Compressive Strength of Light Weight Concrete Using Natural and Artificial Aggregate

Rita Singh[1], Dr. Ravindra Kumar[2]

[1]*Civil Engineering Student, GNIOT College, GREATER NOIDA, INDIA*
[2]*Dr. Ravindra Kumar, Dept. of civil Engineering, GNIOT College, INDIA*

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Abstract - *The intention of the research is to study the comparison of concrete with pumice as natural aggregate and crushed AAC blocks as artificial light-weight aggregate with partial replacement of normal weight coarse aggregate by focusing on its capability to reduce dead load without a considerable reduction in compressive strength. Grade of concrete–M40 has been in use for this project. Testing is geared up for Concrete cube testing as per I.S. guidelines (516-1959), aggregate testing as per I.S. guidelines (2386-1963, 383-1970). Comparison of Pumice and Crushed AAC block for making 90, cubes of concrete mixes. The coarse aggregate has replaced by pumice and crushed AAC blocks like 20%, 25%, 30%, and 35% respected to I.S code and check the compressive strength after 7, 28 and 56 days. In all 90 test specimen was prepared for pumice & crushed AAC for M40 grade concrete.*

***Key Words*: Light-weight Aggregate: Pumice stone, Crushed AAC Block.**

1. INTRODUCTION

Light-weight concrete (LWC) has been utilized within the development trade for the past few decades and want to be examined for performance. A specific type of LWC known as structural light-weight concrete is one that's relatively lighter than normal concrete however at the same time strong enough to be used for structural functions.

Structural LWC has associate in-place density (unit weight) on the order of 1440 to 1840 kg/m� compared to ancient weight concrete density inside the very 2240 to 2400 kg/m� The LWC mixture is made with a light-weight coarse mixture. Light-weight aggregates utilized in structural LWC are usually enlarged sedimentary rock, slate or clay materials that are laid-off during a rotary kiln to develop a porous structure. Different merchandise like cool furnace scum is also used.

There are different classes of non-structural LWC with lower density created with a unique mixture of materials and higher air voids among the cement paste matrix like in cellular concrete.

2. LITERATURE REVIEW

Sundar et al. (2010) prepared a light-weight concrete by using hemalite light-weight aggregate and different other materials i.e. silica fume, fly ash, and GGBS (Ground granulated blast furnace slag). They include additional materials in the concrete to examine the compressive strength. Highest compressive strength was achieved at 10% fly ash (FA) and 5% silica fume (SF) which amount to be 30.2 N/mm^2 in the concrete. This growth was pragmatic 10% as compared to the control mix. The compressive strength was also enlarged with GGBS. The compressive strength outcome was observed at higher at 10% GGBS, 5% SF which amount to be 32.24 N/mm^2. The conclusion of the study revealed that GGBS is more helpful to increase the compressive strength as compared to fly ash.

Chella et al. (2013) worked on high-performance concrete with the use of Super Absorbent Polymers (SAP) and Light-weight fine Aggregates (LWA). 25 % LWA replace by normal aggregate and SAP added was 0.3% by weight of cement. the results with LWA mix has shown 12.35% increases compressive strength, 2.43 % in tensile strength, 19.14% in flexural strength on 28 days than the control concrete mix. The termination of the experimental study was the adding up of internal curing agent increases the degree of hydration, producing a denser microstructure leading to better results. The coefficient of permeability of mix M_2 was 13.68 x10^{-12}m/sec that was minor than all the additional mixes. Lesser the coefficient of permeability betters the results. Here two tests are done first one is strength and the second one is durability.

Sivalinga et al. (2013) performed a study on fiber reinforced lightweight aggregate (Natural Pumice Stone) concrete. The mix design was M20 and the experiment results showed that extra than the target means strength of M20 concrete is achieved with 20 percent replacement of natural coarse aggregate by pumice aggregate and with 1.5 percent of fiber. Furthermore, with 40% pumice and with 0.5% of fibers, the average target means strength of M20 concrete was achieved.

