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EXPERIMENTAL STUDY ON MECHANICAL PROPERTIES LIGHT WEIGHT CONCRETE

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ABSTRACT: Lightweight concrete can be defined as a type of concrete which includes an Expanding agent in it that increases the volume of the mixture while reducing the dead weight. It is lighter than the conventional concrete with a dry density of 300 kg/m3 up to 1840 kg/m3. The main specialties of lightweight concrete are its low density and low thermal conductivity.Lightweight concrete (LWC), with its reduced weight and improved durability, enables longer spans, fewer piers, and longevity for bridge structures. The use of structural grade light weight concrete reduces the self weight and helps to construct larger precast units. In this study, an attempt has been made to study the Mechanical Properties of a structural grade light weight concrete M25 using the light weight aggregate pumice stone as a partial replacement to coarse aggregate and mineral admixture materials like Fly Ash and Silica Fume. For this purpose along with a Control Mix, 12 sets were prepared to study the compressive strength, tensile strength and flexural strength. Each set comprises of 4 cubes, 2 cylinders and 2 prisms. Slump test were carried out for each mix in the fresh state. 28-days Compressive Strength, Tensile Strength and Flexural Strength tests were performed in the hardened state. The study is also can be extended for blending of concrete with different types of mineral admixtures. It is observed that there is retardation in Compressive strength, Split tensile strength, Flexural strength and Young's modulus for the light weight aggregate replaced concrete when compared to the concrete made with normal aggregate. For these light weight aggregate concrete mixes when 'cement' was replaced by 'fly ash' it is noticed that there is a marginal improvement in the properties studied. For 25% replaced light weight aggregate when cement was replaced by 15%, 20%, 25% and 30%fly ash, the maximum gain in compressive strength of 32.8% at 28 days is observed for 20% replacement of fly ash. Similarly the gain in split tensile strength, flexural strength and Young's modulus of Elasticity are 20%, 11.3% and 41.9% is observed at 20% replacement of fly ash respectively.

KEYWORDS: Light weight concrete, Compressive Strength, Flexural Strength, Split tensile Strength.

I. INTRODUCTION

Concrete is the most widely used man-made construction material. It is obtained by mixing cement, water and aggregates (and sometimes admixtures) in required proportions. The mixture when placed in forms and. allowed to cure becomes hard like stone. The hardening is caused by chemical action between water and the cement and it continues for a long time, and consequently the concrete grows stronger with age. The hardened concrete may also be considered as an artificial stone in which the voids of larger particles (coarse aggregate) are filled by the smaller particles (fine aggregate) and the voids of fine aggregates are filled with cement. In a concrete mix the cement and water form a paste called cement water paste which in addition to filling the voids of fine aggregate acts as binder on hardening, thereby cementing the particles of the aggregates together in a compact mass.

The strength, durability and other characteristics of concrete depend upon the properties of its ingredients, on the proportions of mix, the method of compaction and other controls during placing, compaction and curing. The advances in concrete technology have paved the way to make the best use of locally available materials by judicious mix proportioning and proper workmanship, so as to produce concrete satisfying performance requirements.

Among the various properties of concrete, its compressive strength is considered to be the most important and is taken as an index of its overall quality. Many other properties of concrete appear to be generally related to its compressive strength. These properties will be discussed in detail later in the book. The concrete whose density is lower than normal concrete (2200 kg/m3 or 140 lb/ft3) is known as lightweight concrete. It includes an expanding agent in it to increases the volume of the mixture while giving additional qualities. It is lighter than conventional concrete (Dry Density 300 kg/m3 up to 1840 kg/m3). In place density of 90 to 115 lb/ft3compared to the normal concrete of 145 to 150 lb/ft3.

The main specialties of lightweight concrete are its low density and low thermal conductivity. There are many types of lightweight concrete which can be produced by using lightweight aggregate or by using an air entraining agent or by using no fines method. In this project I have worked on all the above mentioned types all of them are non-structural concrete. The use of LWC (Lightweight concrete) has been a feature in the construction industry for centuries, but like other material the expectations of the performance have raised and now we are expecting a consistent, reliable material and predictable characteristics.

