Investigation on various construction material LECA, thermal insulated and conventional blocks

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Abstract. Among the various construction materials, LECA (light weight expanded clay aggregate) is a versatile material due to its unique properties and is utilized in many applications. LECA blocks are highly impermeable and have high performance properties. Thermal insulated blocks are well suited for high rise buildings to withstand high temperature. It requires less steel and concrete for structural members due to its lower density. The LECA is mixed with grade M30 with 50% and 100% of replacement. The molded concrete blocks were tested to determine the strength and workability of the blocks under various experimental conditions and different time periods such as 7 days and 28 days. The tests such as compression test and water absorption test were conducted. From the experimental investigation, we will be able to conclude the best among these blocks based on their strength.

1. Introduction
The historical development of house facilities reveals that man has been modeling his environment throughout the ages for more comfortable living. Through producing and using inexpensive but powerful locally available building materials, these targets can be accomplished in part. It is important to pursue ways in developing countries to reduce construction costs, especially for low-budget housing, as well as to implement easy and efficient solutions for their repair and maintenance. Thermal block is a material’s ability to absorb heat energy and store it. Changing the temperature of high-density materials such as cement, bricks and tiles requires a lot of heat energy. Thermal building blocks are a commercial solution for partition, floor and subversive constructions. Its unique properties are high thermal and noise insulation, good compressive strength, easy to handle and moisture resistance. Thermal building blocks recommended are first-rate thermal insulation which is inbuilt to get U-value targets easier in construction and diminish the carbon dioxide emissions from building. LECA is a unique construction material with light aggregates which is made by fired clay in rotary kiln at very high temperature. After the calcinations process, the organic compounds are destroyed by fire and forcing the bubbles to enlarge and form the product in honeycombed structure. The resulting ceramic pellets are lightweight, porous and highly resistant to crushing. Due to its weightless structure, it possesses an excellent thermal and sound insulation and fire-resistant stability [1]. Hence LECA material can be applied in the construction of under-ground areas, detachment walls inside the room and ceilings. In this research work, the aim is to produce an alternate for the

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conventional block, in terms of strength, low cost, weight of the blocks and hence to promote sustainable development in the field of construction. Conventional blocks can be used only in ordinary environment and it will definitely fail in the point of excessive loading and also handling energy is more. Also we studied about the behaviour of solid blocks and compressive strength of solid blocks.

2. Experimental Work

2.1. Insulation Material

The insulation material used in thermal blocks is polystyrene and its physical properties are mentioned in the table 1 below. Polystyrene material used in this study is shown in figure 1 (a-b) below.

| S. No | Physical Property          | Value          |
|-------|---------------------------|----------------|
| 1     | Specific Gravity          | 1.04           |
| 2     | Flexural Strength         | 83 MPa (12000 PSI) |
| 3     | Tensile Strength          | 53 MPa (7700 PSI) |
| 4     | Melting Temperature       | 210-249 °C (410-480 °F) |
| 5     | Solubility in water       | Insoluble      |

Figure 1 (a-b). Insulation material.

2.2. LECA Material

The physical properties of LECA [1, 5-7] are mentioned in the below table 2. The figure 2 shows the sample LECA material used in this study.

| S.No  | Physical Properties     | Value |
|-------|-------------------------|-------|
| 1     | Specific gravity        | 0.56  |
| 2     | Water absorption        | 18%   |
| 3     | Impact value            | 49.68 |
2.3. General Information

- Coarse aggregate: Light weight expanded clay aggregate
- Fine aggregate: M-sand
- Insulation material: Polystyrene
- Size of mould: 200x200x400mm
- Size of the insulation material: 150x80x300mm
- Grade of concrete used: M30
- Mix ratio: 1:1.9:1.7
- Water cement ratio=0.45 (IS 456 TABLE-5)

2.4. Preparation of Materials

The lightweight construction blocks are prepared by proper relative amount of the concrete mix with LECA. The amount of aggregate proportion is changes from various nature and place of work. For construction within room in which the place not affected by weather, the 100% lightweight proportions is adequate. Similarly, for construction in outdoor projects, medium mix is needed. But important point to be noticed is, the lighter the concrete, the weaker the block [8-11]. Figure 3 and figure 4 depicts the mould and m-sand used in the study respectively.
Figure 4. M-Sand used in the study.

2.5. Testing Process

Experimental test is carried out on the blocks to determine its various parameters which are governing the strength of solid blocks. Test procedure is based on the instruction provided by the standard codes. The compressive strength and water absorption test are performed. The number of sampling required for each test is taken. Average of sampling is taken the results of each test. The compressive strength is determined using compressive testing machine, 3.5N/s to 4N/s rate of loading is applied while applying load to the blocks [12-16].