Dhote et al. (2016) studied the project conducted to study the feasibility of setting up an AAC Blocks Manufacturing Plant. The object of this feasibility study is to provide a framework about the technical, economical & financial aspects in a broader sense and implementation of the project under the projected time-frame. In different words, the study is geared toward analyzing Technical, Economical and Financial viability of setting up an AAC Blocks Manufacturing Plant.

Kurweti et al. (2017) compared the dissimilar types of lightweight concrete according to their substantial properties. In this manuscript, a deep discussion area unit administrated among the properties of CLC, AAC, and ash. AAC(Autoclaved aerated concrete)is a light-weight concrete material that was urbanized in lots of years ago, the main constituents used in manufacture of this type of concrete is cement grade 53, gypsum, class C lime (hydrated lime), aluminum powder(.05-.25%by wt. of cement), fine aggregate or fly ash (class F) combining with explicit size. CLC (Cellular lightweight concrete) is another lightweight concrete material which is extensively used in making infrastructure and high rise building, the main ingredients of making CLC is cement (Ordinary Portland cement grade 53), Fly ash (class F), sand (passing 2mm sieve),foaming agent(either protein based or synthetic based). Fly ash is also taken in this manuscript as a light-weight concrete because it replaces partially fine aggregate and fully coarse aggregate the raw materials of this type of concrete is cement (grade53/grade43), ash (class F), sand (passing 2mm sieve).

3. METHODOLOGY& MATERIALS

The standard tests of all materials have been conceded out in the laboratory as per relevant codes. Physical properties of AAC blocks aggregate and pumice stone such as sieve analysis (grading), water absorption test and specific gravity were carried out. To study the mechanical properties, a design mix of M40 was prepared.

For this rationale, many concrete mixes labeled as M1, M2, M3, M4 and M5 and so more were prepared with different replacement ratios (0 and 20 to 35%) of AAC blocks and pumice stone aggregate with the coarse aggregate.

3.1 NATURAL AGGREGATE:

These invent from bedrocks. Those from the stream beds, stream sand and ex-mines normally rounded in shape and have a flat surface texture. These cumulative area units sometimes obtained from natural deposits of gravel, and sand or from quarries by cutting rocks.

3.1.1 PUMICE:

It is acquired from the Debre-Zeit Bishoftu in Ethiopia Mountains; in Bishoftu could be a dormant volcanic mountain with massive deposits just beneath the superficial vegetation. Pumice is a nonspecific term worn to demonstrate porous solids produced during the cooling of magma as an outcome of volcanic creation.

3.2ARTIFICIAL AGGREGATE:

Broken brick, blast furnace slag, and synthetic aggregate are artificial aggregate. Broken brick known as brickbats is suitable for mass concreting for example, in foundation bases. Blast furnace slag aggregate is obtained from slow cooling of the slag followed by crushing artificial aggregate are usually produced by expanding the rocks such as shale, slate, per tile, vermiculite, etc.

3.2.1 CRUSHED AAC BLOCK:

AAC is a lightweight, load-bearing, high- insulating, durable building product and compares to the red bricks AAC blocks are three times lighter. These include sand, cement, lime, fly ash, gypsum, aluminum powder paste, water, and an expansion agent .silica sand raw material used in the greatest volume in AAC. The low density is achieved by the formation of the air voids. These voids are typically 1mm-5mm.

4. CALCULATION

4.1 Aggregates

Aggregates are the important constituents in concrete. They give shape and body to the concrete, reduce shrinkage and effect economy. The simple undeniable fact that mixture occupies 70-80 P.C of the volume of the concrete, their impact in numerous characteristics and properties of concrete is beyond question appreciable.

