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Study of Effect of Light Weight Aggregate Containing Fly Ash on Properties of Concrete

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ABSTRACT:
The issue of unit weight of aggregate is of prime importance when it comes to designing a concrete mix. This becomes extremely important when it comes to designing for structures that are constructed in areas near to water bodies and in areas which are prone to earthquakes than the usual ones. The importance of unit weight of concrete forms a major factor while designing the structure components such as foundation and other structural members such as columns, beams, and shear walls as the requirement for their reinforcement and strength of concrete thus needed would primarily depend on the weight of the super structure which in directly would depend upon the weight of the non-structural members and structural members of the building. In this regard the introduction of light weight concrete has played a pivotal role in deciding for the factors and thus easing out the requirement for huge amounts of reinforcements in the building foundation and especially assisting the building construction near river bodies and in earthquake prone zones.

1. INTRODUCTION

Lightweight concrete has been defined as a concrete that has been made lighter than the conventional concrete by changing material composition or production method. It is of utmost importance to the construction industry. Most of current research focuses on high-performance concrete by which is meant cost effective material that satisfies demanding performance requirements, including durability. That reduced mass with adequate strength, improved sound and thermal insulations properties, and less energy demand during construction makes the light weight concrete makes it a high performance material. Though it cannot always substitute normal concrete for its strength potential, it has its own advantages like reduced dead load and thus economic structures and enhanced seismic resistance, high sound absorption, high thermal insulation and good fire resistance.

1.2 NEED FOR LIGHTWEIGHT

As the name itself suggests, light weight concrete is the concrete that has lower weight than the normal concrete. The design of Light weight concrete is usually a due to the type of aggregate that is being used in the manufacture of the concrete. The margin by which the concrete will be light weight will particularly be factor of the unit weight of the aggregate used in its manufacture .Lesser the unit weight of the aggregates, the lesser will be the unit weight of the concrete. Light weight concrete is usually made by replacing normal weight aggregate by light weight materials like pumice, shale ,brickbat , sintered flyash, Husk, crushed animal bones ,shells etc

1.3 CLASSIFICATION OF LIGHT WEIGHT AGGREGATES:

Light weight aggregates can be classified into two categories, namely natural light weight aggregates and artificial light weight aggregates as:

Natural light weight aggregate	**Artificial light weight aggregate**
a) Pumice	a)Artificial cinders
b) Diatomite	b) Expanded Perilite
c) Scoria	c) Foamed slag
d) Volcanic cinders	d) Bloated clay
e) Rice husk	e) Sintered fly ash
f) Saw dust	f) Exfoliated vermiculite
	g) Brickbat

2 LITERATURE REVIEW:

In Europe, the use of LWCA occurred 2,000 years ago when the Romans built Pantheon, the aqua ducts, and the Colosseum in Rome. The use of lightweight (LWAC) can be traced to as early as 3,000BC, when Mohenjo-Daro and Harappa were built during the Indus Valley civilization. It was first introduced by the Romans in the second century where 'The Pantheon' has been constructed using pumice, the most common type of aggregate used in that particular year. The building of 'The Pantheon' of lightweight concrete material is still standing eminently in Rome until now for about 18 centuries as shown in Figure 1. It shows that the lighter materials can be used in concrete construction and has an economical advantage. From there on, the use of lightweight concrete has been widely spread across other countries such as USA, United Kingdom and Sweden.

When the literature scanned, one is welcomed by an abundance of studies on the light weight concrete.

- AlaettinKilic, et al.,[1] "HIGH-STRENGTH LIGHTWEIGHT CONCRETE MADE WITH SCORIA AGGRAGATE CONTAINING MINERAL ADMIXTURES" (2003), carried out laboratory work to design SLWAC made with mineral admixture with basaltic-pumice (scoria) used as a LWA. The studies included mixing of concrete by modifying the content of the cement i.e. by replacing 20% of the cement with fly ash. Based on the results of experimental work, they finally concluded that the use of fly ash, which will reduce cost and environmental pollution. The use of mineral additives in SLWAC can reduce the dead weight further and increase the strength.

- D.Fragoulis, et al.,[2] titled "CHARACTERIZATION OF LIGHTWEIGHT AGGREGATES PRODUCED WITH CLAYEYDIATOMITE ROCKS ORIGINATING FROM GREECE" (2004), conducted the studies on use of light weight aggregates produced from the Greek clayey Diatomite rocks. The studies finally concluded that the clayey Diatomite originating from Central Greece could find applications in the production of LWA's that may be used in the industrial construction sector.

