AN EXPERIMENTAL INVESTIGATION ON PROPERTIES OF LIGHT WEIGHT AGGREGATE CONCRETE WITH SILICA FUME AND FLY ASH AS ADMIXTURES

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Abstract:- *Light weight concrete has become popular in recent years owing to the tremendous advantages over the conventional concrete but at the same time strong enough to be used for the structural purpose. One of the disadvantages of the conventional concrete is its high self weight of the concrete. This heavy self weight which makes it an uneconomical for non load bearing structural elements to some extent. Important characteristic of light weight concrete is its low thermal conductivity, due to its low density.*

An investigation has been carried out on properties of light weight cinder aggregate concrete with silica fume and fly ash as admixtures. The cinder aggregate is replaced with normal aggregate in volume percentages of 0%, 25%, 40%, 60%, 75% and 100% respectively and cement was replaced with silica fume in weight percentages of 5%, 10% and 15% and fly ash in weight percentages of 10%, 20% and 30%. The control mix with M20 grade has been casted. In this study a total of 180 specimens were casted varying the parameter and tested for compression and split tensile strength. From these test results it has been found out 60% replacement of conventional aggregate with cinder aggregate by volume attained maximum compressive strength and optimum strength was obtained by 5% replacement of cement with silica fume and 20% fly ash by weight yields designed strength. It has been found that density of concrete varies with volume variation of cinder aggregate this research study yields a reliable data on the study of medium weight concrete.

Key Words: Concrete, Silica Fumes and Fly ash

1.INTRODUCTION

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 lessened the dead weight. It is lighter than the conventional concrete. The main specialties of lightweight concrete having low density and thermal conductivity. Its advantages are that there is a reduction of dead load, faster building rates in construction and lower handling costs.

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 looses strength.

1.1 TYPES OF LIGHT WEIGHT CONCRETE

Lightweight concrete can be categorised in to three groups, such as

- No-fines concrete
- Lightweight aggregate concrete
- Aerated/Foamed concrete

1.1.1 No-fines concrete

No-fines concrete can be defined as a lightweight concrete composed of cement, water and coarse aggregate. 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. Figure 1 shows one example of No-fines concrete.

No-fines concrete 9 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.

1.1.2 Lightweight aggregate concrete

Porous lightweight aggregate of low specific gravity is used in this lightweight concrete instead of ordinary concrete. The light weight 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.

1.1.3 Partially compacted 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 insitu roofs and walls. The main requirement for this type of concrete should have adequate strength and a low density to obtain the best thermal insulation and a low drying shrinkage to avoid cracking.

1.1.4 Structural Light weight concrete

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 concrete structures. Figure 2 shows the feature of lightweight aggregate concrete.

1.2 DESIGN OF LIGHT-WEIGHT AGGREGATE CONCRETE MIX

Mix design methods confine to normal weight concrete are difficult to use with light weight concrete. Light-weight concrete mix design is generally established by trial mixes. The size and the shape of fine aggregate, coarse aggregate, cement and the water requirement are estimated on the basis of later experiences with special aggregate. Various amount of water absorption by different light-weight aggregates is one of the most typicalties in the design of mix proportions. On some occasions the aggregate will be saturated before mixing so that it won't take up the water used for mixing. The pure quality of concrete does not get change on account of absorption by aggregate. It is seen that the strength of resulting concrete is about 5 to 10 percent lesser when the dry aggregate is used for the same amount and workability, due to the fact that in the later case some amount of mixing water is ingested preceding setting. This mixing water is to give something to the workability at the time of setting gets retained later in this manner this will reducing the bad effect of expected water. More importantly, the density of concrete made with saturated aggregate is larger and the durability of such concrete, especially its resistance to be lower. On the other hand, when aggregate having more absorption it is difficult to sustain a sufficient workability and yet cohesive mix, and usually aggregates with absorption of over 10 % are pre-soaked.

There are different definitions for concretes that can be produced with light weight aggregates. When density having low concrete generally is produced with perlite or vermiculate aggregates. When the density is (0.800 KN/M^3) and it contains very low compressive strengths in the range of 0.7 to 6.7 MPa. Structural light weight concrete is typically produced with expanded shale, clays, slates and slag and the can also be manufacture with pumice or scoria, which are naturally occurring volcanic aggregates. The structural light weight concrete has a minimum compressive strength of 17.2 MPa and air dried unit weight of 1440 to 1850 kg/m^3. Moderate strengths concrete falls somewhere in between low density and structural light weight concrete. For comparison, generally normal weight concretes has a dry unit weight of 23.00 to 24.00 KN/m^3

Adjusting the proportions of light weight and normal weight aggregates, the concrete density can be varied depending upon the project requirements. This type of light weight concrete is often called as specified density concrete.