4.2 Coarse Aggregates:

Coarse aggregates are the crushed sandstone is employed for creating concrete. Graded crushed stone habitually consists of only one kind of rock and is busted with sharp edges. Rainbow granite may have black or dark green surroundings with pink, yellowish and reddish mottling; or it can have a pink or lavender background with dark mottling. The density is 2,723 kg/m^3, the specific gravity 2.70, and crushing strength 158 to 220 Mpa. The sizes are from 0.25 to 2.5 in (0.64 to 6.35 cm), even though larger sizes may be worn for massive concrete aggregate.

4.3 Fine Aggregates and Coarse aggregate:

Fine Aggregates are amorphous as the aggregate which passes in the course of 4.75 mm IS sieve and retained on 75 µ IS sieve. The utility of fine aggregate is to plug the open spaces or voids involving particles. Substantial properties of the coarse and fine aggregate are specified in Table 4.1

Table 4.1: Physical properties of the coarse and fine aggregate

Characteristics	Coarse Aggregate	Fine Aggregate	Referred Code
Specific gravity	2.64	2.59	IS:2386 (Part III)
Water Absorption	0.81%	2.00%	IS:383(1970)
Aggregate Impact Value	9.413%	-	IS:2386(1963)

4.4 Pumice and AAC block

Crushed stone of AAC blocks and pumice stone has been used in this study to make the lightweight concrete structures. The physical properties of pumice and crushed AAC blocks are given in Table 4.2.

Table 4.2: Physical properties of pumice and crushed AAC blocks

Characteristics	Pumice Aggregate	Crushed AAC Blocks
Specific gravity	1.34	1.7
Water Absorption (%)	64.83	45.63
Aggregate Impact value	48.97	39.92

4.5 MIX DESIGN:

A concrete mixture of M40 has been intended as per the formula specified in IS: 10262-2009 as particular in Table 3.4.

- Grade designation = M40
- Type of Cement = OPC forty three grade confirming to IS: 8112-1989
- Specific gravity of cement: 3.15
- Specific gravity of coarse aggregate (CA) = 2.7
- Specific gravity of fine aggregate (FA) = 2.43
- Target mean strength $F_t = F_{ck} + 1.5$ S

= 47.5 N/mm^2

b. water cement ratio - 0.45

c. Selection of water content (100 slump) =186 + $\frac{6}{100}$ x 186

Water content = 197 kg/m^3 for 20 mm size aggregate

d. Cement content:

W/C ratio = 0.45

Cement content = 197/ 0.45= 437.77 kg/m^3

e. Coarse aggregate:

$$\frac{\text{Coarse aggregate}}{\text{Volume of coarse aggregate X S.G.of CA}} = 1000 - \left(\frac{\text{cement}}{\text{Specific gravity of cement}}\right) - \text{water content}$$

Quantity of coarse aggregate = 1111.58 kg/m^3

f. Fine aggregate:

$$\frac{\text{Fine aggregate}}{\text{Volume of fine aggregate X S.G.of FA}} = 1000 - \left(\frac{\text{cement}}{\text{Specific gravity of cement}}\right) - \text{water content}$$

Quantity of fine aggregate = 613.165 kg/m^3

Table 4.3 Mix design of the concrete

Ingredients of mix	Value
Cement	437.77 (kg/m^3)
Sand	613.165 (kg/m^3)
Coarse Aggregate	1111.58 (kg/m^3)
W/C ratio	0.45
Water	197

5. RESULT

Table 5.1: Compressive strength of cube specimen of Pumice stone

Mix no.	Pumice stones					
	7 Days		28 Days		56 Days	
	Load(KN)	Compressive strength (MPa)	Load(KN)	Compressive strength (MPa)	Load(KN)	Compressive strength (MPa)
Control mix	635.18	28.23	1006.89	44.75	1070.98	47.60
20% PA	712	31.64444	1045.45	46.46444	1076.45	47.84222
25% PA	728.23	32.36578	1074.56	47.75822	1094.74	48.65511
30% PA	765.98	34.04356	1112.76	49.456	1123.97	49.95422
35% PA	621.38	27.61689	968.56	43.04711	1056.54	46.95733

