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Research Article

EXPERIMENTAL STUDY OF STRENGTH CHARACTERISTICS OF CELLULAR LIGHT WEIGHT CONCRETE

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A R T I C L E I N F O

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A B S T R A C T

Lightweight concrete has been widely used in different structural applications and its consumption grows every year on a global basis. The reason for this is that using lightweight concrete has many advantages. These include: a reduction in the dead load of the building, which minimizes the dimensions of structural members; the production of lighter and smaller pre-cast elements with inexpensive casting, handling and transportation operations; the provision of more space due to the reduction in size of the structural members; a reduction in the risk of earthquake damage; and increased thermal insulation and fire resistance. The main objective of this dissertation is to study the properties of cellular lightweight concrete blocks. Lightweight cellular concrete blocks are casted with 65% of Fly ash and 35% of cement with foam content 1.5% of total weight and to increase its strength sand and quarry dust is added in its composition which replaces fly ash up to 30% at an interval of 5%.

INTRODUCTION

In India, among the multiple construction applications, masonry structures form the largest proportion of the uses of conventional burnt clay bricks, fly ash bricks, hollow concrete block, which have many drawback (like heavy weight, non-uniform shape and size, low thermal insulation and fire resistance etc.), that can be improved by using lightweight concrete. The utilization lightweight concrete, provides improved thermal insulation and fire resistance, thereby it is considered an effective approach not only in fire protection but also in reducing the U-values (it's the measure of heat loss through a structural element) of structures.

Lightweight concrete can be produced in a practical range of densities between about 300 and 2000 kg/m3, using three methods. The first is so-called no fines, where the fine portion (sand particles) of the total concrete aggregate is omitted. The second method is by introducing stable air bubbles inside the concrete body through mechanical foaming and chemical admixture. This type of concrete is known as aerated, cellular or gas concrete. The third and most popular method is by using lightweight aggregate. This may come from either a natural or an artificial source.

Lightweight foamed concrete can be gaseous or foamed concrete that uses specially prepared chemicals; it can be a no-fines concrete that uses ordinary gravel or crushed stone, a normal-weight aggregate concrete with an excessive amount of entrained air, or a concrete that is made from lightweight aggregates. Lightweight foamed concrete is a class of aerated concrete. Aerated concrete can be classified according to the methods and agents used to introduce air in the concrete. Aerated concrete can be produced by introducing air entraining agent, gas forming chemicals and foaming agents. Concrete which is aerated using foaming agent is known as lightweight foamed concrete. Foaming agents can be synthetic based or protein based.

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Physical Properties

Drying shrinkage*:* Foam concrete possesses high drying shrinkage due to the absence of aggregates, i.e., up to 10 times greater than those observed on normal weight concrete. Autoclaving is reported to reduce the drying shrinkage significantly by 12–50% of that of moist-cured concrete due to a change in mineralogical compositions. The shrinkage of foam concrete reduces with density which is attributed to the lower paste content affecting the shrinkage in low density mixes.

Low Density and High Strength: Due to its low density, foam concrete imposes little vertical stress on the substructure - a particularly important attribute in areas sensitive to settlement. Heavier density (1000 kg/m3 +) foam concrete is mainly used for applications where water ingress would be an issue - infilling cellars, or in the construction of roof slabs

Compressive strength: The compressive strength decreases exponentially with a reduction in density of foam concrete. The parameters affecting the strength of foam concrete are cement–sand and water–cement ratios, curing regime, type and particle size distribution of sand and type of foaming agent used. For dry density of foam concrete between 500 and 1000 kg/m3, the compressive strength decreases with an increase in void diameter. For densities higher than 1000 kg/m3, as the air-voids are far apart to have an influence on the compressive strength, the composition of the paste determines the compressive strength.

***Flexural and tensile strengths**:* Splitting tensile strengths of foam concrete are lower than those of equivalent normal weight and lightweight aggregate concrete with higher values observed for mixes with sand than those with fly ash. Use of Polypropylene fibers has been reported to enhance the performance with respect to tensile and flexural strength of foam concrete.

Applications of Cellular Lightweight Concrete

Building Blocks: Blocks and panels can be made for partition and load bearing walls. They can be made with almost any dimensions.

