A STUDY ON EFFECTS OF LIGHT WEIGHT AGGREGATES ON COMPRESSIVE AND FLEXURAL STRENGTH OF CONCRETE

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ABSTRACT :

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 mailability and lessened the dead weight. It is lighter than the conventional concrete. The main specialties of lightweight concrete are its low density and thermal conductivity. Its advantages are that there is a reduction of dead load, faster building rates in construction and lower haulage and handling costs. Lightweight concrete maintains its large voids and not forming laitance layers or cement films when placed on the wall. This research was based on the performance of aerated lightweight concrete. 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. Therefore, this fundamental report is prepared to study activities and progress of the lightweight concrete. Focused were on the properties of lightweight concrete such as compressive strength, water absorption and density and its applications in various fields of civil Engineering construction. The present day world is witnessing construction of very challenging and difficult civil engineering structures. In this study comparison has been made between plain cement concrete and light weight concrete having different proportion of aggregates and admixtures. i.e., Expanded Clay Aggregates: 0%, 25%, 50%, 75% and 100% with coarse aggregate, silica fumes 10% and PVA (Poly Vinyl Alcohol) 1.6% of constant replacement with cement and water respectively. It helps to increase the volume of concrete and hence reduce the weight. In Design of concrete structures, light weight concrete plays a prominent role in reducing the density and to increase the thermal insulation. These may relate of both structural integrity & serviceability. More environmental and economical benefits can be achieved if waste materials can be used to replace the fine light weight aggregate.

1. INTRODUCTION:

Concrete is one of the oldest manufactured construction material and it has been use extensively in the construction of various structures since ancient day. The continuous research and development of concrete has resulted in the production of many types of concrete. Each of the concrete possesses their own unique characteristic to meet and suit the demand of industry. One of the concrete that itpopularity increase drastically in recent year is lightweight concrete.

The classification of type of concrete is mainly depending on the concrete density. The practical range of concrete density for lightweight concrete is between 300 kg/m3 and1850 kg/m3. Due to the practical and economic advantages, it possesses, the demand for lightweight concrete has increasing over the years and has been partially used as structures such as panel wall, roof slab and etc. Using a lower density concrete can, therefore, significantly reduce the self-weight of concrete structure with a consequence allowing the reduction of columns and foundation size and other loadbearing elements and a corresponding reduction in term of cost. Other advantages of lightweight concrete included it good thermal insulation properties, better fire resistance and more convenience in handling the concrete as the total mass of materials to be handled is reduced, which then lower the haulage and handling cost and increase the productivity.

2. PRODUCTION OF LIGHT WEIGHT CONCRETE

2.1 MIX PROPORTIONNING:

(i) Cement +Foaming Agent:

• While the cement mixer or premix concrete truck is in motion, the water and cement are introduced and allowed to mix until a thoroughly consistent mixture is achieved.

• When this has taken place, the required amount of foam can be injected into the mixer and the mixing continued until the foam is completely enveloped into the total mix.

• The mixture is then ready for discharging into the mounds or wherever it is to be placed.

(ii)Cement + Lightweight Aggregate + Foam:

• The lightweight matrix formed by the mixture of cement, water and foam, lightweight aggregates can be used without the tendency to float when the mix is vibrated.

• Aggregates which are used are:- expanded shale or clay, scoria, pumice, vermiculite or fly ash.

• It is often increasing the overall density for a given strength, since simply a higher foam content can achieve better results.

