Experimental Investigation of Strength of Self Curing Concrete Incorporated With Light Weight Aggregate as Mineral Admixture

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Abstract — When the mineral admixtures react completely in a blended cement system, their demand for curing water (external or internal) can be much greater than that in a conventional ordinary Portland cement concrete. When this water is not readily available, due to depercolation of the capillary porosity significant autogenous deformation and (early-age) cracking may result. To overcome such conditions there is a need of water in concrete internally for complete hydration to achieve the expected strength. This is achieved by Internal curing using different agents which provides the water for hydration through capillary action even after evaporation of external curing water. The strength achieved by Internal curing (IC) could be more than that possible under saturated curing conditions. In present work the internal curing or self curing concept by addition of Light weight aggregate namely Light weight Expanded Clay Aggregate (LECA) as a mineral admixture in partial replacement of coarse aggregate is studied. For experimental investigation, seven mixes of M40 grade concrete with varied percentage of Light weight Expanded Clay Aggregate (LECA) i.e. 0%, 5%, 10%, 15%, 20% and 25% as a replacement of coarse aggregate were used. Among these, first and second mix (M1 & M2) were nominal mixes with 0% LECA. M1 was cured in a curing tank whereas M2 was cured under wet gunny bags. These specimens were then tested for Compressive strength, Split tensile strength, Flexural strength, ultrasonic pulse velocity and continuous immersion in salt water. Results shown that replacing coarse aggregate with LECA up to 10% will produce improvement in strengths in compression, tension and flexure also this mix has shown good resistance to chloride attack when tested in continuous immersion test with improvement of 10.74% in compressive strength. Whereas mix with 15% LECA has shown excellent quality of concrete in ultrasonic pulse velocity test and attained adequate strengths in compression and flexure. This leads to conclude that the optimum content of LECA in replacement of coarse aggregate in concrete should be 10% and it should not exceed 15% for attaining the required strength.

Keywords: Self Curing, Light Weight Aggregate, Light Weight Expanded Clay Aggregate, Poly Ethylene Glycol, Compressive Strength, Flexural Strength, Split Tensile Strength, Ultrasonic Pulse Velocity, Chloride Attack

I. INTRODUCTION

The ACI-308 Code states that “internal curing refers to the process by which the hydration of cement occurs because of the availability of additional internal water that is not part of the mixing water.” Conventionally, curing concrete means creating conditions such that water is not lost from the surface i.e., curing is taken to happen ‘from the outside to inside’. In contrast, ‘internal curing’ is allowing for curing ‘from the inside to outside’ through the internal reservoirs (in the form of saturated light weight fine aggregates, superabsorbent polymers, or saturated wood fibers) created. ‘Internal curing’ is often also referred as ‘self-curing.’

II. LITERATURE REVIEW

A. Mueller, S.N. Sokolova b, V.I. Vereshagin [1] “Characteristics of light weight aggregates from primary and recycled raw materials” in Elseveir journal , (2008), pp 703-712. Performed investigations in the laboratory and in the pilot plant have demonstrated that the variety of constituents suitable for light weight aggregate production can be broadened. Zeolitic rocks are suitable for this, of which there are deposits in many regions of Russia. In Germany, masonry rubble could be used as alternative raw material. The technological process for the manufacture of the granules is similar for both materials.

Dayalan J, Buelth. M [2] “Internal curing of concrete using prewetted Lightweight Aggregate” in International Journal of innovative Research in Science , Engineering and Technology, March 2014 pp 10554-10560, concluded after experimental investigation that the internally cured concrete is proved to be better than conventionally cured concrete by all means. The addition of expanded shale increases the degree of hydration, producing a denser microstructure leading to better curing. Compressive strength results reveal that strength of internal cured specimens at 21 days and 28 days are greater but at the age of 7 days the strength is lower than conventionally cured specimens. The compressive strength for the internally cured concrete resulted in values 20% higher when compared to the plain concrete. The improved hydration also reduce micro cracking as a result of the lower shrinkage tendency of concrete with light weight aggregate (expanded shale) used for internal curing. The rapid chloride migration test showed that the internally cured concrete had a lower diffusion coefficient than the plain concrete (15% and 50%, respectively). The rapid chloride penetrability of the internally cured concrete is lower than the plain concrete at all of the ages tested (approximately 55% at 180 days). The RCPT value for the control mix was found to be greater than the internal cured specimens. From the test results it is very clear that the use of light weight aggregate in concrete as internal curing agent is beneficial for all the aspects investigated in this study. The use of light weight aggregate for internal curing of concrete is particularly beneficial as it reduces various shrinkage cracks. The compressive strength for the internally cured concrete resulted in values 20% higher when compared to the plain concrete. Internal curing enables a high relative humidity within the pore structure of the concrete which reduces internal drying and extends

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hydration process which thereby increases strength and durability of the concrete.