Lightweight concrete (LWC) has been used for more than 2,000 years (ACI 213R)
(American Concrete Institute [ACI], 2003). Early notable LWC structures include the Port of Cosa, the Pantheon Dome, and the Coliseum. In modern times, structural LWC

structures are widely used but to a much lesser extent than normal weight concrete. With the current emphasis on upgrading structures, LWC will be very beneficial since it provides improvements in the superstructure such as wider shoulders and more lanes without the necessity of any major improvements to the substructure. LWC can also provide longer life with low maintenance. There are many examples of the successful use of LWC in and outside the United States ACI defines structural LWC as structural concrete made with low-density aggregate that has an air-dry density of not more than 115 lb/ft3and a 28-day compressive strength of more than2,500 psi (ACI 116R) (ACI, 2000). Air-dry density is referred to as equilibrium density. It is defined by ASTM International (ASTM) in ASTM C567 (ASTM, 2005) as the density reached after exposure to a relative humidity of 50 ± 5% and a temperature of 73.5 ± 3.5 ºF for a period of time sufficient to reach constant mass. The use of lightweight concrete dates back to as early as the eighteenth century, and as advances in building and construction technology have increased, so has the use of lightweight concrete as the benefits of lighter dead load concrete have become apparent. In the U.S., lightweight concrete became more common around the 1930s and continues to provide advantages to the building and creative industries as different types of lightweight concretes are developed for use. Those advantages include not only weight considerations, but also insulation value, sound reduction, and workability.

The basic principle behind the making of light weight concrete is by inducing the air in concrete. To achieve the above principle practically, there are 3 different ways.

- By replacing the conventional mineral aggregates by cellular porous aggregates (Light weight aggregate Concrete).
- By incorporating the air or gas bubbles in concrete (Aerated concrete).
- By omitting the sand from the concrete (No- fines concrete).

OBJECTIVE OF WORK: The main objective of the present investigation is to develop light weight concrete using partial replacement of aggregate by other light weight materials and compare it with conventional concrete.

II. MATERIALS USED

MATERIALS:
The constituent materials used in this study are given below :
1. Cement
2. Normal Weight Coarse Aggregate
3. Fine Aggregate
4. Fly Ash
5. Silica Fume
6.Pumice Stone (Light Weight Coarse Aggregate)


Figure 1 Fly Ash


Figure 2 Silica Fume

LIGHT WEIGHT AGGREGATE (PUMICE):
Pumice is a natural aggregate of abundant resource around the world and it is environmentally friendly. However, pumice is far from being fully utilized in lightweight concrete at the time being. Concrete structures are generally designed to take advantage of its compressive strength. Light weight aggregate (pumice) is procured from Turkey. The size of light weight aggregate is 20mm. Some of its properties are as follows

- Specific Gravity coarse aggregate is 1.14.
- Specific Gravity LWA -25%-2.1
- Specific Gravity LWA- is 33.33%- 2.3
- Fully compacted density of Lightweight coarse aggregate is 85kg/m3
- Loose density of Light weight coarse aggregate is 140kg/m3


Fig: 3 Light weight Aggregate (Pumice)

III. METHODOLOGY

The experimental investigation consists of casting and testing of 9sets along with control mix. Each set comprises of 4 cubes, 2 cylinders and 2 prisms for determining compressive, tensile and flexural strengths respectively. Pumice stone is used in the study with different percentages as a partial replacement to natural weight coarse aggregate along with the varying percentages of the different admixtures like Silica Fume and Fly Ash. Cube section dimension is of15cmx15cmx15cm, cylinder section dimension is 15cmx30cm and prism dimension is 50cmx10cmx10cm. The moulds are applied with a lubricant before placing the concrete. After a day of casting, the moulds are removed. The cubes, cylinders and prisms are moved to the curing tank carefully.

For all test specimens, moulds were kept on table vibrator and the concrete was poured into the moulds in three layers by tamping with a tamping rod and the vibration was effected by table vibrator after filling up moulds. The moulds were removed after twenty four hours and the specimens were kept immersed in clean water tank. After curing the specimens in water for a period of 3 days,7 days & 28 days the specimens were taken out and allowed for drying under shade before testing.

MIX DESIGN:

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. Mix design for each set having different combinations are carried out by using IS: 10262 – 2009 method .The mix design for a concrete of M25 grade

Water	Cement	F.A	C.A
191.58	383.16	561.95	1195
0.5	1	1.426	3.119

The mix design for a concrete of m 25 grade with replacement of cement by fly ash 20%.

Water	Cement	F.A	C.A
191.58	383.16	533.3	1164
0.5	1	1.391	3.03

Metal moulds, preferably steel or cast iron, strong enough to prevent distortion is required. They are made in such a manner as to facility the removal of the moulded. Specimen without damage and are so maintained that, when it is assembled, the dimensions and internal faces are required to be accurate with in the following limits.

