COMPARATIVE STUDY AND PERFORMANCE OF CELLULAR LIGHT WEIGHT CONCRETE

Anik Gupta
Research Scholar, Academy of Scientific and Innovative Research CRRI Staff Quarters, New Delhi 110025, India.

Mukul Rathore
Research Scholar, Academy of Scientific and Innovative Research CRRI Staff Quarters, New Delhi 110025, India.

Abstract- Cellular Lightweight Concrete has been successfully used and it has gained popularity due to its lower density and comparative strength than conventional brick. It is created by uniform distribution of air bubbles throughout the mass of concrete. The foam contains isolated air bubbles, which creates million of unconnected tiny voids/cells in the mix resulting in lighter weight of concrete. CLC can be produced in wide range of controlled densities from 400 kg/m$^3$ to 1,800 kg/m$^3$. So, this report presents a comparative study of CLC with equal strength of brick having lower density as compared to bricks. Further we have analyzed the economical savings in structural design requirements as per the deduction in dead load of the whole structure, so this also includes an overall capital reduction. It was observed in the study that savings in steel due to use of CLC blocks in terms of weight of beam member were found to be 8.635kg

Keywords- Cellular light weight concrete, CLC, brick masonry,

I. INTRODUCTION

Concrete is known as a common material which is widely used in the construction industry, from basic work to multi-storey building and mega structure. Concrete is a material where mixture by cement, water, and aggregate (fine) which must be workable, resistance to freezing, chemicals resistance, low permeability, wear resistance, and economy. CLC technology has been used in over 45 countries of the world over the past 30 years to construct over a hundred thousand houses, apartments, schools, hospitals, industrial, commercial buildings etc. The introduction in India of a modified version using over 25% fly ash has made it an even more eco-friendly and cost effective version of CLC. In the process, the product brings quality housing closer to the masses at a faster and at a lower cost. CLC, is the first of its kind with a very simple method of production, which can easily be adopted in pre-cast plants or even at the project-site itself under ambient conditions. It requires only a nominal investment. The CLC version with fly ash as one of its major constituents, is still cheaper and more environment friendly. CLC has moderate embodied energy content and performs very well as thermal insulation. Blocks are made to very exacting dimensions and are usually laid in thin-bed mortar that is applied with a toothed trowel, although more conventional thick-bed mortar can be used. CLC has a long life and does not produce toxic gases after it has been put in place. It offers a substantial material savings as little cement and no gravel is used. Cellular Lightweight Concrete (CLC) is produced by the mixing of sand, fly-ash cement foam and water in requisite proportion in ready mix plant or ordinary concrete mixer. The mixed slurry is then poured into moulds of
pre-cast blocks / structural components / assembled form-work of building elements. It is essentially air-cured, thus can be produced at project site, utilizing equipment and moulds normally in use for conventional concrete. The foam is produced with the help of a Foam Generator by using a foaming agent. The foam contains isolated air bubbles, which creates million of unconnected tiny voids/cells in the mix resulting in lighter weight of concrete. CLC has a long life and does not produce toxic gases after it has been put in place. It offers a substantial material savings as little cement and no gravel is used. It is easier to handle and place one CLC block as compared to equal volume of bricks. (1 Block=14 Bricks approx.). CLC, like conventional concrete ages well, increasing its strength by as much as 50% (!) between 28 and 90 days after pouring. As long as CLC draws humidity from the atmosphere it will keep on increasing its mechanical properties. Curing takes place within the same period as conventional concrete. If casting is done in the evening, the concrete could be demoulded the next morning. Curing can be speeded up by heat, steam or chemical (accelerators). CLC is an excellent and competitive material for low-rise, load-bearing construction and outside walls as well as partitioning work in multi-storied building

II. ADVANTAGES OF CLC

A. REDUCTION OF DEAD LOAD
Unstable ground conditions or desire to add extra floors on to existing structures often limits application of normal dense concrete. Lightest possible dead load is also highly appreciated for economy in structural design in high earthquake prone areas.

B. MATERIAL SAVING
CLC uses no gravel-only sand, cement, water, fly ash, and foam. The use of cellular cement concrete yields substantial savings where gravel is not readily available or hard to obtain or is very costly. In multi storey constructions, partitions, floor, and other non-load bearing building elements are recommended to be made in cellular cement concrete, thereby substantially reducing the dead-load of the structure therefore consequently saving reinforcing steel required for foundations and main structural elements.