It is worthwhile to note that the light weight concrete can also be produced with special production methods in the combination with or without light weight aggregates. A base advantage of precast concrete is that it is make at a manufacturing plant in a quality nature. Since an each piece must be send to another location, pre casters are often need to cut off the weight of every shipment because of highway weight export. These exports have limit the quantity of units that can be put on every shipment, regardless of the possibility that more space is accessible on the truck or trailer Another reason to possibility of using light
weight aggregates is that sometimes the dead load make near or above the capacity of crane being utilized at a plant or at work site with light weight aggregates. It might be accomplished to lessen the weight of the item with the goal that unique cranes would not be important, or to create bigger segments than would be attained with normal weight concrete. A reduction in crane movements may be to exist since longer reaches are possible with lighter loads.

2. REVIEW OF LITERATURE

Light weight concrete is a special type of concrete. One of the weaknesses of the traditional solid is the high self weight of the cement. Thickness of the ordinary solid is in the request of 22.00 to 26.00 KN/M^3. This overwhelming self weight will make it some degree an uneconomical structural material. Endeavours have been made in the past to diminish the self weight of the cement to build the productivity of the cement as a structural material. The light weight solid is a solid whose thickness shifts from 300 to 18.50 KN/M^3.

Ganesh Babu. K et al.,[1] depicted has the Behavior lightweight stretched polystyrene cement containing silica fume and he concentrated on the Lightweight concrete can be created by supplanting total with lightweight total, either somewhat or completely, contingent on the necessities of thickness and quality, furthermore considered the quality and the sturdiness execution of EPS cements. These blends were planned by utilizing the effectiveness of silica fume at the diverse percentages.

Niyazi Ugur Kockal et al.,[2] portrayed has strength and elastic properties of structural lightweight concrete. The study introduces the impact of attributes of four total sorts (two sintered lightweight fly cinder aggregate, normal weight crushed limestone aggregate and cold-bonded lightweight fly ash aggregate) on the strength and elastic properties of concrete mixtures. Different models were also used in order to predict the strength and modulus of elasticity values of concretes. The results of this study revealed the achievement of manufacturing high-strength air-entrained lightweight aggregate concretes using sintered and cold-bonded fly ash aggregates.

Siva Linga Rao.N et al.,[3] has studied an investigation has been made to understand the behavior of conventional aggregate concrete in which normal aggregate is replaced with cinder in volume percentages of 20,40,60,80 and 100 and cement is replaced with silica fume in weight percentages of 0,5,8,10,15 and 20.

From the study it is concluded that 60 percent replacement of conventional aggregate with cinder by volume along with cement replaced by 10 percent of silica fume by weight yields the target mean strength. the unit weight of the cinder concrete is varying from 1980Kg/m^3 to 2000Kg/m^3 with different percentages of cinder.

Bhaskar Desai et al.,[4] describe experimental investigation an attempt is to be made to study the strength properties of light weight cinder aggregate cement concrete in different percentage proportions of 0, 25, 50, 75 and 100 by volume of light weight aggregate concrete can be prepared. By using this the properties such as compressive strength, split tensile strength, modulus of elasticity, density and shear stress.

Rathish Kumar P. et al .,[5] has studied the strength and sorptivity attributes of concrete made with cinder based lightweight aggregates. Before this the span of cinder based light weight aggregate was enhanced. The mechanical properties, compressive quality and split tensile strength were learned at the end what's more 28 days for mid-range evaluation concrete with diverse sizes of total. It was noted that with 12.5mm size total and 30% fly ash the mechanical properties were predominant in 20MPa Lightweight Concrete, while 10 mm size total with a 30% fly powder substitution properties of 30MPa concrete.

P.S. Raghu Prasad et al.,[6] has concentrated on the coarse aggregates in the customary robust solid concrete were supplanted in part with Cinder (12mm) and tried for compressive strength at the age of 3days, 7days and 21days. From the aftereffects of the examination, it can be reasoned that strong solid block with 15% substitution of coarse aggregate by cinder records more quality than the traditional one.