- Unal, et al.,[3] "USE OF LIGHT WEIGHT BLOCKS PRODUCED WITH DIATOMITE IN BUILDINGS" (2005) investigated physical and mechanical property of LWC produced with Diatomite aggregate. They stated that diatomite, regarding its properties of insulation, could be used as aggregate in certain ratios (30% fine, 40% medium and 30% coarse aggregate of diatomite) in the light weight concrete.

3.1 OBJECTIVES AND METHODOLOGY

3.1.1 OBJECTIVES

With Light-weight aggregate, cement and fine aggregate as the main constituents, materials like fly ash as an admixture to produce Light-weight concrete (LWAC). As reported in literature, even when studies have been conducted using similar materials, the results have been different, as performance of concrete will vary with variation in properties of starting materials.
With this background a detailed experimental program is planned with the following objectives:

1. To cast the cubes, cylinders and beams of strength M 20 and M 25 of LWAC with specified materials mentioned above and conventional concrete.
2. To compare the densities of the produced LWAC and Conventional concrete.
3. To determine the strength properties such as cube Compressive Strength, Split Tensile Strength for cylinders and Flexural Strength for beams of produced LWAC with Fly ash as an admixtures for different percentages such as 0%, 10%, 20% and 30% and compared with conventional concrete.

3.1.2 METHODOLOGY

3.1.2.1 INGREDIENTS FOR LIGHT WEIGHT AGGREGATE CONCRETE:

- **Cement:** Ordinary Portland Cement (OPC) conforming to 43 grade.
- **Fine aggregate:** Locally available river sand.
- **Light weight coarse aggregate:** Nodular light weight aggregate prepared from naturally available diatomite. Diatomite is a porous, lightweight sedimentary rock resulting from accumulation and compaction of diatom remains. The color of pure diatomite is white or near white, but possible impurities found with it may darken the color.Diatomite is currently being used as raw material in various industrial sectors worldwide and is also in use in the construction industry, aimed at improving characteristics of concrete and cement, and in producing heat-insulating bricks, using various binders.

3.1.2.2 Admixtures:

Mineral Admixture:

Fly ash, blast furnace slag, and silica fume, sometimes rice husk ash, colloidal silica act as the mineral admixtures in the concrete. Among them fly ash is one common type of admixture used in the production of concrete. It is one of the residues generated in combustion, and comprises the fine particles that rise with the flue gases. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and crystalline) and calcium oxide (CaO). The types of fly ash are:

Class F fly ash: The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. This flies ash ispozolanic in nature, and contains less than 20% lime (CaO).
Class C fly ash: Fly ash produced from the burning of younger lignite or sub-bituminous coal, in addition to having pozzolanic properties, also has some self-cementing properties. In the presence of water, Class C fly ash will harden and gain strength over time. Class C fly ash generally contains more than 20% lime (CaO). Unlike Class F, self-cementing Class C fly ash does not require an activator.
As per the literature survey, the sstudies reveal that the addition of mineral admixtures(fly ash) produces concrete with High strength and also increases the compressive strength of the concrete. Specifically we are making use of Class C fly ash as a mineral admixture to produce the light weight aggregate concrete.

3.1.2.3 Chemical Admixtures:

Super plasticizers are the organic or combinations of organic substances, which allow a reduction in water content for the given workability, or give a higher workability at the same water content. They achieve reduction in the water content up to 30% without loss of the workability. Particularly, SP430 is used as a super plasticizer to meet the above requirements. SP430 is supplied as a brown liquid instantly dispersible in water. SP430 has been specially formulated to give high water reductions up to 25% without loss of workability or to produce high quality concrete of reduced permeability.

TESTS ON FRESH CONCRETE:

- **Workability test:**
  The workability of the fresh concrete is found by conducting the slump test.

5.3.2 TESTS ON HARDENED CONCRETE:

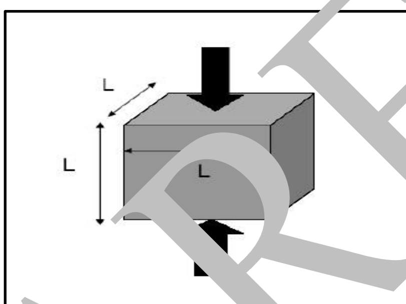
- **Cube Compressive Strength test:**

The compression test is used to determine the hardness of the cube specimens of concrete. The specimens are tested in a compressive testing machine of a capacity of 200 tonnes after their respective curing periods. Load will be applied and the value at which the specimen ultimately fails will be noted. Compressive strength will be calculated by dividing the maximum load by cross-sectional area of the specimen.

$$\mathbf{F_c = {}^{P}/_{A}} \qquad \text{………….[5.1]}$$

Where,

Fc = Cube compressive strength in 'N/mm^2'
P= Cube compressive load causing failure in 'newton'
A= Cross sectional area in 'mm^2'



