

Experimental Study of Light Weight Concrete using Perlite

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Abstract- Structural Low Density Aggregate Concrete has an ability to reduce the self-weight of the structure as well as reduces the risk of earthquake damages to a structure because earthquake forces are proportional to mass of the structure. For structural application of lightweight concrete, the density is more important than the strength. A low density for the same strength level reduces the self-weight, foundation size and construction costs. In this study, structural lightweight aggregate concrete was designed with natural Perlite aggregate that will provide an advantage of reducing dead weight of structure also compared the strength of normal concrete with perlite concrete by fully replacing coarse aggregate with perlite by varying the water cement ratio in perlite concrete. The investigations were carried out using several tests which include compressive test, split tensile test. By analyzing the test results the perlite concrete can be effectively used in non-load bearing walls and in-fill walls and the dead load of the structure can be effectively reduced.

Keywords: Low density concrete, Perlite aggregate, Self-weight reduction, Compressive strength analysis, Tensile strength analysis

I. INTRODUCTION

Concrete is a mixture of fine and coarse aggregate bonded together with cement mortar that hardens over time. Portland cement is most commonly used for making concrete. Concrete is used in the construction of various structures like beams, columns, slabs, foundation and other load bearing elements. There are many types of Non Cementitious materials exists by using different binding aggregate like asphalt concrete in combination with a bitumen binder.

The term light weight concrete according to ACI is also known as Light density concrete. It is defined as the concrete which is made with light weight coarse aggregate and normal weight fine aggregate with

possibly some light weight fine aggregate. This concrete is of density less than 1950 kg/m^3 . The aggregate used here has high porosity, small apparent density, more water absorption and low strength. Structural Light Weight Aggregate are typically expanded shale, Clay or slate materials fired in a rotary kiln to develop a porous structure.



1.1 Objectives

The following are the objectives

- To reduce the self-weight of the structure by producing structurally light weight aggregate concrete with the help of perlite as coarse aggregate.
- To compare the conventional concrete with structurally light weight aggregate concrete by fully replacing coarse aggregate as perlite with different water content of 0.45% and 0.5 %
- The investigations are to be carried out using tests which include compressive test and split tensile test.

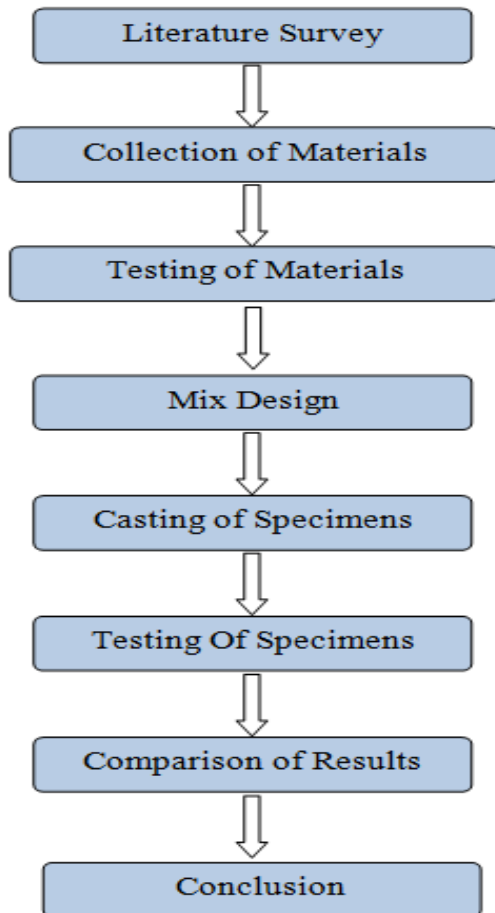
II. LITERATURE REVIEW

Bhuvaneshwari. K et al. (2017) studied that the structural light weight concrete when designed with natural perlite aggregate provides an advantage of reducing the dead weight of the structure and also the strength of normal concrete with perlite concrete by

partially replacing perlite with sand as a percentage of 5%, 10%, 15%, 20% and 25% in normal concrete mix. The result shows that the Compressive strength increased by 1.85%, Split Tensile strength increased by 10.46% and Flexural strength by 10.20% through the optimum replacement of 10% of sand by Perlite.