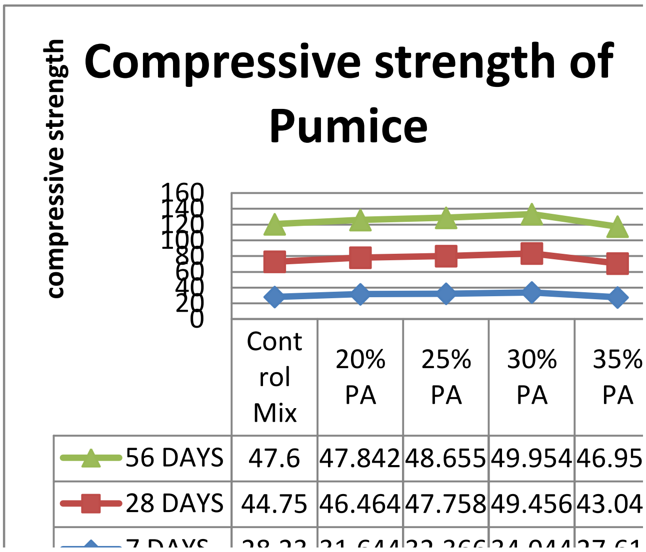

Figure 5.1 (Graphical representation of compressive strength of pumice stone)

Table 5.2: Compressive strength of cube specimen of crushed AAC blocks:

Mix no.	Crushed AAC blocks					
	7 Days		28 Days		56 Days	
	Load(KN)	Compressive strength (MPa)	Load(KN))	Compressive strength (MPa)	Load(KN)	Compressive strength (MPa)
Control mix	624.13	27.74	1016.28	45.168	1081.63	48.07
20% AAC	698.89	31.06178	1076.94	47.864	1119.29	49.74622
25% AAC	788.54	35.04622	1123.12	49.91644	1165.32	51.792
30% AAC	621.21	27.60933	1012.07	44.98089	1065.54	47.35733
35% AAC	601.79	26.74622	1004.56	44.64711	1032.45	45.88667

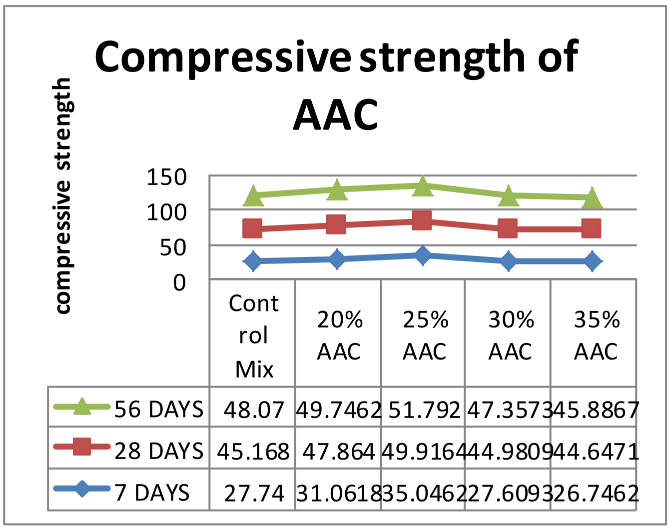

Figure 5.2 (Graphical representation of compressive strength of AAC Block)