Ahmad Mustafa Sabaon, Navinderdeep Singh [3], “A Review Paper on Self Curing Concrete”, International Research Journal of Engineering and Technology (IRJET), January 2018, pp 745-747, observed that As a self-curing agent the polyethylene glycol -400 or polyethylene glycol -600 is a good admixture and by adding of 1% of this admixture for M25 and M20 grade of concrete it had good result but adding 2% of polyethylene glycol decreased strength of concrete. From studying of many papers it found that strength of self-curing concrete is more than conventional concrete. We can use wood powder as self-curing agent. Self-curing concrete is the way for solving the difficulty faced with curing. Self-curing concrete is the best answer for desert area where the availability of water is very less or not available.

Amal Viswam, Arjun Murali [4], “Review on the study of self curing concrete”, in IJARIE, January 2018, pp 271-274, shown a study that water retention for the concrete mixes incorporating self-curing agent is higher compared to conventional concrete mixes, as found by the weight loss with time, self-curing concrete resulted in better hydration with time under drying condition compared to conventional concrete. Water transport through self curing concrete is lower than air-cured conventional concrete and slump value increases with increase in the quantity of PEG 5. Self curing concrete is the answer to many problems faced due to lack of proper curing.

Tuptewar Shripirasad Madhvrao, Unde Rajeshwar Houshiram, Rukare Suraj Sangappa, Salunke Shubhamkumar Suresh [5], “Study and design of self curing concrete for M30 grade”, International Research Journal of Engineering and Technology, May 2017, pp 1076-1078, Investigated Water retention of concrete containing self curing agents, weight loss in concrete and internal relative humidity measurements with time were carried out, in order to evaluate the water retention of self curing concrete. Non-evaporable water at different ages was measured to evaluate the hydration. Water transport through concrete is evaluated by measuring absorption %, permeable voids %, water absorptivity, and water permeability. The water transport through self-curing concrete is evaluated with age. From the tests conducted, it is observed that self-curing concrete does not have shrinkage as compared with conventional concrete and self-curing concrete is more economical because it eliminates the curing charges.

III. METHODOLOGY

A. Material Properties

Concrete of M40 grade with following constituents will be taken for testing-

<table>
<thead>
<tr>
<th>Mix</th>
<th>Cement (Kg)</th>
<th>Coarse Aggregate (Kg)</th>
<th>Natural Fine Aggregate (Kg)</th>
<th>Light Weight Aggregate (Kg)</th>
<th>Water (Lit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M₁(M40,0% LECA, conventional curing)</td>
<td>450</td>
<td>1063</td>
<td>588</td>
<td>0</td>
<td>157</td>
</tr>
<tr>
<td>M₂(M40,0% LECA, wet gunny bag curing)</td>
<td>450</td>
<td>1063</td>
<td>588</td>
<td>0</td>
<td>157</td>
</tr>
<tr>
<td>M₃ (LECA 5%)</td>
<td>450</td>
<td>1009.85</td>
<td>588</td>
<td>11</td>
<td>157</td>
</tr>
<tr>
<td>M₄ (LECA 10%)</td>
<td>450</td>
<td>956.7</td>
<td>588</td>
<td>22</td>
<td>157</td>
</tr>
<tr>
<td>M₅ (LECA 15%)</td>
<td>450</td>
<td>903.55</td>
<td>588</td>
<td>33</td>
<td>157</td>
</tr>
</tbody>
</table>

1) Cement -The Ordinary Portland Cement of 43 grade conforming to IS: 12269-1987 is used. Various tests were performed to find the properties of cement. The specific gravity of cement was found to be 3.16. The standard consistency of cement was obtained to be 40%. The initial and final setting times for cements are found to be 145 minutes and 265 minutes.