3. Results and Discussion

The table 3, represents the compressive strength of various building blocks tested as per IS 516-1959 standard on day 7. It indicates that due to the partial addition of LECA material in conventional material block gives better results than other building blocks.

| S. No | Name of the Block              | Weight of Blocks (kg) | Area of Blocks (mm²) | Load on Testing (kN) | Stress (N/mm²) |
|-------|--------------------------------|-----------------------|----------------------|----------------------|----------------|
| 1     | LECA (Partially Replaced)     | 30.13                 | 80000                | 1107                 | 13.83          |
| 2     | LECA (Fully Replaced)         | 26.49                 | 80000                | 1069                 | 13.36          |
| 3     | Thermal Insulated Block       | 28.31                 | 80000                | 490                  | 6.125          |
| 4     | Conventional Block            | 32.4                  | 80000                | 739                  | 9.26           |

In the below table 4, compressive strength of various kinds of building blocks tested as per IS 516-1959 standard on day 28. It is clear that the addition of LECA material in conventional material block gives better results.
Table 4. Compressive strength on 28th day of solid block.

| S. No | Name of the Block                   | Weight of Blocks (kg) | Area of Blocks (mm²) | Load on Testing (kN) | Stress (N/mm²) |
|-------|-------------------------------------|-----------------------|----------------------|----------------------|----------------|
| 1     | LECA (Partially Replaced)           | 30.3                  | 80000                | 2067                 | 25.81          |
| 2     | LECA (Fully Replaced)               | 26.72                 | 80000                | 1855                 | 23.18          |
| 3     | Thermal Insulated Block             | 28.53                 | 80000                | 1072                 | 13.4           |
| 4     | Conventional Block                  | 33.54                 | 80000                | 1020                 | 12.75          |

Comparison of the compressive strength of various building blocks which were tested as per IS 516-1959 standard on day 7 and 28 were shown on the table 5 below. It indicates that the partial addition of LECA material in block gives better results than fully replaced LECA material blocks and thermal insulated blocks. Figure 5 and figure 6 shows the images of the blocks loaded for compression testing and images of the blocks after testing respectively.

Table 5. Comparison of the compressive strength at different days.

| S. No | Name of the block                   | Load on testing - 7 days (KN) | Load on testing - 28 days (KN) |
|-------|-------------------------------------|------------------------------|-------------------------------|
| 1     | LECA (Partially Replaced)           | 1107                         | 2067                          |
| 2     | LECA (Fully Replaced)               | 1069                         | 1855                          |
| 3     | Thermal Insulated Block             | 490                          | 1072                          |
| 4     | Conventional Block                  | 739                          | 1020                          |

Figure 5. Compression test on blocks.
The table 6, represents water absorption test results of different building blocks in terms of percentage. The water absorption tests were conducted as per IS 1124-1974 standard. The images of the water absorption tests were shown in the below figure 7.

| S. No | Name of the Block                | Dry weight of the blocks (kg) | Wet weight of the blocks (kg) | Water Absorption (%) |
|-------|----------------------------------|------------------------------|-------------------------------|----------------------|
| 1     | LECA (Partially Replaced)        | 30.3                         | 39                            | 28.71                |
| 2     | LECA (Fully Replaced)            | 26.72                        | 35.95                         | 35.03                |
| 3     | Thermal Insulated Block          | 28.18                        | 34.37                         | 22.15                |
| 4     | Conventional Block               | 33.54                        | 45.75                         | 36.4                 |

The presented research results show that the compressive strength of partially replaced LECA is 13.83 N/mm$^2$ and for fully replaced LECA is 13.36 N/mm$^2$ at seventh day. Similarly, the compressive strength of partially replaced LECA is 25.81 N/mm$^2$ and for fully replaced LECA is 23.18 N/mm$^2$ at twenty eighth day. On other hand, thFe obtained results shows the enhancement in compressive strength for partially replaced LECA than thermal insulated blocks (125% and 92.82% higher than
thermal insulated blocks at day 7 and day 28. The water absorption percentage of partially replaced and fully replaced LECA is less than conventional blocks (26% and 3.9% lesser at day 28) and less than 64% compared with thermal insulated blocks. From this we can conclude that the reduction in the weight of concrete will reduce the dead weight of concrete. Hence, the construction cost gets decreased by reducing the amount pay out for construction of buildings.

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