Internal Curing Efficiency of Pre-Wetted Lightweight Fine Aggregates on Strength Parameters of Concrete

T. Mohan krishna, K. Prafulla Devi

Abstract: Internal cured concrete (ICC) using pre-wetted lightweight aggregates is to replace conventional type of curing. Normally curing for conventional type is done by external to internal, which requires a large membrane and a large amount of water is required to do this type of procedure and the water which we use for curing may get runoff or get evaporated. But in ICC type of curing it cure inside to outside, the pre-wetted lightweight aggregates provides sufficient moisture to hydrate cement inside the concrete. The pre-wetted light weight aggregates, which stores water inside and acts as a reservoir. It release water when hydration process is done. Lightweight aggregates such as expanded clay or shale, vermiculite, pumice, slate, perlite having high water absorbing capacity are generally used for internal cured concrete. In this study, vermiculite and expanded clay had been used as replacements of fine aggregate, 2.5%, 5%, 7.5%, 10% and 12.5% are replaced for vermiculite and 5%, 10%, 15%, 20% and 25% for expanded clay.

I. INTRODUCTION

Concrete is a composite material composed of hydrated cement (binder), sand (fine aggregate), gravels or crushed stones (coarse aggregate) and water. Concrete is the only material used in construction in the whole world. Water is the important component to get cement hydration process. The hydration process which gives strength to the concrete. It is well known that ‘curing’ is the main factor to get the strength at early ages to the concrete.

A. Internal Curing

Internal curing is done by using pre-wetted lightweight aggregates. These light weight aggregates which used as a replacement in fine aggregate. The lightweight aggregates are soaked for 24 hours before the mix is done. When the lightweight aggregates are soaked they absorbs water in their voids, so they act as reservoir in the concrete. These reservoirs which are in the concrete are get released in the time of hydration of cement. Internal curing is defined as “supplying water through the fresh concrete mixture by the reservoirs, via pre-wetted lightweight aggregates, which releases water for the hydration or to replace moisture lost through evaporation”. For external curing it is done only on the top surfaces of the cross-section of the concrete and depth of penetration is influenced based on the quality of the mix.

The advantages of ICC reduce early age cracks, shrinkage cracks, lightweight and limited water is used.

Fig 1: Figure shows the conventional curing vs internal curing

B. Pre-wetted Lightweight Aggregates

In Internal Curing concrete we use pre-wetted lightweight aggregates, initially the lightweight aggregates hold water and acts as a reservoir inside the concrete. The lightweight aggregates like expanded shale, expanded clay, vermiculite, slate and pumice the materials are having a capacity to absorb water inside their pours. They initial pre-wetted for 24 hours before the mix is done. These pre-wetted lightweight aggregates are used in mix as a replacement as fine aggregates in concrete. There will be no change in w/c ratio or the amount of water used in mix. The pre-wetted lightweight aggregates did not influence on the water content used in mix. In this we used vermiculite and expanded clay as lightweight aggregates are soaked in water for 24 hours before the mix.

II. MATERIALS

A. Cement

The cement used was locally available brand Ultra-tech (Ordinary Portland Cement) of 53 grade conforming to IS: 12269-1987. The test results conducted for cement are tabulated in below table

| S.no | Properties          | Test Results |
|------|---------------------|--------------|
| 1    | Normal consistency  | 32%          |
| 2    | a) Initial setting time | 45min        |
|      | b) Final setting time | 420min       |
| 3    | Fineness of cement  | 3.6%         |
| 4    | Specific gravity    | 3.12         |

Table 1: Properties of Cement

Revised Manuscript Received on July 06, 2019.
T. Mohan krishna, Post graduate student, Gudlavalluru Engineering College, Gudlavalluru, India.
K. Prafulla Devi, Asst. Professor, Department of Civil Engineering College, Gudlavalluru Engineering College, India.
B. Fine aggregates
The locally available sand had been used as fine aggregate conforming to the requirements of IS: 383-1970. The test results conducted for fine aggregate are tabulated in table below.

| S.no | Properties       | Test results |
|------|------------------|--------------|
| 1    | Specific gravity | 2.6          |
| 2    | Fineness modulus | 2.81         |