3. ENGINEERING PROPERTIES OF LWC

In order to study the behavior 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. Following are some distinguished properties of light weight concrete:

3.1 COMPRESSIVE STRENGTH:

Compressive strength is the primary physical property of concrete (others are generally defined from it), 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 use to determine compressive strength; cube, cylinder, or prism test. The ‘concrete cube test' is the most familiar test and is used as the standard method of measuring compressive strength for quality control purpose. The compressive strength decreases exponentially with a reduction in density of lightweight foamed concrete. Besides the concrete density, the specimen shape and size, method of pore formation, direction of loading, curing age, water content, characteristic of ingredients used and the method of curing are reported to influence the strength of lightweight foamed concrete as well. Other parameters such as the cement-sand and water-cement ratios, curing regime, type and particle size distribution of sand and type of foaming agent used can be the factors that affecting the strength of lightweight concrete as well

3.2 STRENGTH AND DENSITY RELATIONSHIPS

The purpose of this test is to identify the performance of aerated lightweight concrete in term of density and compressive strength. Based on Figure below, it can be seen that compressivestrength for aerated lightweight concrete are low for lower density mixture. The increment of voids throughout the sample caused by the foam in the mixture will lower the density. As a result, compressive strength will also decrease with the increment of those voids.

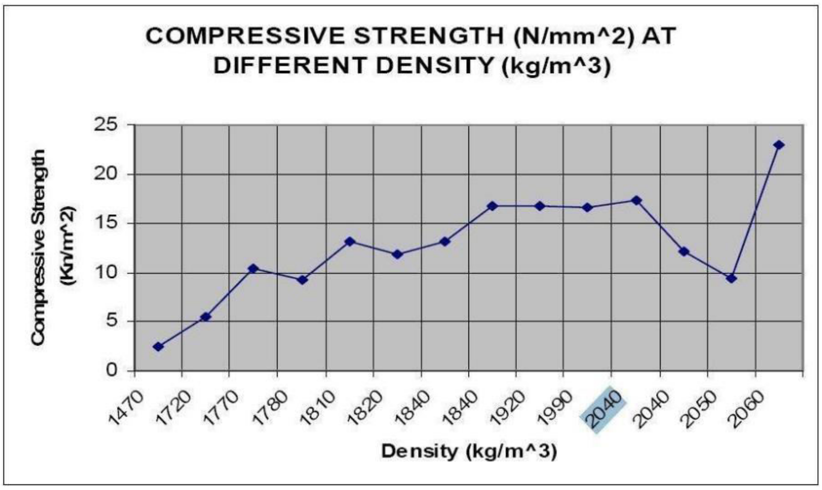


Figure 4 Strength Density Relationships (source – A.M. Neville)

LITERATURE REVIEW

T. Parhizkar, M. Najimi and A.R. Pourkhorshidi (2011) have presented experimental investigation on the properties of volcanic pumicelightweight aggregates concretes. To this end, two groups of lightweight concretes(lightweight coarse with natural fine aggregates concrete, and lightweight coarse and fineaggregates concrete) are built and the physical/mechanical and durability aspects of them arestudied. The results of compressive strength, tensile strength and drying shrinkage show thatthese lightweight concretes meet the requirements of the structural lightweight concrete.

N. Sivalinga Rao, Y.Radha Ratna Kumari, V. Bhaskar Desai, B.L.P. Swami (2013) have studied on Fibre Reinforced Light Weight Aggregate (Natural Pumice Stone) Concrete. In their study, the mix design was M20 and the test results are as follows: More than the target means strength of M 20 concrete is achieved with 20 percent replacement of natural coarse aggregate by pumice aggregate and with 1.5 percent of fibber. Also with 40% pumice and with 0.5% of fibbers average target mean strength of M 20 concrete is achieved.

P.C.Taylor presently a professor at Wuhan University of Technology has said that mineral admixtures affect the physical and mechanical properties of High Strength Structural Light Concrete. Addition of Fly Ash enhances the compressive strength and splitting tensile strength of HSSLC when FA was more than 20% in cementitious materials, its 28 days compressive strength and splitting tensile strengths are less than those of the concrete without FA. Addition of silica fume enhances the compressive strength about 25% and splitting tensile strength also. Incorporating

Swamy R.H & Lambert G.H (1984) studied above the light weight aggregate and proved that the thermal efficiency is very more to the light weight concrete and the load carrying capacity of the light weight concrete is same as the normal concrete by using some mineral and chemical admixtures.

