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Internal Curing of Concrete using Pre wetted Light Weight Aggregates

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Abstract - The use of lightweight aggregates to supply a source of internal curing for Low Cracking, High Performance Concrete is evaluated. Applying water externally to the concrete is the conventional approach for curing. In practice conventional type of curing is difficult to perform as it shall need curing membrane and also large amount of water is wasted due to evaporation and runoff. Concrete curing is of paramount importance in order for concrete to meet performance requirements. Conventionally, curing has been conducted by means of water sparkling, wet burlap or a curing compound. For performance and environmental reasons, internal curing has been gaining increased attention. However, more data is needed for the effectiveness of this curing technique when used in various concrete mixtures. Light weight aggregates such as expanded shale or clay is used for internal curing of concrete. The major advantages in internally cured concrete are, the concrete is light weight, free from shrinkage cracks, 3-dimensional curing, and limited use of water. In this study, expanded clay has been used in replacement for coarse aggregates in 0%, 5%, 10%, 15%, 20% and 25 %.

Key Words: Internal curing, Light weight aggregate, expanded clay.

1. INTRODUCTION

Internal curing provides a set of water-filled reservoirs within the concrete that supply water on demand to the hydrating cement paste from the time of mixing (i.e., for reducing plastic shrinkage and maintaining workability) until the time when moisture equilibrium is achieved between the reservoirs and the surrounding cement paste for reducing dry shrinkage. Internal curing is achieved by replacing a percentage of coarse aggregate with light weight aggregate such as expanded clay. Curing has a strong influence on hardened concrete; adequate curing will aid achieving desired durability, strength, water tightness, abrasion resistance, volume stability, and resistance to freezing and thawing and deicers (ACI 308R). Water loss, during or after concrete finishing (i.e. evaporation), may delay or prevent sufficient hydration. Proper curing should retain water or compensate water loss in the concrete to allow for a full hydration process. This will allow for strength development of concrete. Figure 1 shows the effect of different curing periods on strength gain; it improves quickly at early ages, and then continues slowly for an indefinite period. The water stored in the lightweight aggregates is typically stored in pores that are larger than those in a hydrating cement paste. As a result the water moves from the light weight aggregate to the surrounding cement paste keeping the small pores saturated. The internal curing process utilizes cement more efficiently during the hydration process. Internal curing improves the workability and reduces the cracks due to plastic, drying and thermal shrinkage. The strength of the concrete is increased as the bond between the light weight aggregate and the hydrated cement becomes continuous due to decrease in permeability.

2 .LITERATURE SURVEY

Hoff. G.C. described the use of near-saturated lightweight aggregate (LWA) as a replacement for a portion of the normal weight aggregate (NWA) in high-strength/high-performance concrete in order to mitigate or eliminate the self-desiccation and autogenous shrinkage that can occur which can further lead to early age cracking and long-term durability problems. The amount of LWA used to achieve beneficial internal curing is a function of the type of LWA, its size and amount, the degree of moisture preconditioning the LWA receives, the amount and type of binders in the mixture, the water binder ratio at mixing, and the amount and duration of external moist curing provided to the concrete element.

Arnon Bentura et.al. studied that the concrete with saturated lightweight aggregate exhibited no autogenous shrinkage, whereas the normal-weight concrete with the same matrix exhibited large shrinkage. The study shows that the partial replacement of normal-weight aggregate by 25% by volume of saturated lightweight aggregate was very effective in eliminating the autogenous shrinkage and restrained stresses of the normal-weight concrete. It is noted that the internal supply of water from the saturated lightweight aggregate to the high-strength cement matrix caused continuous expansion, which may be related to continuous hydration.

3. MATERIALS

A. Cement:

The Ordinary Portland Cement of 43 grade conforming to IS: 12269-1987 is used.

Name of tests	results
Normal consistency	32%
Setting time of cement	Initial 210 min, final 340 min
Compressive strength of cement	For 7 days = 23.02 N/mm^2 For 28 days = 45.04 N/mm^2
Specific gravity	3.15

B. Coarse Aggregate:

The fractions from 20 mm to 4.75 mm are used as coarse aggregate, conforming to IS: 383 is use.

