day and immersed in water for 3, 7, 14, 21, 28, for curing.

Similarly concrete cubes are casted by partially replacing convential coarse aggregates by flyash based light weight aggregates.

Mix 1 – 0% la
Mix 2 - 10% LA
Mix 3 - 15% LA
Mix 4 - 20% LA
Mix 5 - 25% LA
Mix 6- 20% Dry LA

Figure 2: Casted Specimens

5. Results and Discussions

The compressive strength of the cylinders was measured at 7, 28 days and calculated as an average of three cylinders for each age as given in Table 4. Initially the internally cured concrete showed a lower compressive strength, but later the strength of the concrete increased and exceeded the plain concrete. Even though light weight aggregates prove to be weaker than normal aggregates, because of its internal curing property, the compressive strength prove to be greater than that of conventional concrete.

By using 20% of light weight aggregate as a partial replacement to natural coarse aggregates the compressive strength is promising. The effect of adding lightweight aggregate does not significantly decrease strength of any one mix.

The density of concrete is found to decrease with the increase in percentage replacement of natural aggregate by light weight aggregate.

The compressive strength of concrete is found to decrease with the increase in LCA beyond 20% content. The compressive strength obtained by using light weight aggregates not being prewetted is much below the target mean strength of M40 grade cement.

Table 4: Compressive Strength Results

Mix Designation	Compressive Strength (N/mm^2)	
	7 days	28 days
Mix 1	38.07	52.1
Mix 2	37.4	55.1
Mix 3	37.9	56
Mix 4	38.9	59.4
Mix 5	38.3	58.72
Mix 6	31.74	47.2

The test is extended to testing different mix proportions of concrete at various curing conditions like curing in air the entire time, curing only for 3day, 7days, 14days, and 28days in water. The compressive strength is being tested at the 28^{th} day for all the specimens. so as to draw conclusion that internal curing enables to reduce the curing period.

From results its clear, mix 7 (20% LA: 80 % CA), obtained a strength nearby to mean target strength by 7 days of curing in water, and at by 14days of curing, the strength at 28^{th} day of testing exceeded strength of control mix cured in water for 28days as in shown in table 5 and figure 3.

Hence we can draw the conclusion that internal curing helps in reduction of curing period from 28days to 7 days.

Table 5: Compressive Strength Results with Reduction in Number of Days of curing

MIX Designation	Curing period in days	Compressive Strength at 28th Day of Testing (N/mm²)				
		In air entire time	In air after 3days	In air after 7days	In air after 14 days	Moist cured entire time
Mix 1		21.92	27.8	40.84	43.2	52.1
Mix 2		27.55	33.02	44.08	49.4	55.1
Mix 3		28.6	36.4	45.6	53.2	56
Mix 4		30.7	38.8	48.8	55.9	59.4
Mix 5		30.3	36.23	47.1	54.2	58.72

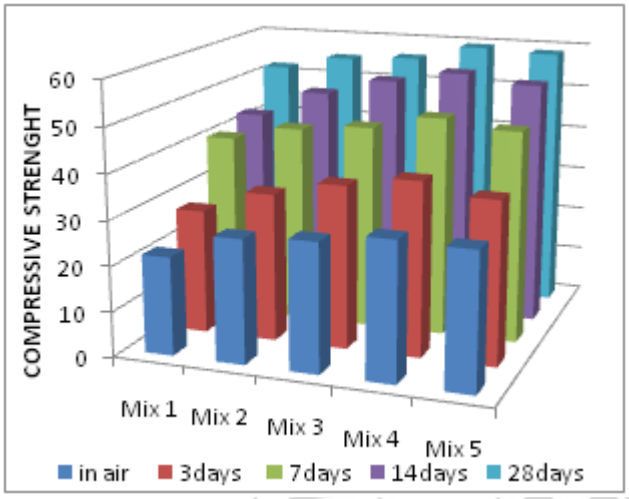

Figure 3: Compressive Strength Results with Reduction in Number of Days of curing.

6. Conclusion

Internal curing is not a substitute for external curing. As a minimum, evaporative moisture loss (after set) must be prevented using conventional external measures. It can be concluded that optimum partial replacement of coarse aggregate is 20%, for the economical mix of concrete. Disposal of flyash has become a vast problem; hence usage of flyash based Light weight aggregates gives a better solution for waste management problem.

From results it's clear, mix 7(20% LA: 80 % CA), obtained a strength nearby to mean target strength by 7 days of curing. Hence the curing period can be reduced to 7days. Above all wastage of water as well as time of building constructions can be reduced.

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