***Floor Screed*:** Foamed concrete can be used for floor screeds, creating a flat surface on uneven ground and raising floor levels.

***Roof Insulation*:** Foamed Concrete is used extensively for roof insulation and for making a slope on flat roofs. It has good thermal insulation properties and because it is lightweight foamed concrete does not impose a large loading on the building.

***Road Sub-Base*:** Foamed Concrete is being used road sub base on a bridge. Foamed concrete is lightweight so that the loading imposed on the bridge is minimized.

Advantages of Cellular Lightweight Concrete

Fly ash foamed concrete add to the diminishment of building dead weight along these lines bringing about more monetary basic configuration. Generation of more financial basic outline will diminish the measure of material utilized and in the long run chopping down the expense of development venture itself bringing about benefit increment to the contractual worker. Other than that, different scientists included that the gentility of structure makes it less demanding to be transported and took care of. Furthermore, it's additionally has a low warm conductivity that makes it a fantastic flame assurance property.

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.

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.

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 ruining 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.

Saving in Transportation Costs: Reduced weight of materials and zero transportation of CLC produced at project site imply less/nil transportation expenses.

Ease of Handling: Building elements of CLC can be handled manually in larger dimensions (double sized) in comparison with those of dense concrete.

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.

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.

Sound Insulation: -Over the efforts to keepon increasing the thermal capacity of building members, other aspects have been neglected, such as sound insulation. Sound is experienced asair-borne or foot-fall sound (impact).

Objective of Research Work

Cellular Light weight Concrete (CLWC) is not a new invention in concrete world. It has been known since ancient times. It was made using natural aggregates of volcanic origin such as pumice, scoria, etc. The Greeks and the Romans used pumice in building construction. Lightweight concrete can be defined as a type of concrete which includes an expanding agent in that it increases the volume of the mixture while giving additional qualities such as inability and lessened the dead weight. The usage of Cellular Light-weight Concrete (CLC) blocks gives a prospective solution to building construction industry along with environmental preservation. In this paper, parametric experimental study for producing CLWC using fly ash is presented. The performance of cellular lightweight concrete in term of density and compressive strength are investigated. From the result, it can be seen that compressive strength for cellular light weight concrete is low for lower density mixture. The increments of void throughout the sample caused by the foam in the mixture lowers the density.

Cellular Light Weight Concrete is a versatile material which is made up of cement, fly ash and protein based foam. Basically it is a new material which is currently using in India for walling purpose. Cellular Light Weight Concrete gives better sound insulation, thermal insulation, durable, lightweight, uniform size & shape, reduce permeability. It is non-load bearing structural element which has lower strength than conventional concrete. Cellular concrete is popular because of its light weight which reduces self-weight of structure. In this paper light weight cellular concrete blocks are casted with 65% of Fly ash and 35% of cement with foam content 1.5% of total weight and to increase its strength sand and quarry dust is added in its composition which replace fly ash upto 30% at an interval of 5%. to check properties of these cellular lightweight concrete (CLC) blocks test like compressive strength, density and water absorption is done in the laboratory.

MATERIALS AND METHODOLOGY

Materials

Ordinary Portland cement: For current work, for the production of cellular light weight concrete, Ordinary Portland Cement 53 grade is used. Specific gravity of cement is 3.15 with a standard consistency of 32%.

Fly Ash: In this research, for the production of cellular light weight concrete, fly ash is used which is collected from Guru Gobind Singh Thermal Power Plant, Ropar, Punjab with specific gravity 2.56 and fineness 3.5%.

Quarry Dust: Quarry dust is collected from nearest crusher plant i.e., Dhillon crusher plants, Road, SalempurKhurd, Punjab.

Water: Water is main constituent which used in for experimental study possesses superiority for drinking purpose. It also effectively reacting with cement and makes sticky stuff binds the concrete constitue*nts to give it in a dense form.* Water should be avoided if it contains large quantities of suspended solids, excessive amounts of dissolved solids, or appreciable amounts of organic materials. Water which is used in this project is confirming to the specification of IS 456: 2000.