Table 2: Properties of Fine aggregate

C. Coarse aggregates
The locally available fraction from 20mm to 4.75mm are used as coarse aggregate, conforming to IS: 383. The test results conducted for coarse aggregates are tabulated in below table.

| S.no | Properties       | Test results |
|------|------------------|--------------|
| 1    | Specific gravity | 2.78         |
| 2    | Fineness modulus | 7.29         |

Table 3: Properties of Coarse aggregate

D. Vermiculite
Vermiculite is a mineral, when it applied to heat it get expanded than its original size. The process of heating and expanding is called exfoliation. Vermiculite is passed from furnace which is having a temperature of 540 – 810°C, it get expands then it is called exfoliated vermiculite. The test results conducted for vermiculite are tabulated in below table.

| S.no | Properties       | Results  |
|------|------------------|----------|
| 1    | Specific gravity | 2.47     |
| 2    | Water absorption | 10.36%   |
| 3    | Density          | 225 kg/mm³ |

Table 4: Properties of Vermiculite

E. Expanded clay
Expanded clay or lightweight expanded clay aggregates (LECA) is a lightweight aggregates are manufactured by heating clay at 1200°C in rotary kiln. The clay by heating under yielding gases itforms thousands of small bubbles forming inside the clay producing honeycomb structure. Due to circular moment in the rotary kiln the LECA are rounded in shape and is available in different sizes. The test results conducted for expanded clay are tabulated in below table.

| S.no | Properties       | Results  |
|------|------------------|----------|
| 1    | Specific gravity | 1.62     |
| 2    | Water absorption | 24%      |
| 3    | Density          | 425 kg/mm³ |

Table 5: Properties of Expanded clay

III. EXPERIMENTAL WORK

A. Concrete mixing
Lightweight aggregates are pre-wetted for 24 hours of period to absorb water in the voids of vermiculite and expanded clay before the mix done. The saturation is very important to these light weight aggregates when the hydration process is started. The pre-wetted aggregates which are once saturated, act as reservoir which releases water when hydration process of cement paste occurs. A different mixes are casted using both the vermiculite and expanded clay as a light weight aggregates. Vermiculite and Expanded clay are partially replaced with fine aggregate at percentages of 2.5%, 5%, 10% and 12.5% for vermiculite and 5%, 10%, 15%, 20% and 25% for expanded clay. The mix design is taken as M30. The below table shows mix proportions of M30 grade concrete.

| Materials              | Quantity              |
|------------------------|-----------------------|
| Cement                 | 437.75 kg/m³         |
| Water                  | 175.1 liters          |
| Fine aggregate         | 676.78 kg/m³         |
| Coarse aggregate       | 1218.89 kg/m³        |
| w/c                    | 0.4                   |

Table 6: Mix proportion

The cubes and cylinders were casted according to the quantities as shown in above tables. Cubes with sizes of 150mmx150mmx150mm and cylinders with sizes of 150mmx300mm. Cubes for compressive strength and cylinders for split tensile strength. The cubes and cylinders are removed from the specimen after 24 hours of casting. The cubes were kept at air curing at ambient temperature.

IV. EXPERIMENTAL RESULTS
Compressive strength and split tensile strength of cubes were tested at 7 days, 14 days and 28days, reported the average value of 3 cubes.

A. Compressive Strength
i) For Vermiculite

| % of vermiculite | Compressive Strength (N/mm²) |
|------------------|------------------------------|
|                  | 7 days | 14 days | 28 days  |
| 0%               | 32.75  | 38.24   | 43.25    |
| 2.5%             | 30.28  | 36.91   | 43.16    |
| 5%               | 29.62  | 35.42   | 43.02    |
Table 7: Compressive strength of vermiculite concrete

| % of vermiculite | 7.5% | 10% | 12.5% |
|------------------|------|-----|-------|
| 7 days           | 29.09| 34.60| 34.86 |
| 14 days          | 28.22| 34.60| 37.91 |
| 28 days          | 24.58| 28.25| 32.54 |