Nataraja M C et al.,[7] studied to development a step-wise strategy to extent plain and slag concrete blends with burnt coal soot squander as coarse aggregate. The mix design can be economized by using significant amount of GGBS as replacement to cement. Concrete mixes are designed with cement alone and with cement and GGBS at 30% and 60% replacement levels using burnt coal cinder. Concrete with conventional granite aggregate is also cast and tested for comparison.

3. EXPERIMENTAL INVESTIGATION

3.1 Procurement of materials and its testing

Materials used in the concrete are fine aggregate, coarse aggregate(granite), light weight aggregate (cinder), cement, water, Silica fume, Fly ash have been procured from various places. Fine aggregate has been procured from Tungabhadra River Kurnool. Coarse aggregate (20mm) has been procured from Lakshmipuram Kurnool. Local drinking water is used for mixing and curing. Cinder (20mm) has been procured from Lakshmipuram at Kurnool. The Silica fume is obtained from Astraa chemicals Ltd Chennai.

3.2 Cement

Locally available Ultra Tech Ordinary Portland Cement (OPC) of 53 grade of Cement conforming to ISI standards has been procured, and following tests have been carried out according to IS 8112:1989.

The results of following tests are tabulated in table 4.1

- Specific gravity of Cement
- Normal Consistency of Cement
- Initial and Final setting time of Cement
- Compressive Strength of Cement

3.3 Fine aggregate

Fine aggregate is locally available natural river sand and is found to be conforming to grading zone-2 of table 4. of IS 383:1970 it has been used as fine aggregate. Following tests have been carried out as per the procedure given in IS 383:1970.

- Specific gravity
- Sieve Analysis

3.4 Conventional natural aggregate (granite) and light weight aggregate (cinder)

Machine Crushed granite aggregate conforming to IS 383:1970 consisting 20 mm maximum size of aggregates has been obtained from the local quarry. The Cinder are hand broken to 20 mm size. Both granite and cinder have been tested for Physical and Mechanical Properties such as Specific gravity, Bulk Density, Sieve Analysis, Crushing and Impact tests.

3.5 water

Locally available water used in the experimental program for mixing and curing.

3.6 Mix case considered

Mix design can be characterized as the methodolgy of selecting suitable ingredients of concrete and determining their relative proportions with the objective of producing concrete of certain minimum strength as economically as possible. The design of concrete mix is not a easy task on basis of widely varying properties of constituent materials.

Design of concrete mix requires complete learning of different properties of the constituent materials, in case of changes on these conditions at the site.

In the present investigation M20 grade of concrete has been considered. The mix design of concrete is taken as per the guidelines given in IS 10262:2009. Mixes were prepared with a replacement of granite aggregate with cinder aggregate in the percentages of 0, 25, 40, 60, 75 and 100 and the replacement of cement by silica fume in percentages of 5, 10, 15 and fly ash in the percentages of 10, 20, 30 by weight of cement. Standard Mix design using conventional aggregate has been given in Appendix-A.

3.7 Mixing of concrete

Initially the ingredients cement and Silica fume, were mixed, to which the fine aggregate and coarse aggregate, light weight aggregate (cinder) were added and thoroughly mixed. Water was measured exactly. Then it was added to the dry mix and it was thoroughly mixed until a uniform mix will come and then ready for casting. Prior to casting of specimens, workability was measured by slump test and compaction factor.

3.8 Moulding of specimens

After the Completion of workability tests, the concrete placed in the standard metallic moulds in three layers and it was compacted by tamping rod. The concrete in the moulds was vibrated for 2 min using the vibrating machine and the surface of the specimens was finished smoothly.