C. SAVING IN TRANSPORTATION COSTS
Reduced weight of materials and zero transportation of CLC produced at project site imply less/nil transportation expenses.

D. EASE OF HANDLING
Building elements of CLC can be handled manually in larger dimensions (double sized) in comparison with those of dense concrete.

E. HILLY AREA
Construction in hilly areas is easier with CLC as expensive transportation of bricks is dispensed with.

F. ECO-FRIENDLY
CLC is remarkably eco friendly. It saves depletion of the top soil, while at the same time it can actually use fly ash as industrial waste as one of its major constituents. The production process of CLC or its use does not release any harmful effluents to ground, water or air (unlike smoke of brick kilns and ruin of top soil in production of bricks). CLC due to its low weight is ideal for making partition walls. The use of CLC for this purpose will reduce the need for plywood partitions. This consequently will result in reduction in deforestation and will benefit environment.

G. THERMAL INSULATION
Air is known to be the best insulation material available. Air voids, if smaller than 2mm in size consequently increase thermal insulation subsequently. Normal aggregate concrete has a specific thermal conductivity of 2.1W/m.k compared to 0.404 only for 1200 kg/cum cellular concrete. To offer identical
thermal insulation as a 100 mm thick wall, the equivalent thickness of dense concrete wall would have to be more than five times thicker (i.e. 500mm) and ten times heavier.

H. FIRE PROTECTION
Fire rating of cellular light weight block is far superior to that of brickwork or dense concrete. Just a 100mm thick wall of 1200kg/cum CLC offers fire endurance (heat transmission) of 3 hours. Moreover, there are no dangerous fumes or spread of fire as experienced with plywood partitions having rigid (styro, urethane) insulation material often the reason for loss of life of individuals due to toxic fumes during fires.

I. ISOLATION:
CLC blocks can be used as an isolated wall as it cannot trespass of heat and cold from the wall made from CLC blocks.

J. MISCELLANEOUS
Speedy construction, universal applicability, easy to handle, uniformity and good quality.

III. TEST PERFORMED
A. DIMENSIONS
Concrete masonry units shall be made in sizes and shapes to fit different construction needs. They include stretcher, comer, double comer or pier, jamb, header, bull nose and partition block and floor units.

CLC block shall be referred to by its nominal dimensions. The term 'nominal' means that the dimension includes the thickness of the mortar joint. Actual dimensions (length and height) shall be 10 mm short of the nominal dimension (or 6 mm short in special cases where finer jointing is specified).

The nominal dimensions of the concrete blocks shall be as follows:

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>400, 500 or 600 mm</td>
</tr>
<tr>
<td>Height</td>
<td>250 or 300 mm</td>
</tr>
<tr>
<td>Width</td>
<td>100, 150, 200 or 250 mm</td>
</tr>
</tbody>
</table>

Fig. 1 Faces of CLC Block
A concrete masonry unit, anyone of external dimensions of which is greater than the corresponding dimension of a brick as specified in IS 3952 and of such size and mass as to permit it to be handled by one man is called a block. Gross Area is the total area occupied by the block on its bedding face, including areas of cavities and end recesses. Overall dimensions shall be measured with a steel scale graduated in 1 mm divisions.

B. DENSITY
The density calculated by dividing the mass of an oven dry block by the overall volume, including the holes or cavities and end recesses. The average block density, when determined as given shall not vary by more than ± 5 percent of the density specified in Table I of IS 2185. Three blocks taken at random from the samples selected in accordance with 11, shall be dried to a constant mass in a suitable oven heated to approximately 100°C. After cooling the blocks to room temperature, the dimensions of each block shall be measured in centimeters (to the nearest millimeters) and the overall volume computed in cubic centimeters.
The blocks shall then be weighted in kilograms (to the nearest 10g) and the density of each block calculated:

\[
\text{Density} = \frac{\text{Mass of Block in kg}}{\text{Volume of Specimen in cm}^3} \times 10^6 \text{kg/m}^3
\]

The average of the densities for the three blocks shall be taken as the average density.