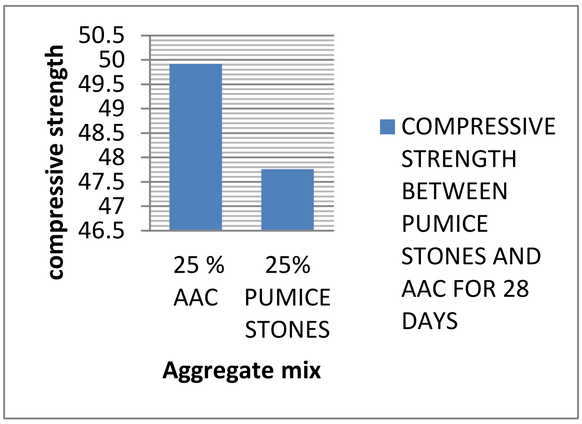

Figure 5.3 (Comparison of pumice stone and crushed AAC block for 28 days at 25% Replacement of LWA)

5.1 DISCUSSION OF RESULTS

The compressive strength of the concrete specimens is increment significantly on the addition of pumice stone and crushed AAC blocks as a replacement of coarse aggregate. This increase of compressive strength is with the increase in the percentage of the crushed AAC blocks because AAC block has a quantity of lime, cement and Fly Ash. It has also been observed that as the percentages of crushed AAC blocks material increases, the compressive strength decreases at the 30% replacement of crushed AAC blocks and for pumice, compressive strength decrease at the 35% replacement of pumice stone. Achieve the optimum value of the crushed AAC blocks at 25% and achieve the optimum value of the pumice stone at 30%.

6. CONCLUSION

Concrete which is of utmost importance to the construction industry has also undergone rapid and phenomenal development in the past few years. As a result, lightweight concrete (LWC) has emerged as the concrete which serves both economic and environmental concerns. Lightweight aggregate concrete with crushed AAC blocks (LWAC) proves to be a good alternative to the conventional concrete in comparison to pumice. The replacement of normal weight coarse aggregate by crushed AAC blocks and pumice stone in concrete mix shows has good potential as a structural member for economical construction

Following are the observations on the basis of experimental results of pumice stone:

- The increment of compressive strength is up to 12.97%, 3.84% and 0.51% after 7 days, 28 days and 56 days of curing at 20% replacement of coarse aggregates by Pumice stone.
- The increment of compressive strength is up to 2.28%, 2.78% and 1.70% after 7 days, 28 days and 56 days of curing at 25% replacement of coarse aggregates by Pumice stone.
- The increment of compressive strength is up to 5.19%, 3.56% and 2.67% after 7 days, 28 days and 56 days of curing at 30% replacement of coarse aggregates by Pumice stone.
- The decrement of compressive strength is up to18.9%, 12.96% and 5.99% after 7 days, 28 days and 56 days of curing at 35% replacement of coarse aggregates by Pumice stone.

Following are the observations on the basis of experimental results of crushed AAC block:

- The increment of compressive strength is up to 11.97%, 5.968% and 3.487% after 7 days, 28 days and 56 days of curing at 20% replacement of coarse aggregates by crushed AAC blocks.
- The increment of compressive strength is up to 12.827%, 4.289% and 4.112% after 7 days, 28 days and 56 days of curing at 25% replacement of coarse aggregates by crushed AAC blocks.
- The decrement of compressive strength is up to 21.22%, 9.888% and 8.562% after 7 days, 28 days and 56 days of curing at 30% replacement of coarse aggregates by crushed AAC blocks.
- The decrement of compressive strength is up to 3.126%, 1.649% and 3.054% after 7 days, 28 days and 56 days of curing at 35% replacement of coarse aggregates by crushed AAC blocks.

Conclusion of Pumice stone and Crushed AAC Block

1. Optimum compressive strength percentage is achieved of crushed AAC block at 25% and pumice stone is achieved at 30%.
2. Cost of crushed AAC block is Rs. 32-34 per cubic feet that is less than to the comparison of pumice stones is Rs.40-48 per cubic feet.
3. The specific gravity of crushed AAC block is 1.7 this value is 26.86% greater when compared to the specific gravity of Pumice stone which is 1.34.
4. The water absorption of crushed AAC block is 45.63 this value is 29.615% lower when compared to the water absorption of pumice stone which is 64.83.

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