4. DISCUSSIONS OF TEST RESULTS

4.1 Compressive strength of concrete with replacement of silica fume and Cinder aggregate

The compressive strength results with 100% natural aggregate being replaced by 0 % cinder aggregate and with different percentages replacements of cement by silica fume are shown in table 1. The graphical variations of compressive strength versus percentage replacement of cement by silica fume are shown in fig 1. From the above table 7 and fig 1 it may be observed that there is an increase in compressive strength for the replacement of cement by silica fume as 5% and for 10% and 15% the strength gets decreased

Table-1: Compressive strength of concrete with replacement of cinder aggregate and silica fume

S.No.	Mix Designation	Compressive Strength, N/mm^2
1	C A-0 SF5	32.2
2	C A-0 SF10	44.28
3	C A-0 SF15	30.2
4	C A-25 SF5	31.4
5	C A-25 SF10	30.3
6	C A-25 SF15	29.8
7	C A-40 SF5	27.3
8	C A-40 SF10	23.3
9	C A-40 SF15	25.3
10	C A-60 SF5	30.03
11	C A-60 SF10	27.25
12	C A-60 SF15	30.33
13	C A-75 SF5	34.5
14	C A-75 SF10	23.4
15	C A-75 SF15	25.4
16	C A-100 SF5	28.3
17	C A-100 SF10	26.6
18	C A-100 SF15	21.4

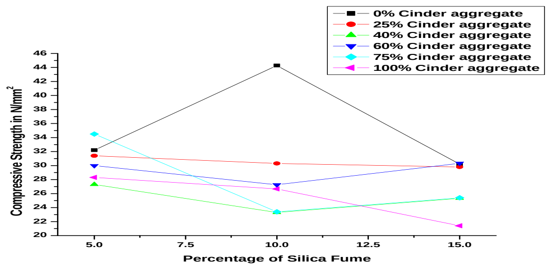

Fig-1: Compressive strength with different percentages of cinder aggregate with different percentages of silica fume

4.2 Compressive strength of concrete with replacement of cinder aggregate and fly ash

The compressive strength results with 100% natural aggregate being replaced by 0 % cinder aggregate and with different percentages replacements of cement by fly ash are shown in table 2. The graphical variations of compressive strength versus percentage replacement of cement by fly ash are shown in fig 2. From the above table 2 and fig 2 it may be observed that there is an increase in compressive strength for the replacement of cement by fly ash as 20% and from 10% and 30% the strength gets decreased.

Table-2: Compressive strength of concrete with replacement of cinder aggregate and fly ash

S.No	Mix Designation	Compressive Strength, N/mm²
1	C A-0 FA10	25.8
2	C A-0 FA20	29.4
3	C A-0 FA30	26.66
4	C A-25 FA10	23.2
5	C A-25 FA20	26.6
6	C A-25 FA30	27.77
7	C A-40 FA10	24.4
8	C A-40 FA20	29.3
9	C A-40 FA30	24.84
10	C A-60 FA10	23.8
11	C A-60 FA20	27.3
12	C A-60 FA30	25.33
13	C A-75 FA10	20.7
14	C A-75 FA20	24.4
15	C A-75 FA30	23.3
16	C A-100 FA10	19.4
17	C A-100 FA20	21.4
18	C A-100 FA30	20.4

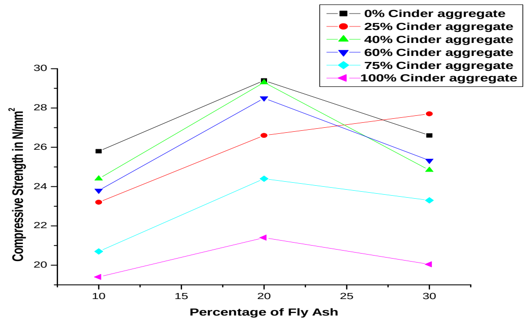

Fig-2: Compressive strength with different percentages of cinder aggregate with different percentages of fly ash

4.3 Split tensile strength of concrete with replacement of cinder aggregate and silica fume

The split tensile strength results with 100% natural aggregate and with different percentages replacements of cement by silica fume are shown in table 3. The variation of split tensile strength versus percentage replacement of cement by silica fume are shown in fig 3. From the above table 3 and fig 3 it may be observed that there is an increase in split tensile strength for the replacement of cement by silica fume as 5% and from 10% and 15% the strength gets decreased.