2) Coarse aggregate -The fractions from 20 mm to 4.75 mm are used as coarse aggregate, conforming to IS: 383 is used. The properties of coarse aggregates such as specific gravity were found to be 2.69 and water absorption was 3.08%. The fineness modulus obtained was 2.672.

3) Fine aggregate - The fine aggregate type used in the study was river sand. The river sand is screened to eliminate over size particles. The fine aggregate of zone-I confirming IS: 383 was used. The properties of sand such as specific gravity was found to be 1.567 and water absorption was 16.29%. Fineness modulus obtained is 3.12.

4) Light Weight Aggregate- For the present work lightweight aggregate used was Light weight Expanded Clay Aggregate (LECA). The light weight aggregate of the fraction between 7 and 15 mm has a specific gravity of 0.253. This LECA was surface coated with lime powder in order to reduce the porosity of LECA. The specific gravity of this lime coated LECA is found to be 0.557 and dry density as 325.64 Kg/m³.

5) Water- Potable water was used for mixing of concrete.

6) Superplasticizer- Connix SP1030 was superplasticizer used for making M40 grade of concrete. Marsh cone test was conducted for determining the saturation point and optimum dosage of this superplasticizer. The saturation point is observed on 1.1% dosage of superplasticizer i.e. 22ml for 2 kg of cement.

7) Lime powder -To provide surface coating on LECA lime powder of specific gravity 2.26 was used.

B. Casting and Curing Programme:

Initially the mix is prepared without using light weight expanded clay aggregate. Then the specimens were made by adding percentage of LECA. The cubes which are intended for self-curing were kept in indoor at room temperature and cured by wet gunny bags. The mix design and material required for mix are shown in table 1. As far as curing is concerned nominal mix (M₁) which was made as per mix design of M40 grade was prepared without adding LECA and cured conventionally in a curing tank. One more nominal mix (M₂) was made with same proportion and cured under wet gunny bags in order to compare the strengths of nominal mixes cured in these two ways. All other mixes were including percentile content of LECA as 5,10,15,20 and 25 were also cured under wet gunny bags.
C. Testing Programme:
In order to find the mechanical properties and durability of self-curing concrete the following tests were conducted on both self-cured concrete and conventional concrete.
1) Slump test
2) Compressive strength test
3) Split tensile strength test
4) Flexural strength test
5) Ultrasonic pulse velocity test
6) Continuous immersion test

IV. RESULTS

Fig. 1: Graphical analysis of slump test

Fig. 2: Graphical analysis of compressive strength test

Fig. 3: Graphical analysis of split tensile strength test

Fig. 4: Graphical analysis of flexural strength test

Fig. 5: Graphical analysis of ultrasonic pulse velocity test

Fig. 6: Graphical analysis of continuous immersion test

V. CONCLUSION
From the study of results obtained following conclusions are made
1) From results of Slump cone test it can be concluded that greater percentage of LECA makes concrete more workable.
2) From Compressive strength test results it can be concluded that for good results 10% LECA can be added in replacement of coarse aggregate, however mix with 15% LECA can also attain adequate compressive strength.
3) It can be concluded from compressive strength test results that mix M4 (mix with 10% LECA) and M5 (mix with 15% LECA) are attaining the required strength in half of the time required for nominal concrete mix. This make the use of self curing concrete beneficial in rigid
pavements where curing period makes trouble to passenger after construction or repair work of pavement.
4) The split tensile strength test results shows that increasing percentage of LECA beyond 10% may lead to reduction in split tensile strength of concrete.
5) Flexural strength of concrete can be improved up to 51% by replacing coarse aggregate with LECA by 10%.
6) Ultrasonic pulse velocity test results has shown that concrete with 15% LECA is as durable as nominal concrete mix.
7) Continuous immersion test results shows that insufficient curing to the nominal mix may lead to threat of chloride attack while concrete with LECA is observed to be resistive to the chloride attack even though it is cured under wet gunny bags.
8) From above findings it can be concluded that Optimum percentage of LECA in concrete for good performance in all aspects can be taken as 10% to 15% in replacement of coarse aggregate.

REFERENCES