EXPERIMENTAL PROCEDURE

The experimental investigation is carried based on volume proportions and the cement content was taken to be 394.1kg/m3 . Water/cement ratio (w/c) was taken to be 0.45 from previous studies and from various trial mixes. Mix proportion pertaining to 0%, 25%, 50%, 75% and 100% replacement of expanded clay aggregate is considered to carry out investigation. Aggregate sizes ranging from 16 mm - 20 mm were used to prepare the samples of various mix proportions.

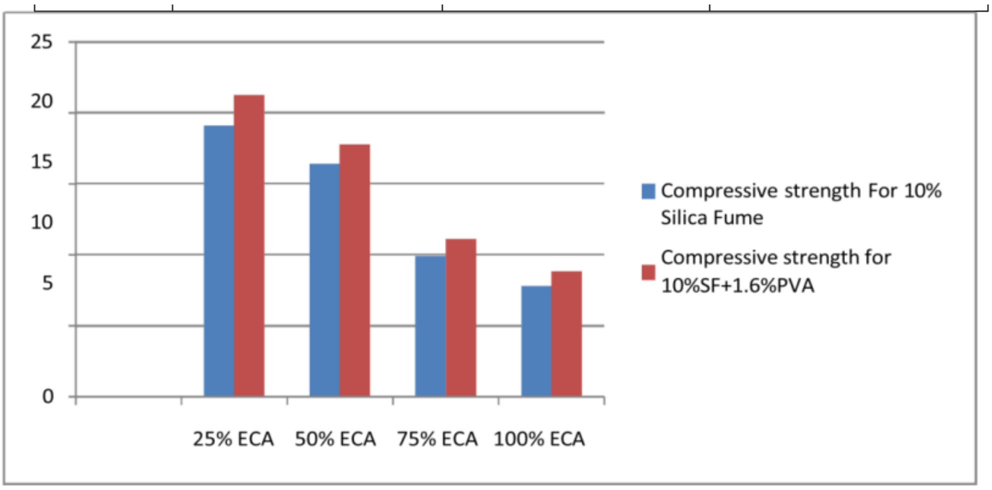
4.1. COMPRESSIVE STRENGTH

4.1. FLEXURAL STRENGTH

5. RESULTS AND CONCLUSIONS

5.1 COMPRESSIVE STRENGTH The compressive strength test is carried out as per IS 516:1959 test on hardened concrete. The load is applied without shock and increased continuously at a rate of approximately 140 kg/sq cm/min until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained. The maximum load applied to the specimen shall then be recorded and the appearance of the concrete and any unusual features in the type of failure shall be noted. Table 7 Compressive strength for 28 days for various mix proportions

S.No	Coarse Aggregate Replacement in %	Compressive strength For 10% Silica Fume (MPa)	Compressive strength for 10%SF+1.6%PVA (MPa)
1	Nominal	34.6	34.6
2	25% ECA	19.1	21.23
3	50% ECA	16.4	17.78
4	75% ECA	9.89	11.1
5	100% ECA	7.8	8.8



5.2 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.

Table 8 Density 28 days for various mix proportions

S.No	Coarse Aggregate replacement	Density of cubes for 10% SF+ 1.6% PVA	Density of beams for 10% SF+ 1.6% PVA
1	Nominal	2530.37	2408.25
2	25% ECA	2077.04	2168.89
3	50% ECA	1854.81	1893.97
4	75% ECA	1558.51	1690.16
5	100% ECA	1444.74	1456.16

Figure 6 Density of Different Mixes

FLEXURAL STRENGTH

The axis of the specimen is carefully aligned with the axis of the loading device. No packing shall be used between the bearing surfaces of the specimen and the rollers. The load shall be applied without shock and increasing continuously at a rate such that the extreme fibre stress increases at approximately 7 kg/sq cm/mm. that is, at a rate of loading of 400 kg/min for the 15· 0 cm specimen. The load shall be increased until the specimen fails, and the maximum load applied to the specimen during the test shall be recorded. The appearance of the fractured faces of concrete and any unusual features in the type of failure shall be noted.