C. WATER ABSORPTION

The average water absorption, when determined in the manner prescribed as here shall not exceed the values prescribed in Table I. Three full-size units shall be used. The test specimens shall be completely immersed in water at room temperature for 24h. The specimens shall then be weighed, while suspended by a metal wire and completely submerged in water. They shall be removed from the water and allowed to drain for 1min by placing them on a 10mm or coarser wire mesh, visible surface water being removed with a damp cloth, and immediately weighed. All specimens shall be dried in a ventilated oven at 100°C to 115°C for not less than 24h and until two successive weighing at intervals of 2h show an increments of loss not greater than 0.2 percent of the last previously determined mass of the specimen.

Calculate the water absorption as follows:

\[
\text{Water Absorption (\%)} = \frac{A - B}{B} \times 100
\]

A = Wet Mass of Unit in kg;
B = Dry Mass of Unit in kg.

TABLE I

PERMISSIBLE VALUE OF WATER ABSORPTION AS PER IS:2185-2008

<table>
<thead>
<tr>
<th>Block Density in Oven</th>
<th>Water Absorption (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>800</td>
<td>12.5</td>
</tr>
<tr>
<td>1000</td>
<td>12.5</td>
</tr>
<tr>
<td>1200</td>
<td>10.0</td>
</tr>
<tr>
<td>1400</td>
<td>10.0</td>
</tr>
<tr>
<td>1600</td>
<td>7.5</td>
</tr>
<tr>
<td>1800</td>
<td>7.5</td>
</tr>
</tbody>
</table>

D. COMPRESSION STRENGTH

The compressive strength of a concrete masonry unit shall be taken as the maximum load, in Newton, divided by the gross cross-sectional area of the unit, in square millimeters. The gross area of a unit is the total area of a section perpendicular to the direction of the load, including areas within cells and within re-entrant spaces unless these spaces are to be occupied in the masonry by portions of adjacent masonry. The term ‘characteristic compressive strength’ means that value of the strength of the material below which not more than 5 percent of the test results are expected to fall. The average and the minimum individual compressive strength when determined in the manner described here shall be not less than that prescribed. The testing machine shall be equipped with two steel bearing blocks one of which is a spherically seated block that will transmit load to the upper surface of the masonry specimen, and the other a plane rigid block on which the specimen will rest. When the bearing area of the steel blocks is not sufficient to cover the bearing area of the masonry specimen, steel bearing plates should be used.

Specimens shall be tested with the centroid of their bearing surfaces aligned vertically with the centre of thrust of the spherically seated block of the testing machine and as per code IS 456-1957.

Gypsum Plaster Capping neat paste of special high-strength plaster and water shall be spread evenly on a non-absorbent surface that has been lightly coated with oil. Such gypsum plaster, when gauged with water at the capping consistency shall have a compressive strength at a 2h age of not less than 25 N/mm², when tested on 50mm cubes.

The load up to one-half of the expected maximum load may be applied at any convenient rate, after which the control of the machine shall be adjusted as required to give a uniform rate of travel of the moving head such that the remaining load is applied in not less than one nor more than two minutes.
Report be results to the nearest 0.1 N/mm² separately for each unit and is the average for the 8 units.

<table>
<thead>
<tr>
<th>Block Density in Oven Dry (kg/m³)</th>
<th>Compressive Strength in N/mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average Min.</td>
</tr>
<tr>
<td>800</td>
<td>2.5</td>
</tr>
<tr>
<td>1000</td>
<td>3.5</td>
</tr>
<tr>
<td>1200</td>
<td>6.5</td>
</tr>
<tr>
<td>1400</td>
<td>12.0</td>
</tr>
<tr>
<td>1600</td>
<td>17.5</td>
</tr>
<tr>
<td>180</td>
<td>25</td>
</tr>
</tbody>
</table>

TABLE II

IV. RESULT AND DISCUSSIONS

The specimen for various tests has been discussed in above mentioned tests. In this chapter, discussion will be focused on the performance of Cellular lightweight concrete. All the tests method adopted were described in the previous chapter. The results presented in this chapter are regarding the compressive strength test, density and water absorption for different mixes of the Cellular lightweight concrete.

The amount of steel reinforcement used in the CLC block was found to be 1513.53 mm² whereas the amount of steel reinforcement required for brick masonry was 1681.64 mm². Therefore savings obtained using CLC blocks is approximately 168.1 mm² i.e. 8.635 Kg. Also this study has shown that the use of fly ash in foamed concrete, can greatly improve its properties. Most of the cleaner production effort is required in India and hence CLC blocks may be used as a replacement of burnt clay bricks, for construction purpose, which is advantageous in terms of general construction properties as well as eco-friendliness.

V. REFERENCES