Foam agent: Protein based standard foaming agents or hydrolyzed protein agents are made by protein hydrolysis from animal proteins such as keratin (horn meal and hoof), cattle hooves and fish scales, blood and saponin, and casein of cows, pigs and other remainders of animal carcasses. This leads not only to occasional variations in quality, due to the differing raw materials used in different batches, but also to the very intense stench of such foaming agents. Their self-life is about 1 year under sealed conditions.

Methodology

- ✓ Properties of all ingredient materials cement, fly ash, water, Foam agent required for are studied experimentally.
- ✓ The design of required concrete mix is prepared.
- ✓ For different doses of Foam agent, the concrete parameters such as compressive strength
- ✓ Based on the experimental results the compressive strength, flexural strength and split tensile strength for various dosages.

Observations and Test Performed

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

Density =Mass of block /volume of specimen

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 increment of loss not greater than 0.2 percent of the last previously determined mass of the specimen. Calculate the water absorption as follows:

Water Absorption (%) =(A-B)/B x100
A = Wet Mass of Unit in kg;
B = Dry Mass of Unit in kg.

Compressive 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 millimetres. 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. Permissible value of compressive strength as per IS:2185-2008 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/mm separately for each unit.

Mix Proportion: Concrete mix design is the manner of selecting suitable constituents of concrete and determining the relative amount of the materials with the objective of producing the most economical concrete while holding the specified minimum properties such as strength, consistency and durability. There is no standard method of for proportioning the cellular light weight concrete like conventional concrete. From the literatures reviewed, it is quite significant that the density is the prime factor to be considered for manufacturing the cellular light weight concrete. The properties of cellular light weight concrete are directly or indirectly related to its density, such as the strength of the cellular light weight concrete decreases exponentially with the reduction in its density. Thermal and sound insulation is increased with the reduction in density. There are also some other factors like cement filler ratio and foam percentage, which indirect effects the density of the concrete. So that the density is prime concern for the production of cellular light weight concrete rather than target mean strength in conventional concrete. Six trail mix is casted with target density of approximately 1500 kg/m3. The details of mix proportion for cellular light weight concrete are given in Tables below

Table 1 Mix Proportion of cellular light weight concrete

Sr. No.	Mix Name	Cement Content (%)	Fly Ash Content (%)	Quarry Dust (%)
1.	CC	35	65	0
2.	T1	35	60	5
3.	T2	35	55	10
4.	T3	35	50	15
5.	T4	35	45	20
6	T5	35	40	25
7	T6	35	35	30

RESULTS AND DISCUSSION

Dry Density: For this project target density is 1500 kg/m3, density of the cubes totally depend upon foam content as foam content is increased in mix dry density decreased. 1.5% of the foam is mixed for this study. Result of dry density is given in table 1 and graph 1-2. It is also observed that quarry dust content increases the density of the CLWC.

Table 2 Dry Density of Cellular LightWeight Concrete

Mix	Density (kg/m^3)
CC	1510
T1	1524
T2	1538
T3	1541
T4	1549
T5	1550
T6	1568

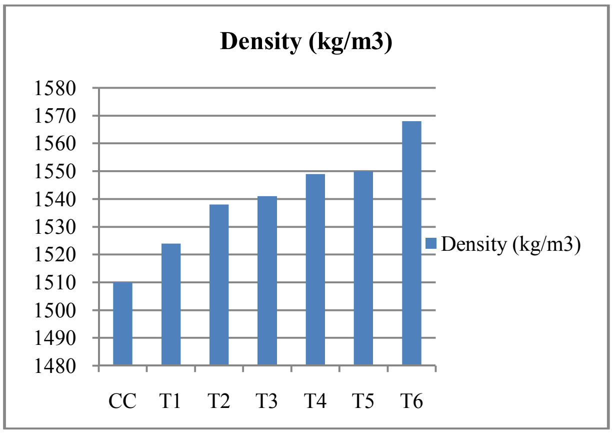

Fig 1 Result of Dry Density of Cellular Light Weight Concrete (Bar Chart)

