Experimental Investigation of Light Weight Aggregate with Internal Curing Agent by Using Fly ash Aggregate

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Abstract. The point of this research was to research the impact of a high volume of rooftop tile squander coarse total as an inside relieving specialist on compressive strength in the paste of fly-ash concrete. Interior relieving with squander total expanded the compressive strength of fly-ash concrete and diminished modulus of versatility. Squander total can be utilized as an inside repository to build the compressive strength and demonstrate cement design with high volume substitution of class-fly ash.

Keywords: Lightweight aggregate; Recycled concrete aggregate; Wooden fibers

1. Introduction
One way to provide IC to the concrete is by presoaking lightweight [1] aggregate (LWA) and introducing these Lightweight aggregates in the concrete. This study features the use of presoaked lightweight aggregate to facilitate internal curing using fly ash aggregates. The [2] fly ash aggregates will maintain the humidity conditions favoring proper hydration process, and also it will prevent shrinkage and improve the concrete quality.

1.1 Curing
The curing method concentrates on controlling temperature and moisture [3] movement in and out of the concrete for a sufficient period to arrive at the desired strength level.

1.2 Internal curing
Internal [4] curing is the method of supply water from the inside of concrete. The internal curing agents are presoaked in water before adding to the concrete. The [5] internal curing agent acts as a locally available water reservoir to maintain the concrete matrix’s hydraulic balance.

2. Methods for internal curing:
The most common materials used for curing agents are as follows:

- Porous LWA
- Recycled concrete aggregate
- Wooden fibers
- Superabsorbent polymers.

2.1 Lightweight aggregate (LWA)
The most commonly used LWA are obtained from materials such as clay, shale, slate,[6] perlite, foamed slag, sintered fly ash, brick bubble, and crushed stone, etc.
2.2 *Fly ash LWA*
Fly ash aggregates are [7] manufactured by agglomeration or spheronization of the fly ash particles by pelletization and compaction, followed by the hardening process.

The most commonly used hardening processes are as follows
a) Sintering
b) Hydrothermal processing (auto cleaving)
c) Cold bonding.

3. **Objectives and scope of the study**
1. LWA has been used as a replacement for normal concrete for a long time.
2. The main advantages [8] of using Lightweight aggregate are it reduces the mass of the building, and at the same time, it gives maximum strength.
3. By using LWA, the curing time is also reduced.
4. To improve the aggregates' characteristics, a certain method like [9] alteration of binder content and hardening process were varied.
5. LWA is fly ash aggregates from class C fly ash with cement binder besides class F fly ash with bentonite and metabolite binder.
6. The disk pelletization technique will be adopted for fly ash aggregate manufacture.

4. **Methodology**
Interior relieving with squander total expanded the compressive strength of fly-ash concrete and diminished modulus of versatility. Squander total can be utilized as an inside repository to build the compressive strength and demonstrate cement design with high volume substitution of class-fly ash. Figure 1 shows workflow of proposed system in steps by steps executions.

![Figure 1: workflow of proposed system](image)
4.1 Internal curing
In the internal curing process, when dry LWA is added to the concrete, it will absorb the moisture in the mixing water and release the absorbed water for curing. This method will increase the quality of LWA or reduce the assumed quantity that the LWA will absorb as a factor of safety.

4.2 Properties of internal curing agents

4.2.1 Porosity: As the curing period of the aggregate increases, there will be more C-S-H gel construction in the aggregates. This will reduce the porous nature of the aggregates. A comparison of steam cured and autoclaved aggregates showed a reduction of 10% on water absorption characteristics.

4.2.2 Water absorption: The water absorption features of an aggregate are based on the hydrophilicity of the pores' surface in the aggregates. The LWA will absorb water till 4.2 hrs after mixing of concrete and then act as water donors if the LWA is not completely saturated.

4.2.3 Water desorption: An efficient internal curing LWA should desorb maximum absorbed [10] water at high relative humidity. When the concrete matrix is in the fluid stage, the water gets imbibed by the LWA, whereas at the time of solidification, the internal curing water depercolates out of the LWA. [11] The water absorption for expanded slate is 6% to 12%, and for expanded shale, it is 10% to 20% at 24hrs.

4.2.4 Water migration: The water flow distance is based on many factors like cement content, w/c ratio, [12] and pore structure of LWA. The size of the LWA decided the spatial factors for internal curing water migration, about 0.1 to 3mm.

4.2.5 Degree of hydration: Water transport in the cementitious system happens due to a pressure gradient. [13] The volume of the hydration products is 10% less than that of the reactants. For the glue with a water-cement ratio of 0.3 under sealed conditions, hydration ceases at a hydration degree of 0.73.