- **Flexural strength:**

The flexural strength expressed in terms of modulus of rupture is defined as the minimum tensile stress in concrete at rupture in the flexural test. There exists also a test for flexural strength of the concrete computed by the formula,

$$\mathbf{{}^{f}/_{y} = {}^{M}/_{I}} \qquad \text{………….[5.2]}$$

Where,

f = Stress in extreme fibre in 'N/mm2'
M = The Bending moment at the failure section in 'N-mm'
I = Moment of Inertia of the cross section in 'mm4'
y = Distance b/w neutral axis of the section to the extreme fibre in 'mm'

In this test, failure occurs when the tensile of a concrete in the extreme fibre immediately under the load point is exhausted. The systems of loading used in finding out the flexural tension are central point loading and third point loading. In the former, maximum fibre stress will come below the point of loading where bending moment is maximum whereas in latter case, the critical crack may appear at any section. Centre point loading test gives a higher value of modulus of rupture.

Placing of specimen in the testing machine:

The specimen is placed in the machine in such a manner that the load is applied to the uppermost surface as cast in mould. Two line spaced 13.3cm apart. The axis of the specimen is carefully aligned with the axis of the loading device. No packing is used between the bearing surface of the specimen and the rollers. The load is applied without shock and increasing continuously at a rate such that the extreme fibre stress increases at approximately 0.7kg/cm2/min i.e. at rate of loading of 4180 kg/min for the 10 cm specimens. The load is increased until the specimen fails and maximum load is applied to the specimen during the test is recorded.

If fracture occurs within the central one third of the beam, the modulus of rupture is calculated on the basis of ordinary elastic theory and is thus equal to,

$$f_b = PL/bd^2 \qquad \text{.............[5.3]}$$

Where,

f_b = Flexural strength of the specimen
P = Max. total load on the beam
L = Span length
b = Width of the beam
d = Depth of the beam

If however, fracture occurs outside the load points say, at 'a' from the near support, 'a' being the average distance measured on the tension surface of the beam, but not more than the 5% of the span, then the modulus of rupture is given by $3Pa/bd^2$.

- **Split tensile strength:**

The tension is more in limiting the cracking caused by shrinkage etc. The tensile strength is obtained by placing a concrete cylinder horizontally between the loading surfaces of a compression testing machine and the load is applied until the failure of cylinder along vertical diameter. The loading condition produces a compressive strength immediately below the two generators to which the load is applied. But the larger portion corresponding to the depth is subjected to a uniform tensile stress acting horizontally. It is estimated that the compressive stress is acting for about 1/6th depth and the remaining 5/6th depth is subjected to tension. Due to high compressive force, the cylinder is subjected to uniform tensile stress over a depth of 0.87D acting horizontally. The force splits the cylinder vertically into two halves. The tensile stress developed is taken as an index of tensile strength of concrete.

The horizontal tensile stress will be calculated by

$$\text{Horizontal Tensile Stress} = 2P/(\pi LD) \qquad \text{.............[5.4]}$$

P = Compressive load on the cylinder in 'newton'
L = Length of the cylinder in 'mm'
D = Diameter of the cylinder in 'mm'

CONCLUSION:

Based on the results and discussions, it can be inferred that

- The cube compressive strengths of M 20 and M 25 grade light weight aggregate concrete achieved for 3 days, 7 days and 28 days was around 68%, 70% and 70% respectively when compared with the strength parameters of the conventional concrete.
- The split tensile strengths of M 20 and M 25 grade light weight aggregate concrete achieved for 7 days and 28 days was around 60% and 70% respectively when compared with the strength parameters of the conventional concrete.
- The flexural strengths of M 20 and M 25 grade light weight aggregate concrete achieved for 7 days and 28 days was around 60% and 65%respectively when compared with the strength parameters of the conventional concrete.
- The cube compressive strength, split tensile strength and flexural strength of light weight aggregate concrete using fly ash as an admixture are reduced when compared to the conventional concrete.
- The LWAC with fly ash as admixture increases the compressive strength of the concrete.Higher strength was achieved for 10% replacement of cement by fly ash. The optimum replacement of cement by fly ash is around 10% - 20%.
- With the higher percentage fly ash as admixture in Light weight aggregate concrete reduces the compressive strength, split tensile strength and flexural strength of the concrete.
- From the results, it is observed that there is a reduction in the density of light weight concrete as compared to conventional concrete. The reduction of density was about 22% - 30%.
- The workability of light weight aggregate concrete with fly ash admixture gets considerably increased when fly ash is added.

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