Compacting: The testing cube specimens are made as soon as possible after mixing and in such a manner to produce full compaction of the concrete with neither segregation nor excessive bleeding.

Curing: The test specimens are stored in a place free from vibration in moist air of at least 90% relative humidity and at a temperature of 27o2oC for 24 hours from the time of addition of water to the dry ingredients. After this period, the specimens are marked and removed from the moulds.

Testing:

(i) Compressive Strength: After 28 days curing, cubical specimens are placed on compression testing machine having a maximum capacity of 3000 KN and a constant rate of loading of 40 kg/m2 per minute is applied on test specimen. Ultimate load at which the cubical specimen fails is noted down from dial gauge reading. This ultimate load divided by the area of specimen gives the compressive strength of each cube.

(ii) Tensile Strength: After 28 days curing, cylinder specimens are placed on tensile testing machine having a maximum capacity of 1000 KN and a constant rate of loading of 40 kg/m2 per minute is applied on the test specimen by placing two steel plates below and above the cylinder in the horizontal direction. Ultimate load at which the cylindrical specimen fails is noted down from dial gauge reading.

(iii) Flexural Strength: After 28 days curing, prismatic specimens are placed on flexural testing machine having a maximum of 100 KN and a constant rate of loading of 40 kg/m2 per minute is applied on the test specimen by placing the specimen in such a way that the two point loading should be placed at a distance of 13.3 cm from both the ends. Ultimate load at which the prismatic specimen fails is noted down from dial gauge reading.

IV. RESULTS AND DISSUSSION

TEST RESULTS:

For each percentage of fly ash, 3 cube specimens have been cast. In all 165 cubes of size 150 mm x 150 mm x 150 mm have been cast. The cube compressive strength of concrete at different days for the different replacements of fly ash with the cement and with 25% light weight aggregate replaced in coarse aggregate and are shown in Table below

COMPRESSIVE STRENGTH:

Table1 Compressive Strength

S.NO	% replacement of fly ash	Compressive Strength(Mpa)		
		3 days	7 days	28 days
	0% NA	20	24	34
1.	0% Fly Ash 25 % LWA	15.288	16.28	23.2
2.	15% Fly Ash 25 % LWA	16.5	17.88	28.2
3.	20% Fly Ash 25 % LWA	17.78	19.07	30.5
4.	25% Fly Ash 25 % LWA	16.7	18	28.5
5.	30% Fly Ash 25 % LWA	16.2	17.5	28.2

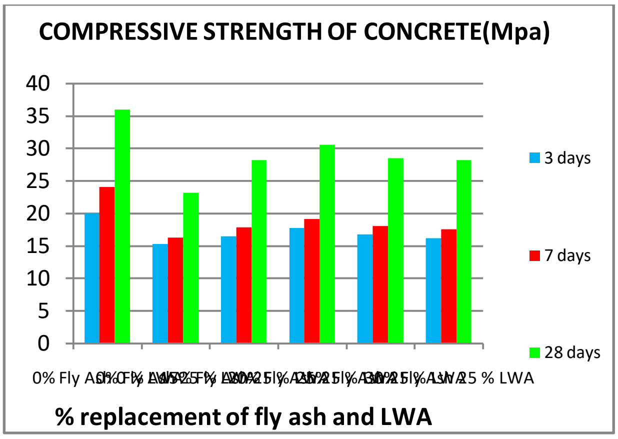

Figure 4 Compressive strength results

SPLIT TENSILE STRENGTH:

For each percentage of fly ash, 3 cylindrical specimens have been cast. In all 54 cylinders of size 150 mm diameter and 300 mm height, have been cast. In this present investigation based on the Compressive strength results obtained for 25% light weight aggregate with different proportions as of fly ash replacement in cement. It is noticed that the maximum compressive strength is obtained for 20% fly ash replacement in cement. Hence the split tensile proposing is studied for the combination of 25% light weight aggregate, replacement in coarse aggregate and 20% replacement of fly ash in cement and are shown in Table below.