4.2.6 Distribution: A finely dispersed LWFA system will be superior to the larger porous LWFA. [14] The spatial distribution of superabsorbent curing reservoirs and curing water mobility in the hardening cement paste determines the concrete's cured volume.

4.3 Manufacture of fly ash aggregate

4.3.1 Batching and mixing: The fly ash, along with the solid binder, is also weighed mixed in a mixer. After several trials, the mix's total quantity was fixed as 2kg, and it was observed to be the most efficient charge for the pelletizer dimension in the laboratory [15].

4.3.2 Dry mixing: The mixture for the pellets is dry mixed for 2 minutes in the mixer machine for F fly ash. In the case of class C fly-ash, water is also added at the beginning of the mixing process to avoid flying off the mixture. The flying of the mixture is due to the cenosphere's presence, which causes the fineness of the fly ash.

4.3.3 Wet mixing: After dry mixing, wet mixing is continued. At the time of wet mixing, 75% of the mixing water is added. This will help in the uniform blend of the dry mixture, and the water is added. This will help in a uniform blend of the dry mixture and the water. After 5 min of mixing, the contents are transferred into the pelletizer.
4.4 Physical properties of cement, Coarse aggregate, and fine aggregate

Table 1: Physical properties of cement

| Description               | Values  |
|---------------------------|---------|
| Consistency of cement     | 29.50%  |
| Initial time              | 50 min  |
| Final time                | 330 min |
| Fineness of cement        | 280 m²/kg |
| Specific gravity          | 3.05    |

Table 2: Physical properties of fine aggregate

| Description               | Values  |
|---------------------------|---------|
| Specific gravity          | 2.612   |
| Water absorption          | 1.07%   |
| Fineness modulus          | 5.4     |
| Zone as per IS:383-1970   | II      |

Table 3: Physical properties of coarse aggregate

| Description               | Values  |
|---------------------------|---------|
| Specific values           | 2.9     |
| Water absorption          | 0.33%   |
| Bulk density              | 1657 kg/m³ |
| Crushing value            | 29%     |

The concrete's fresh and dry densities were below the marginal value of normal concrete due to a rise in the volume of the aggregates. The concrete's workability was higher than cold bonded concrete, in the range of 100 to 180 mm. The compressive strength of the sealed cured samples was similar to the values of samples cured under pond and mist curing. Table 1 shows Physical properties of cement and Physical properties of fine aggregate discussed in Table 2. Table 3 explains about Physical properties of coarse aggregate and Table 4 discussed about Test study of concrete's fresh and dry densities.

5. Conclusions:
Internal curing using fly ash aggregates as internal curing agents was experienced in this study. The aggregate's manufacturing process was pelletization. The major difference lies in the types of fly ash used and the corresponding methods of hardening. The size fractions, cement quantity, and water-cement ratio were maintained constant. In the case of concrete different curing methods were followed. All these parameters are the properties of the concrete. The conclusions from the experimental results are taken.
Table 4: Test study of concrete's fresh and dry densities

| Concrete depth | 12.5% replacement of LWA | 25% replacement of LWA |
|----------------|--------------------------|------------------------|
|                | Range 0-2 Cm | 2-4 cm | 4-6 cm | 6-8 cm | 8-10 cm | 0-2 Cm | 2-4 cm | 4-6 cm | 6-8 cm | 8-10 cm |
| 4.75 - 6.3 mm  |
| horizontal c/s | Min  7 | 8 | 9 | 8 | 4 | 11 | 12 | 15 | 7 | 11 |
|                | Max  13 | 14 | 20 | 15 | 14 | 24 | 28 | 23 | 24 | 22 |
|                | Mean 10 | 12 | 14 | 12 | 8 | 18 | 19 | 18 | 16 | 15 |
|                | Min  8 | 3 | 3 | 9 | 3 | 22 | 15 | 19 | 1 | 14 |
|                | Max  22 | 16 | 21 | 16 | 11 | 40 | 26 | 28 | 24 | 22 |
|                | Mean 14 | 9 | 10 | 11 | 8 | 31 | 20 | 25 | 19 | 17 |
| 12.5 - 16 mm   |
| horizontal c/s | Min  8 | 2 | 5 | 9 | 6 | 2 | 2 | 1 | 0 | 1 |
|                | Max  12 | 16 | 14 | 21 | 18 | 6 | 6 | 7 | 4 | 5 |
|                | Mean 10 | 9 | 10 | 12 | 11 | 4 | 4 | 4 | 2 | 4 |
|                | Min  5 | 8 | 8 | 3 | 5 | 3 | 1 | 1 | 2 | 2 |
|                | Max  12 | 13 | 13 | 11 | 12 | 10 | 7 | 6 | 6 | 7 |
|                | Mean 8 | 10 | 11 | 8 | 8 | 7 | 3 | 4 | 4 | 5 |

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