Dinesh. A et al. (2016) This study states that in the design of Concrete Structures, Light weight concrete plays a prominent role in reducing the density and to increase the thermal insulation. Structural light weight aggregate concrete was designed with the use of Perlite aggregate, Vermiculite aggregate and expanded clay aggregate. With respect to Compressive strength and Split tensile strength they concluded that the replacement of Vermiculite and Perlite aggregate by 50% of weight of aggregate increases strength with increase in age of concrete and obtain early strength.

III. METHODOLOGY



IV. EXPERIMENTAL PROCEDURE

4.1 Collection of Materials

The materials needed for the project are Ordinary Portland cement of 53 grade, 20mm sized coarse aggregate, fine aggregates passing through IS 4.36mm sieve and perlite aggregate of size 10mm and water. The cement, fine and coarse aggregate is collected from factory nearby.

4.2 Material Properties

4.2.1 Cement

Properties	Result
Initial setting time	38 minutes
Final setting time	466 minutes
Specific gravity	3.10
Fineness	8%
Consistency	30%

Table-1: Properties of Cement

4.2.2 Fine Aggregates

Properties	Result
Grading zone	Zone III
Bulk density(kg/m ³)	1860
Specific gravity	2.64
Fineness modulus	2.68

Table-2: Properties of Fine Aggregates

4.2.3 Coarse Aggregates

Properties	Result
Bulk density(kg/m ³)	1620
Specific gravity	2.60
Fineness modulus	4.68

Table-3: Properties of Coarse Aggregates

4.2.4 Perlite Aggregate

Properties	Result
Size	10mm
Water absorption	1.5%
Specific gravity	0.15
Color	white
Fineness modulus	5.17

Table-4: Properties of Perlite Aggregate

4.3 MIX DESIGN

A mix for M₃₀ grade of concrete was designed as per IS 10262-2009.

Data:

Characteristic compressive strength required = 30 MPa

Maximum size of aggregate = 20 mm

Degree of workability = 0.80

Degree of quality control = Good

Type of exposure = Mild

Standard deviation = 5.00

N/mm²

Specific gravity of Cement = 3.15

Specific gravity Coarse aggregate = 2.60

Specific gravity Fine aggregate = 2.64

Design:

4.3.1 Target mean strength:

Risk factor is 1.65

$$\begin{aligned}\text{Target mean strength} &= f_{ck} + (t \times s) \\ &= 30 + (1.65 \times 5) \\ &= 38.25 \text{ N/mm}^2\end{aligned}$$

4.3.2 Selection of water/cement ratio:

As per IS: 10262-2009,

Water / Cement ratio = 0.4

4.3.3 Selection of water and sand content:

For nominal maximum size of aggregate = 20 mm,

Water content (for 25mm to 50mm slump and 20mm aggregates) = 186 litre

Required water content for 100 mm slump = 186 + (0.06 x 186) = 197 litre

Water / Cement ratio = 0.4

Hence,

$$\begin{aligned}\text{Cement Content} &= (\text{Water}) / (0.4) \\ &= (197) / (0.4) \\ &= 492 \text{ kg/m}^3\end{aligned}$$

Volume of coarse aggregate for w/c ratio 0.4 = 0.62m³

Volume of fine aggregate = 0.38m³

4.3.4 The mix calculation is given as follows:

(a) Volume of concrete = 1m³

(b) Volume of cement = mass of cement / (specific gravity x 1000)

$$\begin{aligned}&= 492 / (3.15 \times 1000) \\ &= 0.156 \text{ m}^3\end{aligned}$$

(c) Volume of water = 140 / 100

$$= 0.140 \text{ m}^3$$

$$\begin{aligned}\text{(d) Volume of all in aggregates} &= a - (b + c) \\ &= 0.704 \text{ m}^3\end{aligned}$$