Name of tests	results
Specific Gravity Of Coarse Aggregate	2.86
Crushing Value Of Coarse Aggregate	23.13%
Water Absorption Test On Coarse Aggregate	1%

C. Fine Aggregate:

The river sand conforming to the requirements of IS: 383 – 1970 is used as fine aggregate.

Name of tests	Results
Specific Gravity Of Fine Aggregate	2.31
Sieve Analysis Test On Fine Aggregate	Zone 4
Moisture Content In Fine Aggregate	2.62%

C. Expanded clay:

The clay is mined, crushed and fired under high temperatures in a rotary kiln, producing a clean, inert, porous, and light material. Expanded shale has improved physical properties such as reduced dead weight, high internal stability, high permeability, and high thermal resistance (Fig.1).

Table -1: Properties of Expanded clay

Sl.No	Property	Value
1	Water absorption	32.5%
2	Specific gravity	0.71
3	Bulk density	572.66kg/m^3

Figure: Expanded clay

4. M 30 MIX DESIGN

Following are the M 30 mix proportions as per IS 10262:2009.

Table 2: M 30 mix proportions

Cement	447.72 kg/m^3
Water	197 kg/m^3
Fine aggregate	500.82 kg/m^3
Coarse aggregate	1270.38 kg/m^3
Water-cement ratio	0.44
Mix ratio	1 : 1.11 : 2.82

5. PREPERATION OF SPECIMENS

The grade of concrete adopted is M 30. The water-cement ratio and target mean strength is 0.44 and 38.25 N/mm^2. This is lower than the maximum value of 0.45 prescribed for Mild exposure in IS: 456-1978.The mix design for the concrete blocks is prepared as per IS 10262-2009. The expanded clay is mixed in proportions of0%, 5%, 10%, 15% , 20% and 25% by replacing the coarse aggregates. Preparing a cubes, cylinders, beams by replacing coarse aggregates and it will be cured for 7 and 28 days and conduct a test on that specimens.

Mix Designation	% of replacement of Expanded clay
M0	0%
M5	5%
M10	10%
M15	15%
M20	20%
M25	25%

5. RESULTS AND DISCUSSIONS

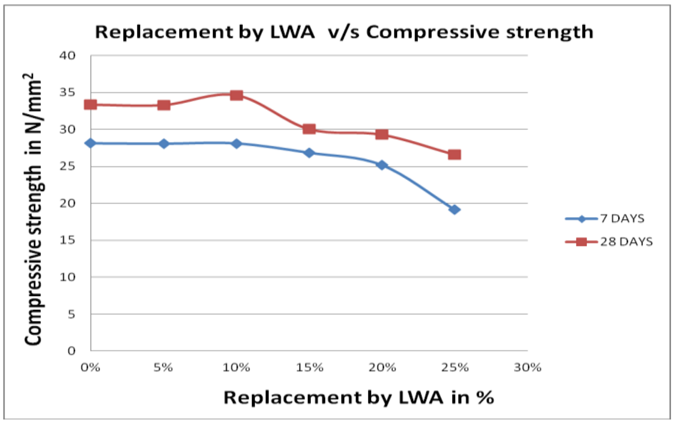
5.1 Compressive strength test

The compressive strength of the cubes was measured at 7, 28 days and calculated as an average of two cylinders for each age as given in Table 4.

Table 4: compressive strength results

Sl.No	Replacement by LWA in %	7 days compressive strength (N/mm^2)	28 days compressive strength (N/mm^2)
1	0%	28.12	33.35
2	5%	28.07	33.30
3	10%	29.62	34.63
4	15%	26.85	30.05
5	20%	25.19	29.29
6	25%	19.18	26.59

Graph:



Discussions:
It is observed that,

- The compressive strength of the concrete at 7 days for 10% replacement of the coarse aggregate with expanded clay is 5.33% more than the normal cement concrete cube.
- The compressive strength of the concrete at 28 days for 10% replacement of the coarse aggregate with expanded clay is 3.83% more than the normal cement concrete cube.

