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Study on Cellular Lightweight Concrete and its Strength & Characteristics

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Abstract:— **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 availability and lessened the dead weight. Lightweight concrete maintains its large voids and not forming laitance layers or cement films when placed on the wall. However, sufficient water cement ratio is vital to produce adequate cohesion between cement and water. Insufficient water can cause lack of cohesion between particles, thus loss in strength of concrete. Likewise too much water can cause cement to run off aggregate to form laitance layers, subsequently weakens in strength.This mini project is prepared to show the activities and progress of the lightweight concrete. The performance of lightweight concrete such as compressive strength tests, water absorption and density and supplementary tests and comparisons made with other types of lightweight concrete were carried out.**

I. INTRODUCTION

Concrete is most important construction materials. Concrete is a material used in building construction, consisting of a hard, chemically inert particulate substance, known as an aggregate that is bonded together by cement and water. In upcoming years there has been an increasing worldwide demand for the construction of buildings, roads and anairfield which has mitigate the raw material in concrete like aggregate. In some rural areas, the huge quantities ofaggregate that have already been used means that local materials are no longer available and the deficit has to be madeup by importing materials from other place. Therefore a new direction towards Cellular Lightweight Concrete inbuilding and civil engineering construction is used.

The origin of the CLWC is difficult to assess, it would not be an exaggeration to say that its roots are from the ancient period. With the increase in the demand of CLWC and the unavailability of the aggregates, technology for producing lightweight aggregates has been developed. Lightweight concrete is the type of concrete which includes an expanding agent in that it increases the volume of the mixture and lessened the dead weight. It is lighter than the conventional concrete. It was first introduced by the Romans in the second century where 'The Pantheon' has been constructed using pumice. It is most common type of aggregate used in second century.

From there on, the use of lightweight concrete has been widelyspread across other countries.The main specialties of lightweight concrete are its low density and thermalconductivity. Its advantages are that there is a reduction of dead load, faster building ratesin construction and lower haulage and handling costs. The building of 'The Pantheon' oflightweight concrete material is still standing eminently in Rome until now for about 18centuries as shown in Figure 1. It shows that the lighter materials can be used in concrete construction and has and economical advantage.

Fig1. 'The Pantheon'

1.1 Literature Review

Neville (1999) suggests three main means of reducing density of concrete. The most common is to use a lightweight aggregate which results in a lightweight aggregate concrete. The other ways include increasing air content in cement paste, which results in cellular concrete, and creating air voids between coarse aggregate particles as in the case of no-fines concrete [1]. A. K. Marunmale (2014) stated in " Designing, Developing and Testing of Cellular Lightweight Concrete Brick (CLC) Wall built in Rat-Trap bond" that cellular lightweight concrete reduces the use of material (natural river sand and red soil) and uses the waste material (fly-ash), hence it is green construction material. Also the results on CLC brick are quite satisfactory and it can be used for non-load bearing exterior and interior wall. Also the light weight of CLC brick reduces the dead load on the structure and provides good thermal insulation [2]. Neville, (1999) reports that the density of no-fines concrete using normal weight aggregate ranges from 1,600kg/m^3 to 2,500kg/m^3 with corresponding compressive strengths of between 1.5MPa and 14MPa. He also states that because no-fines concrete has large pores and that it is subject to limited capillary suction, the capillary pores are not fully saturated, which makes this type of concrete frost resistant [1].

1.2 Types of Lightweight Concrete

Lightweight concrete can be prepared either by injecting air in its composition or it can be achieved by omitting the finer sizes of the aggregate or even replacing them by a hollow, cellular or porous aggregate. Particularly, lightweight concrete can be categorized into three groups:

i) No-fines concrete
ii) Lightweight aggregate concrete
iii) Aerated/Foamed concrete
iv)Thermocol concrete

Fig2.Lightweight concrete

(i) No-fines concrete :-

No-fines concrete can be defined as a lightweight concrete composed of cement and fine aggregate. Uniformly distributed voids are formed throughout its mass. The main characteristics of this type of lightweight concrete is it maintains its large voids and not forming laitance layers or cement film when placed on the wall. No-fines concrete is usually used for both load bearing and non-load bearing for external walls and partitions. The strength of no-fines concrete increases as the cement content is increased. However, it is sensitive to the water composition. Insufficient water can cause lack of cohesion between the particles and therefore, subsequent loss in strength of the concrete. Likewise too much water can cause cement film to run off the aggregate to form laitance layers, leaving the bulk of the concrete deficient in cement and thus weakens the strength.

(ii) *Lightweight aggregate concrete* :-

Porous lightweight aggregate of low specific gravity is used in this lightweight concrete instead of ordinary concrete. The lightweight aggregate can be natural aggregate such as pumice, scoria and all of those of volcanic origin and the artificial aggregate such as expanded blast-furnace slag, vermiculite and clinker aggregate. The main characteristic of this lightweight aggregate is its high porosity which results in a low specific gravity.