Mass of coarse aggregate = (d) x volume of coarse aggregate x specific gravity x 1000

$$= 1134 \text{ kg}$$

Mass of fine aggregate = (d) x volume of fine aggregate x specific gravity x 1000

$$= 706 \text{ kg}$$

Table 5: Mix Proportion

Water	Cement	Fine Aggregate	Coarse Aggregate
197 litre	497 kg/m ³	706 kg/m ³	1134 kg/m ³
0.4	1	1.42	2.28

4.4 CASTING OF SPECIMENS

After mixing, the conventional concrete mix and perlite concrete mix with different water cement ratio are filled in cubic and cylindrical moulds for testing. The specimens are demoulded after 24 hours for curing and the curing is done for 28 days in the curing tank.



Fig -1: Casting of concrete

4.4.1 Curing of Specimens

The curing procedure used here is water curing. The mould is dismantled and the cubes are taken out and placed in the curing tank for 7 and 28 days, so that the concrete could attain its full strength.



Fig -2: Curing of concrete

V. TESTING OF CONCRETE

5.1 Compressive Strength

After 7 and 28 days of curing, cube specimens were removed from the curing tank and cleaned to wipe off the surface water. Cubes were tested at the specified age using compression testing machine as shown in Figure. The maximum load to failure at which the specimen breaks and the pointer starts moving back was noted. The test was repeated for three specimens and the average value was taken as the mean strength. The conventional concrete and the structurally light weight aggregate concrete has been tested. The structurally light weight perlite concrete of series 1 (water content ratio 0.4) and series 2 (water content 0.5) is tested after 7days for its compressive strength.



Fig -3: Cube Testing

5.2 Split Tensile Strength

The tensile strength for continuously moist cured lightweight concretes was correlated mainly with the compressive strength and may be considered equal to that of equal compressive strength normal weight concrete. The tensile strength of lightweight concretes which undergoes drying is more relevant in respect to behavior of concrete in structures.



Fig -4: Cylinder Testing

In drying of the concrete, moisture losses progress at a slow rate into the interior of concrete members, which results in the probable development of tensile stresses on the exterior faces and balances compressive stresses in still moist interior Zones. Hence the tensile resistance to external load of dried lightweight concrete would be reduced from that indicated by continuously moist cured concrete. The splitting tensile strength of all-lightweight concretes varies from approximately 100-70 percentage to that of normal weight reference concrete when comparisons are made equal to compressive strength of the cylinder specimen.

VI. RESULT AND DISCUSSIONS

Table-6: Load at Failure in Compression

Trial No.	7 days Compressive load (MPa)		28 days Compressive load (MPa)	
	CC	PC	CC	PC
1	20.8	17.6	31.2	26.4
2	21.5	18.2	32.0	27.1
3	22.0	17.9	31.6	26.8
Average	21.43	17.9	31.60	26.77

Table-7: Load at Failure in Tension

Trial No.	7 days Tensile load (MPa)		28 days Tensile load (MPa)	
	CC	PC	CC	PC
1	2.05	1.62	3.12	2.54
2	2.12	1.58	3.25	2.48
3	2.08	1.60	3.18	2.51
Average	2.08	1.60	3.18	2.51

VII. CONCLUSIONS

1) Thence, based on the test results acquired, it can be inferred that, the perlite concrete using natural perlite as coarse aggregate reduces the self-weight of the concrete blocks to a considerable quantity compared to normal conventional concrete.

2) This type of light weight concrete is used in earthquake prone areas to resist the seismic forces.

3) The compressive strength and tensile strength of perlite concrete is compared with conventional concrete which is of same water cement ratio and the strength of the perlite concrete is greatly reduced but the density achieved by perlite concrete is relatively

low hence, it can be the vital replacement of concrete in non-load bearing walls, light weight roof decks, floor fills and in-fill walls by which the structural dead load of the building can be effectively reduced.

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