Table2 Split tensile Strength

S.NO	% replacement of fly ash	Split tensile strength (Mpa)		
		3 days	7 days	28 days
1	0% LWA 0 % Fly Ash	2.6	1.9	2.2
2	25% LWA 0% Fly Ash	1.9	2.1	2.3
3	25% LWA, 20% Fly Ash	2.2	2.3	2.8

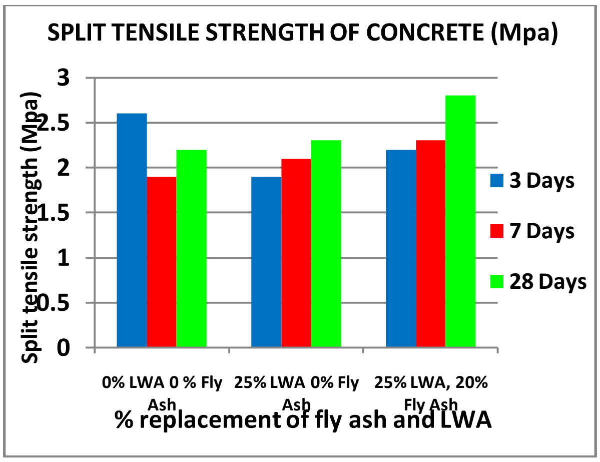

Figure 5 Split tensile Strength results

FLEXURAL STRENGTH

For each percentage of fly ash, 3 beam specimens have been cast. In all 108 beams of size 700 mm x 150 mm x 150 mm, have been cast and the results are shown in table

Table3 Flexural Strength

S.NO	% replacement of fly ash	Flexural Strength (Mpa)		
		3 days	7 days	28 days
1	0% LWA 0 % Fly Ash	2.69	2.82	3.72
2	25% LWA 0% Fly Ash	2.43	2.6	2.93
3	25% LWA, 20% Fly Ash	2.53	2.7	3.26

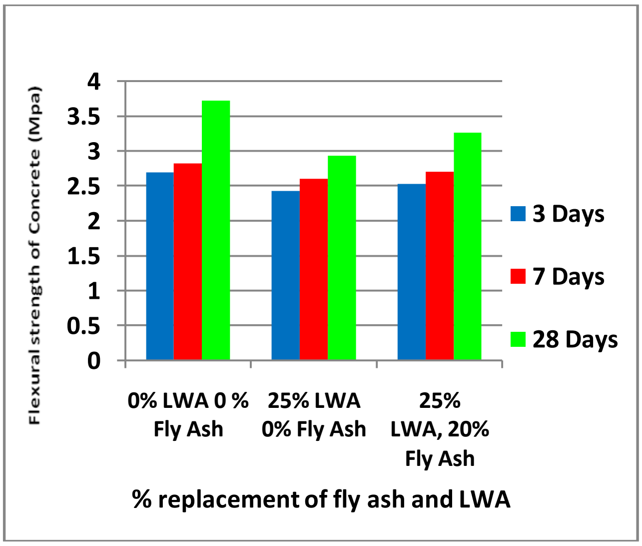

Figure 6 Flexural Strength results

V. CONCLUSIONS

The results obtained with 25% light weight aggregate replacement in normal aggregate were studied with fly ash replacement in cement by 0%, 15% 20%, 25% and 30%. At 20% replacement of cement by fly ash the maximum compressive strength is observed for 25% LWA replacement in coarse aggregate.

- Compressive strength tends to decrease with use of LWA. At 28 days normal concrete attained a compressive strength of 34 MPa, but with increased LWA and Fly ash content compressive strength reduces and at 20% Fly ash and 25% LWA, compressive strength reaches its peak value of 30.5 MPa.
- The split tensile strength at 28 days for 0% replacement of cement by fly ash and 25% light weight aggregate replacement in normal coarse aggregate it is observed as 2.25 MPa
- Further split tensile strength at 28 days for 20%

replacement of cement by fly ash and 25% light weight aggregate replacement in normal aggregate it is observed as 2.7 MPa

- The Flexural strength at 28 days for 0% replacement of cement by fly ash and 25% light weight aggregate replacement in normal coarse aggregate it is observed as 2.92 MPa.
- Further The Flexural strength at 28 days for 20% replacement of cement by fly ash and 25% light weight aggregate replacement in normal aggregate it is observed as 3.25MPa
- The young's modules at 28 days for 0% replacement of cement by fly ash and 25% light weight aggregate replacement in normal coarse aggregate it is observed as 2.58X104MPa
- Further the young's modules at 28 days for 20% replacement of cement by fly ash and 25% light weight aggregate replacement in normal aggregate it is observed as 3.663X104 Mpa

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