The lightweight aggregate concrete can be divided into two types according to its application. One is partially compacted lightweight aggregate concrete and the other is the structural lightweight aggregate concrete. The partially compacted lightweight aggregate concrete is mainly used for two purposes that is for precast concrete blocks or panels and cast in-situ roofs and walls. The main requirement for this type of concrete is that it should have adequate strength and a low density to obtain the best thermal insulation and a low drying shrinkage to avoid cracking.

Structurally lightweight aggregate concrete is fully compacted similar to that of the normal reinforced concrete of dense aggregate. It can be used with steel reinforcement as to have a good bond between the steel and the concrete. The concrete should provide adequate protection against the corrosion of the steel. The shape and the texture of the aggregate particles and the coarse nature of the fine aggregate tend to produce harsh concrete mixes. Only the denser varieties of lightweight aggregate are suitable for use in structural concrete.

Fig 3. Concrete cubes

(iii) Aerated/Foamed concrete:-

Aerated concrete does not contain coarse aggregate, and can be regarded as an aerated mortar. Typically, aerated concrete is made by introducing air or other gas into a cement slurry and fine sand. In commercial practice, the sand is replaced by pulverizedfuelash or other siliceous material, and lime maybe used instead of cement. There are two methods to prepare the aerated concrete. The first method is to inject the gas into the mixing during its plastic condition by means of a

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chemical reaction. The second method, air is introduced either by mixing-in stable foam or by whipping-in air, using an air-entraining agent. The first method is usually used in precast concrete factories where the precast units are subsequently autoclaved in order to produce concrete with a reasonable high strength and low drying shrinkage. The second method is mainly used for in-situ concrete, suitable for insulation roof screeds or pipe lagging.

(iv) Thermocol concrete:-

Like aerated concrete, thermocol concrete does not contain coarse aggregate. Thermocol balls are used to make the concrete lightweight. Along with thermocol balls some air entraining agent and admixtures (such as Auramix-300) can be used to make the concrete lightweight. Lightweight concrete is mainly used for precast concrete blocks or panels.

II. METHODOLOGY

➢ ***Testing Program Of Lightweight Concrete*:-**

In order to study the behaviour of lightweight concrete, normal concrete testing was done to determine the material and structural properties of each type of lightweight concrete and how will these properties differ according to a different type of mixture and its composition. Once concrete has hardened it can be subjected to a wide range of tests to prove its ability to perform as planned or to discover its characteristics. For new concrete this usually involves casting specimens from fresh concrete and testing them for various properties as the concrete matures.

➢ ***Compressive Strength:-***

Compressive strength is the primary physical property of concrete, and is the one most used in design. It is one of the fundamental properties used for quality control for lightweight concrete. Compressive strength may be defined as the measured maximum resistance of a concrete specimen to axial loading. It is found by measuring the highest compression stress that a test cylinder or cube will support. There are three type of test that can be used to determine compressive strength; cube, cylinder, or prism test. The 'concrete cube test' is the most familiar test and is used as thestandard method of measuring compressive strength for quality control purposes.

Fig 4. CTM machine

➢ ***Water Absorption***

These properties are particularly important in concrete, as well as being important for durability. It can be used to predict concrete durability to resist corrosion. Absorption capacity is a measure of the porosity of an aggregates; it is also used as a correlation factor in determination of free moisture by oven-drying method The absorption capacity is determined by finding the weight of surface-dry sample after it has been soaked for 24 hr and again finding the weight after the sample has been dried in an oven; the difference in weight, expressed as a percentage of the dry sample weight, is the absorption capacity. The test is intended as a durability quality control check and the specified age is 28-32 days

➢ ***Density***

The density of both fresh and hardened concrete is of interest to the parties involved for numerous reasons including its effect on durability, strength and resistance to permeability. Hardened concrete density is determined either by simple dimensional checks, followed by weighing and calculation or by weight in air/water buoyancy methods. To determine the density of lightweight concrete sample, the simple method is preferred.

III. PROPORTION:

Sr. No.	Materials	Proportion
1	Cement	300kg/m^3
2	Fly ash	150 kg/m^3
3	River sand	200 kg/m^3
4	Admixture	3.5 kg/m^3
5	Water	170 kg/m^3
6	Thermocol balls	13 kg/m^3
7	Air entraining agent	0.1 %

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IV. MATERIALS:

Cement, sand, water, air entraining agent, fly ash, thermocol ball & admixture were used.