Table 8: Compressive strength of expanded clay concrete

| % of replacement | 0% | 5% | 10% | 15% | 20% | 25% |
|------------------|----|----|-----|-----|-----|-----|
| 7 days           | 32.75| 33.06| 33.27| 33.69| 34.01| 31.19|
| 14 days          | 38.24| 38.52| 38.71| 39.98| 39.21| 37.95|
| 28 days          | 43.25| 45.64| 46.98| 47.03| 48.34| 43.68|

Table 9: Split tensile strength of vermiculite concrete

| % of vermiculite | 0% | 2.5% | 5% | 7.5% | 10% | 12.5% |
|------------------|----|------|----|------|-----|-------|
| 7 days           | 2.91| 2.85 | 2.63| 2.52 | 2.58| 2.36  |
| 14 days          | 3.82| 3.61 | 3.46| 3.32 | 3.26| 3.09  |
| 28 days          | 4.25| 4.16 | 4.11| 4.09 | 3.72| 3.53  |

Table 10: Split tensile strength of expanded clay concrete

| % of clay | 0% | 5% | 10% | 15% | 20% | 25% |
|-----------|----|----|-----|-----|-----|-----|
| 7 days    | 2.50| 2.96| 3.08| 3.12| 3.25| 2.61|
| 14 days   | 3.82| 3.92| 3.95| 4.08| 4.39| 3.86|
| 28 days   | 4.25| 4.53| 4.86| 5.04| 5.17| 4.73|
Graph 4: Graph shows the split tensile strength of expanded clay concrete

C. Cube Weight
   i) For Vermiculite

| % of replacement | weight of cube (kgs) |
|------------------|---------------------|
| 0%               | 9.25                |
| 2.5%             | 8.89                |
| 5%               | 8.63                |
| 7.5%             | 8.48                |
| 10%              | 8.34                |
| 12.5%            | 8.21                |

Table 11: Weight of the vermiculite concrete

Graph 5: Graph shows the weight of the vermiculite concrete

ii) For Expanded Clay

| % of Expanded Clay | Weight of Cube (kgs) |
|--------------------|---------------------|
| 0%                 | 9.25                |
| 5%                 | 8.51                |
| 10%                | 8.32                |

Graph 6: Graph shows the weight of the expanded clay concrete

D. Density of Cubes
   i) For Vermiculite

| % of Vermiculite | Density of Cubes (kg/m³) |
|------------------|--------------------------|
| 0%               | 2740.74                  |
| 2.5%             | 2634.07                  |
| 5%               | 2625.18                  |
| 7.5%             | 2512.59                  |
| 10%              | 2471.11                  |
| 12.5%            | 2432.59                  |

Table 13: Density of concrete with different % of replacement of vermiculite

Graph 7: Graph shows the density of concrete with different % of replacement of vermiculite
ii) For Expanded Clay

| % of Expanded Clay | Density of Cubes (kg/m³) |
|-------------------|-------------------------|
| 0%                | 2728.88                 |
| 5%                | 2521.48                 |
| 10%               | 2465.18                 |
| 15%               | 2358.51                 |
| 20%               | 2257.77                 |
| 25%               | 2154.07                 |

Table 14: Density of concrete with different % replacement of expanded clay

Graph 8: Graph shows the density of concrete with different % replacement of expanded clay

V. CONCLUSIONS

1) Based on this experiment, it is found that vermiculite and expanded clay can be used as an alternative material to natural river sand and can be used as a constructional material.

2) The compressive strength and tensile strength for vermiculite is less than the conventional concrete, but up to 7.5% of replacement the compressive strength are obtained more than target mean strength.

3) The optimum compressive strength and split tensile strength for expanded clay is at 20%.

4) There is an increase in percentage of compressive strength as compared with nominal mix is increased by using expanded clay by 11.54% (44.34 N/mm²) for 28 days.

5) The percentage increased in split tensile strength as compared with nominal mix is increased by using expanded clay by 10.11% (4.68 N/mm²).

6) For both the vermiculite and expanded clay, when increased in percentage of replacement there is decrease in weight of concrete.