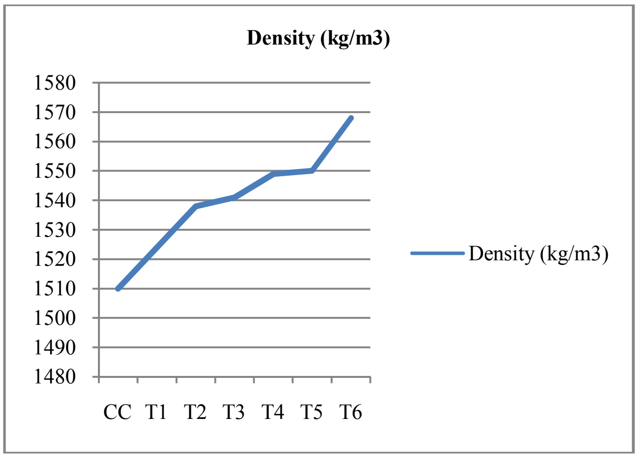

Fig 2 Result of Dry Density of Cellular Light Weight Concrete (Line Chart)

Compressive Strength

Result of compressive strength test of CLWC is given in table 3 and fig 3-4 Introduction of quarry dust in CLWC proportion increases the compressive strength of CLWC. Compressive strength increases as quarry dust content in proportion is increases. Fly ash: Cement (65:35) CC mix gives compressive strength of 5.78 MPa after 28 days of curing and T 6 mix which contains 30% quarry dust possess 8.67 MPa of compressive strength after 28 days of curing.

Table 3 Result of Compressive Strength of Cellular Light Weight Concrete

Mix	Compressive Strength (Mpa)	
	7 Days	28 Days
CC	2.35	5.78
T1	3.67	6.51
T2	4.12	6.92
T3	4.95	7.34
T4	5.37	8.12
T5	5.74	8.38
T6	6.17	8.67

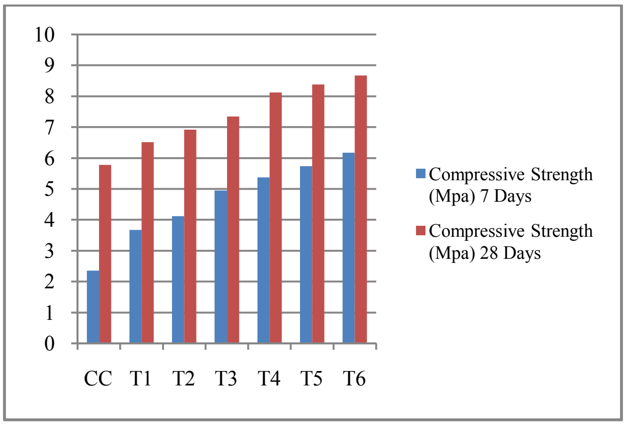

Fig 3 Compressive Strength of Cellular Light Weight Concrete (Bar Chart)

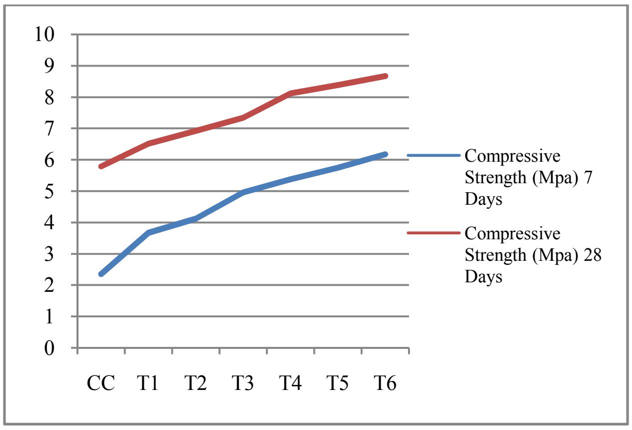

Fig 4 Compressive Strength of Cellular Light Weight Concrete (Line Chart)

CONCLUSION

Present study contains a study of properties of Cellular light weight concrete and also the utilization of quarry dust in the proportion of Cellular light weight concrete. Conclusions is drawn from the present study is given below:

Dry density of the CLWC is increased when quarry dust is partially replaced by fly ash content in it. It is also concluded that increasing content of quarry dust in the composition, increases the density of CLWC, replacement of fly ash by quarry dust up to 30% possess increment of 3.70% in dry density

Compressive Strength of the CLWC is increased when quarry dust is partially replaced by fly ash content in it. It is also observed that increasing content of quarry dust in the composition, increases the compressive strength of CLWC, replacement of fly ash by quarry dust upto 30% possess increment of 33.33% in compressive strength.

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