- **Cement -** OPC 43 GRADE conforming to IS 8112
- **Sand**-River sand
- **Water-** Potable water
- **Fly ash**
- **Thermocol balls**
- **Admixture-**Auramix-300

➢ **Cement**

Cement is the binding material or agent mixture of argillaceous and calcariferous material which is burnt in rotary kiln at a temperature of 1300ºc and cooled and grinded to a fine powder

Constituent particle of cement

Ingredient	**Formula**	**Percentage**
Lime	CaO	60-67%
Silica	SiO_2	17-25%
Alumina	Al_2O_3	3-8%
Magnesia	MgO	0.1-4%
Gypsum	$CaSo_4$	2-3%
Iron oxide	Fe_2O_3	0.5-0.6%
Alkalies	K_2O	0.1-1%
Sulphur trioxide	SO_3	1-3%

Types of cement-

- Ordinary Portland cement(– IS 12269: 1987)
- Pozzolana Portland cement(IS 1489-1991)
- Rapid hardening cement(IS 8041-1990)
- Sulphate resisting cement(IS 12330-1988)
- Portland slag cement(PSC)(IS 455-1989)
- Quick setting cement
- Super sulphated cement(IS 6909-1990)
- Low heat cement(IS 12600-1989)
- White cement(IS 8042-1989)

➢ ***River Sand***

Good quality river sand was used as a fine aggregate. Locally available sand, specific gravity 2.45, water absorption 2% and fineness modulus 3.18, conforming to I.S. – 383-1970Those fractions from 4.75 mm to 150 micron are termed as fine aggregates.The river sand is used as fine aggregate conforming to the requirements of IS: 383. The river sand is wash and screen, to eliminate deleterious materials and over size particles.

Fig 5. River sand

➢ ***Water***

Water is an important ingredient a concrete as it actively participate in the chemical reaction with the cement.Since it helps to form the strain given cement gel, the quantity & the quality of water is required to be looked into very carefully. It has been discus in about the quantity of mixing water but so for the quality of water has not been discussed .In practice, very obtain great control on property of cement an aggregate is exercise, but the control of quality of water is obtain neglected .Since quality of water of affects the strain, it is necessary for us to go into the purity and quality of water. The water used in the manufacture of concrete masonry units shall be free from matter harmful to concrete or reinforcement, or matter likely to cause efflorescence in the units and shall meet the requirements of IS 456

V. ADVANTAGES AND DISADVANTAGES OF LIGHTWEIGHT CONCRETE:

Table shows the advantages and disadvantages of using lightweight concrete as structure.

Table: Advantages and Disadvantages of Lightweight Concrete

Advantages	**Disadvantages**
i) rapid and relatively simpleconstruction	i) Very sensitive with water contentin the mixtures
ii) Economical in terms oftransportation as well as reduction in manpower	ii) Difficult to place and finishbecause of the porosity andAngularity of the aggregate. Insome mixes the cement mortar mayseparate the aggregate and floattowards the surface

iii) Significant reduction of overallweight results in saving structuralframes, footing or piles	iii) Mixing time is longer thanconventional concrete to assureproper mixing

No. of Days	Weight in gm	Compressive strength of cube in N/mm^2
3 days	2485gms	1.1Mpa
7 days	2499gms	1.87Mpa
28 days	2512gms	3.97Mpa

VI. APPLICATION OF LIGHTWEIGHT CONCRETE:

Lightweight concrete has been used since the eighteen centuries by the Romans.The application on the 'The Pantheon' where it uses pumice aggregate in the constructionof cast in-situ concrete is the proof of its usage. In USA and England in the late nineteenth century, clinker was used in their construction for example the 'British Museum' and other low cost housing. The lightweight concrete was also used in construction during the First World War. The United States used mainly for shipbuilding and concrete blocks. The foamed blast furnace-slag and pumice aggregate for block making were introduced in England and Sweden around 1930s. Nowadays with the advancement of technology, lightweight concrete expands its uses. For example,in the form of perlite with its outstanding insulating characteristics. It is widely used as loose-fill insulation in masonry construction where it enhances fire ratings, reduces noise transmission, does not rot and termite resistant. It is also used for vessels, roof decks and other applications.

VII. RESULTS:

Objective 1:- To Determine Compressive Strength of Light Weight Concrete Sample

Objective 2:- To Determine Absorption Capacity (A.C.)of Light Weight Concrete Sample

A.C.= Increased In Weight (kg) × 100%
Weight of Dry Specimen (kg)
= 0.158 x100 %
2.354
= 6.71%

Objective 3:- To Determine Density of Light Weight Concrete Sample

Density = Average Weight Of Samples (kg)
Volume of Sample (m^3)
=2.485+2.499+2.512
0.15× 0.15 ×0.15
= 2221.037 kg/ m^3

VIII. CONCLUSION

1. The purpose of compressive strength test is to identify the performance of aerated lightweight concrete in term of density and compressive strength. It can be seen that compressive strength for lightweight concrete are low for lower density mixture and vice versa.
2. The increment of voids throughout the sample caused by the thermocol in the mixture will lower the density. As a result, compressive strength will also decrease with the increment of those voids.
3. The purpose of water absorption test is to identify the capability of the concrete to absorb water. Water absorption increases when the percentage of thermocol isincreased. This is because the higher percentage of thermocol applied in each mixture; the total voids distributed in the samples will be increased.
4. Due to increase in total voids will result higher water absorption capacity since sample are capable to absorb more water when more voids are distributed in it.&
5. Finally overall conclusion of our study is - The test results on CLC concrete cubes are quite satisfactory. Also the light weight of CLC reduces the dead load on the structure and provides good thermal insulation. Thus this CLWC has a very good future scope for its development as a commercial product.

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