REFERENCES

1. IS 10262 - 2009 “recommended guidelines for concrete mix design.
2. I. Tamboli, Atul, Harish Kasera, Vivek Mangal, Akriti Zutshi And Ashwin Tyagi (2016), “Effective Internal Curing Using Light Weight Aggregates”, IOSR Journal of Mechanical and Civil Engineering (IOSR-JME) e-ISSN: 2278-1848,p-ISSN: 2320-334X, Volume 13, Issue 2 Ver. IV (Mar- Apr. 2016), PP 49-52.
3. Amin K. Akhnoukh (2018), “Internal Curing Of Concrete Using Lightweight Aggregates”, Particulate Science and Technology, 36,3, pp 362-367.
4. Dayalan J and Buellah M (2019), “Internal Curing of Concrete Using Prewetted Light Weight Aggregates”, JRSSET Vol. 3, Issue 3, March 2014.
5. Ryan Henkensiefken, Javier Castro, Dale Bentz, Tommy Nantung And Jason Weiss (2009), “Water Absorption In Internally Cured Mortar Made With Water-filled Lightweight Aggregate”, Cement and Concrete Research 39, pp 883–892.
6. R.N. Raj Prakash, A.Krishnamoorthi (2017), “Experimental Study On Light Weight Concrete Using Leca” International Journal of ChemTech Research,CODEN (USA): UCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555 Vol.10 No.8, pp 98–109.
7. Zhaeer Ahmed, Akshatha, Dr. Mushtaq Ahmed Bhavikati And Harshith (2019), “An Experimental Study On Internal Curing Of Concrete Using Light Expanded Clay Aggregate”, International Journal of Research and Scientific Innovation (IJRSI) | Volume VI, Issue I, January 2019, ISSN 2321–2705.
8. Devidas Rumlisa, Darius Bačinskasa, Edmundas Spudulis And Adas Melkénasa (2017), “Comparison Of Material Properties Of Lightweight concrete With Recycled Polyethylene And Expanded Clay Aggregates”, Modern Building Materials Structures and Techniques, MBMST 2016, Procedia Engineering 172 (2017) 937–944.
9. Andro Genis J, M.S.Dinesh Kumar, D.Praveen, A.S.Arun Pravin And Anekar Mohammed Uzair (2018), “Flexural Behavior Of Lightweight Expanded Clay Aggregate Concrete Beam Reinforced With Geogrid”, International Journal of Pure and Applied Mathematics, Volume 118 No. 20 2018, pp 3537-3545 ISSN:1314-3395 (on-line version).
10. M.Shankar (2016), “Experimental Investigation On Self Compacting Concrete Using Light Weight Aggregates”, International Journal of Advanced Science and Engineering Research, Volume: 1, Issue: 1, June 2016 ISSN: 2455-9288.
11. Hanamanth Shebannavar, Maneeth And Brijibhushan (2015), “Comparative Study Of Leca As A Complete Replacement Of Coarse Aggregate By Aci Method With Equivalent Likeness Of Strength Of Is Method”, International Research Journal of Engineering and Technology (IJRET), Volume: 02 Issue: 08-Nov-2015.
12. D. Madhu Raj, J.V. Narasimha Raju And M. Suneel (2018), “An Experimental Study On Effect Of Partial Replacement Of Normal Weight Aggregates With Lightweight Aggregates In Flyash Based Geopolymer Concrete”, International Research Journal of Engineering and Technology (IJRET), Volume: 05 Issue: 06, June - 2018.
13. D.Rebekhal and Mr. S.Ramakrishnan (2016), “Internal Curing On High Performance Concrete with Pre-Soaked Light Weight Aggregate to Prevent Shrinkage”, International Journal of Advanced Research in Biology Engineering Science and Technology (IJABEST) Vol. 2, Issue 4, April 2016.
14. R. Gowrishankar, C. Mohanaselvan And R. Kartheeswaran (2017), “Experimental Study On Flexural Behavior Of Bacterial Concrete With Internal Curing”, International Journal of Research and Scientific Innovation (IJRSI) | Volume IV, Issue VS, May 2017, ISSN 2321–2705, pp 43–47.

AUTHOR PROFILE

Mr. T. Mohan Krishna, M.Tech final year in Structural Engineering, Department of Civil Engineering, Gudlavalleru Engineering College, Gudlavalleru, Andhra Pradesh, India.

Ms. K. Prafulla Devi, Assistant Professor in Civil Engineering, Gudlavalleru engineering College, Gudlavalleru, Andhra Pradesh, India.