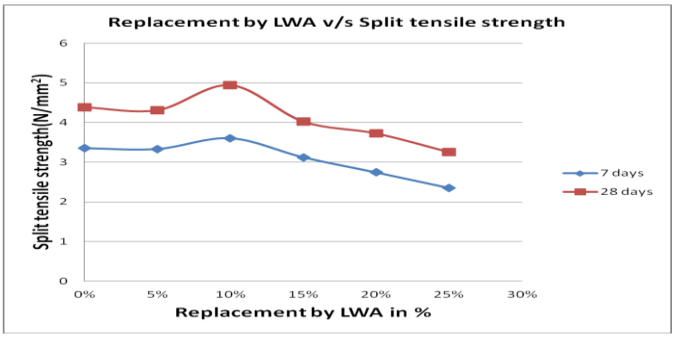
5.2 Split tensile test

The split tensile strength of the cubes was measured at 7, 28 days and calculated as an average of two cylinders for each age as given in Table 5. The split tensile strength of the internally cured concrete at 28 days was about 12.78% higher than the plain concrete because of the continuous hydration of the mixture at later ages, promoted by the extra water stored in the light weight aggregate.

Table 4: compressive strength results

Sl.No	Replacement by LWA in %	7 days Horizontal stress (N/mm²)	28 days horizontal stress (N/mm²)
1	0%	3.35	4.38
2	5%	3.12	4.31
3	10%	3.6	4.94
4	15%	3.12	4.02
5	20%	2.74	3.72
6	25%	2.35	3.25

Graph:



Discussions:
It is observed that,

- The Horizontal stress of the concrete at 7 days for 10% replacement of the coarse aggregate with expanded clay is 7.46% more than the normal cement concrete cylinder.
- The Horizontal stress of the concrete at 28 days for 10% replacement of the coarse aggregate with expanded clay is 12.78% more than the normal cement concrete cylinder.
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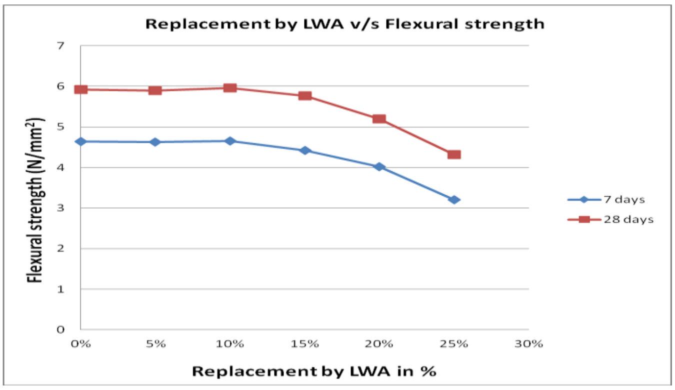
5.3 Two point load test on beam

The Flexural strength of the beam was measured at 7, 28 days and calculated as an average of two beams for each age as given in Table 6. The flexural strength of the internally cured concrete at 28 days is almost equal to the plain concrete.

Table 4: Flexural strength results

Sl.No	Replacement by LWA in %	7 days flexural strength (N/mm^2)	28 days flexural strength (N/mm^2)
1	0%	4.64	5.92
2	5%	4.63	5.90
3	10%	4.64	5.86
4	15%	4.05	5.04
5	20%	3.84	4.76
6	25%	3.20	4.32

Graph:



Discussions:
It is observed that,

- The Flexural strength of the concrete at 7 days for 10% replacement of the coarse aggregate with expanded clay is almost nearer to the normal cement concrete beam.
- The Flexural strength of the concrete at 28 days for 10% replacement of the coarse aggregate with expanded clay is also nearer to the normal cement concrete beam.
- If more than 10% of LWA is added then flexural strength goes on decreasing.

6. CONCLUSIONS

Based on the results it has been concluded that,

- The addition of Expanded clay increases the degree of hydration, producing a denser microstructure leading to better curing.

- The compressive strength for the internally cured concrete resulted in values 3.83% higher when compared to the plain concrete with an replacement of LWA by an 10%.
- The improved hydration also reduce micro cracking as a result of the lower shrinkage tendency of concrete with lightweight aggregate (Expanded clay) used for internal curing.
- Flexural strength results have fairly comparable patterns to those of compressive strength as increased doses yield lower strength.
- For 10% replacement by LWA is the optimum percentage to yield the strength.
- The split tensile strength for the internally cured concrete resulted in values 12.78% higher when compared to the plain concrete with an replacement of LWA by an 10%.

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