Table 9 Flexural strength for 28 days for various mix proportions

S.No	Coarse Aggregate Replacement proportion (%)	Percentage of cement replaced with	Flexure strength (MPa)
1	Nominal	0%	3.91
2	25% ECA	10%SF+1.6%PVA	3.22
3	50% ECA	10%SF+1.6%PVA	2.68
4	75% ECA	10%SF+1.6%PVA	2.07
5	100% ECA	10%SF+1.6%PVA	1.45

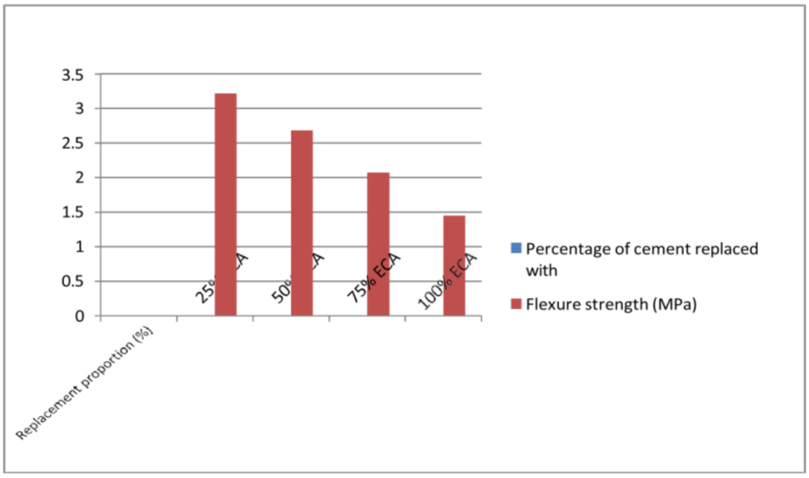


Figure 8 Flexure Strength of Different Mixes

CONCLUSIONS

• Lightweight concrete can be utilized as a normal concrete replacement structure shield.

• Aerated Concrete and Lightweight Aggregate Concrete also can be use as energy absorbent.
• Lightweight aggregate concrete, it depends on the materials used.

• Lightweight concrete can develop to be high strength concrete and good absorbability of impact energy.

• It has a lower modulus of elasticity and higher tensile strain capacity further provides better impact resistance than normal weight concrete.

• In recommendation, more research is required if the capabilities of the material are to be exploited and utilization the reinforcement for enhance the tensile strain capacity of concrete.

• Foamed lightweight concrete is not suitable to be used as load bearing wall as the compressive strength is 27% less than recommended.

• The compressive strength of light weight concrete is lower than the ordinary conventional concrete. Therefore this light weight concrete can be used in places where the external force acting on the structure is minimum. This light weight concrete is only capable to carry its self weight.

• The workability of light weight concrete is not good when it is compared to the ordinary conventional concrete. This workability can be improved by introducing microscopic air bubbles into this concrete or air entrainment

• The partially light weight concrete may also be used as structural concrete on some cases because it is having the compressive strength value which is suitable for structural.

• This light weight concrete has low thermal conductivity and has an ability to absorb sound. So, it can be used for acoustic structures.

• An investigation can be made on pre-wetting of the light weight natural pumice aggregate for different mixes.

• Studies on fibrous (metallic, nonmetallic and natural) light weight aggregate (Pumice) concretes can be evaluated.

• The studies on SSC with light weight aggregate (pumice) can be evaluated)

• Behavior of the pumice aggregate concrete mixes with different mineral admixtures can be made.

• Durability studies can be carried out by exposing to chloride sulphate and acidic environments.

• Elevated temperature studies, freezing, thawing and chloride permeability tests on this particular type of concrete can be studied.

• From the above compressive strength results, it is observed that as the percentage of ECA is increasing the compressive and flexure strength is decreasing since, the density of concrete is reduced by addition of ECA

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