Table-3: Split Tensile strength of concrete with replacement of cinder aggregate and silica fume

S.No	Mix Designation	Split Tensile Strength, N/mm²
1	C A-0 SF5	3.2
2	C A-0 SF10	2.92
3	C A-0 SF15	2.34
4	C A-25 SF5	2.8
5	C A-25 SF10	2.68
6	C A-25 SF15	2.7
7	C A-40 SF5	3
8	C A-40 SF10	2.38
9	C A-40 SF15	2.36
10	C A-60 SF5	2.7
11	C A-60 SF10	2.62
12	C A-60 SF15	2.66
13	C A-75 SF5	2.42
14	C A-75 SF10	2.2
15	C A-75 SF15	2.05
16	C A-100 SF5	2.24
17	C A-100 SF10	2.12
18	C A-100 SF15	2.22

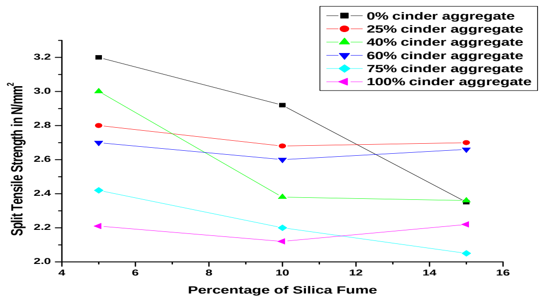

Fig-3: Split Tensile strength with different percentages of cinder aggregate with different percentages of fly ash

4.4 Split tensile strength of concrete with replacement of cinder aggregate and fly ash

The split tensile strength results with 100% natural aggregate and with different percentages replacements of cement by fly ash are shown in table 4. The variation of split tensile strength versus percentage replacement of cement by fly ash are shown in fig 4. From the above table 4 and fig 4 it may be observed that there is an increase in split tensile strength for the replacement of cement by fly ash as 20% and from 10% and 30% the strength gets decreased.

Table-4: Split Tensile strength with different percentages of cinder aggregate with different percentages of fly ash

S.No	Mix Designation	Split Tensile Strength, N/mm²
1	C A-0 FA10	2.8
2	C A-0 FA20	3.06
3	C A-0 FA30	3.04
4	C A-25 FA10	2.68
5	C A-25 FA20	2.64
6	C A-25 FA30	2.7
7	C A-40 FA10	2.48
8	C A-40 FA20	2.4
9	C A-40 FA30	2.36
10	C A-60 FA10	2.54
11	C A-60 FA20	2.7
12	C A-60 FA30	2.58
13	C A-75 FA10	2.36
14	C A-75 FA20	2.54
15	C A-75 FA30	2.33
16	C A-100 FA10	2.18
17	C A-100 FA20	2.2
18	C A-100 FA30	2.12

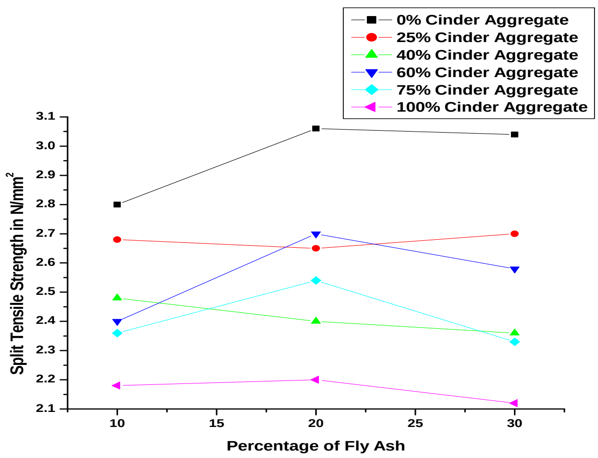

Fig-4: Split Tensile strength with different percentages of cinder aggregate with different percentages of fly ash

5. CONCLUSIONS

From the study it is concluded that 5 % silica fume is giving the best results when compare to 10% and 15% silica fume. and also from fly ash 20% is giving best results when compare to 10% and 30%.

From the study it may concluded that the usage of light weight cinder aggregate to some extent (60%) and granite aggregate (40%) using admixture as silica fume and fly ash has proved to be quite satisfactory strength when compare to various strengths studied.

It can be conclude that due to porous nature Cinder aggregate's quality is low in comparison with normal aggregate

The results indicate that the compressive strength is decreases with the increase in percentage of cinder.

The results indicate that the split tensile strength is decreases with increase in percentage of cinder.

Compressive strength of 5% silica fume concrete is more than the 10% and 15fume concrete at 28 days Similarly tensile strength of 5% silica fume is greater than the 10% and 15% silica fume concrete at 28 days.

Compressive strength of 10% fly ash concrete is more than the 20% and 30% fly ash concrete at 28 days Similarly tensile strength of 10% fly ash concrete is greater than the 20% and 30% fly ash concrete at 28 days.

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