Exploratory Investigation on Light Weight Concrete with Pumice Stone as a Partial Substitution of Coarse Aggregate

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Abstract - *Lightweight concrete in today's world has a high* number of applications as the structural demands are increasing it has many applications in the concrete and construction industry nowadays. In this experimental study, an attempt has been made to compare the conventional concrete with the lightweight concrete which is made by partially replacing the coarse aggregate with Pumice aggregate using a mix of M30. The lightweight concrete has been made by partial replacement of coarse aggregate with the varying percentage of pumice aggregate from 8%, 16%, and 24%. This experiment is focused to determine the strength parameters of the newly designed concrete, to find the most favorable replacement from the above-mentioned replacements and the results are compared with that of the conventional concrete.

Key Words: Light Weight Concrete, Pumice Aggregate, Natural Aggregate, Compressive Strength

1. INTRODUCTION

Concrete is a composite mixture that is obtained by mixing cement, sand, gravel, and water in fixed proportions. These days concrete is used in wide varieties for the structural purpose, the conventional concrete has high self-weight and the density ranges from 2200 to 2600 kg/m3. Due to high self-weight, it becomes uneconomical material to some extent. So, many attempts have been made in order to reduce the self-weight of the concrete and to increase its efficiency as a structural mixture. Aggregate is one of the vital ingredients in term of quality and holding of concrete, it can be further classified into different categories according to their shape such as rounded, angular, flaky, irregular, etc. it can be further divided according to surface texture, i.e. smooth, rough, porous, honeycombed, glassy. By the integrity of aggregates density, the concrete produced is quite heavy having a density of about 2400kg/m3 and by reducing the density of the concrete mix it will lead to an economical construction as it reduces the cost in transportation, handling, and constructability. One of the methods to produce lightweight concrete is the introduction of lightweight aggregate and air-entraining agents. Using lightweight aggregate in the concrete mix results in the reduction of the self-weight of the concrete and it also helps in quick construction and handling of concrete.

1.1 Light Weight Concrete:

Structural lightweight concrete is a type of concrete that includes an expanding agent in it that increases the volume of the mix while reducing the self-weight. Structural lightweight concrete has a density in the range 1440 to 1840 kg/m3 compared to conventional concrete with a density in the range of 2200 to 2600 kg/m3. But the concrete should have a minimum strength of 17 MPa in order to be used as structural concrete. Some lightweight aggregates which can be used in lightweight concrete are shale, pumice, foam, clinker, and perlite.

1.1.1 Advantages of Light Weight Concrete:

- Fast and easy construction.
- Efficient in terms of transportation and reduces labor demand.
- Lower coefficient of thermal expansion
- High strength in earthquakes

1.1.2 Disadvantage of Light Weight Concrete:

- Longer mixing time as compared to conventional concrete
- Sensitive to water content
- High water demand due to porous nature of light weight aggregate

1.2 Types of light weight aggregate:

Natural Lightweight aggregate	Artificial lightweight aggregate
Pumice	Artificial cinders
Diatomite	Coke breeze
Scoria	Foamed slag
Volcanic cinders	Expanded shale
Sawdust	Expanded perlite
Rice husk	Thermocol beads

1.3 Pumice Stone:

Pumice stone is a natural lightweight aggregate that has its origin from the sudden cooling of the molten volcanic matter such as lava. Pumice stone is a colorless or light grey colored coarse aggregate. Pumice stone specific gravity is 1.04 and the constituents are silica (70%) and alumina (14%), along with iron oxide as 2.5%, calcium oxide as 1%, and sodium oxide as 9%.

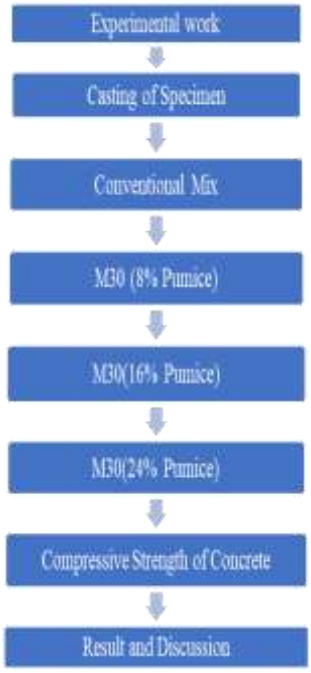
Fig -1: Pumice Stone

2. Literature Review:

K. Guru Kesav Kumar, et al (2016) M20, M25 and M30 grade of concrete used with replacement percentage 10% and 20% can be effectively used for structural purpose. Replacement of 30% can only be used for nonstructural purpose and optimum strength of replacement for 20% is effective.

A.Suba lakshmi, et al (2017) Maximum value of strength is obtained in 50% replacement of Pumice with coarse aggregate. The light weight concrete has density 1500kg/m^3 and conventional concrete 2400kg/m^3. The increasing percentage of pumice stones will show negative impact on strength of concrete (strength decreases).

3. Methodology:



4. Design Mix:

A) Mix Design:

In this experimental study, the concrete used is of M30 grade with the nominal mix prepared as per the guidelines of IS 456:2000 and IS 10262:2009. The concrete mix proportion by weight for 1m3 and water-cement ratio of 0.42 was used for the experimental study. The density of the conventional concrete is 2400 kg/m3 and the density of lightweight concrete is 1500 kg/m3.

B) Preparation of Test Specimens:

Compressive strength was found by using the cubes of standard size of 150 mm x 150 mm x 150 mm. A total of 30 cubes were casted with 6 cubes for each mix design. After the casting process, the cubes were kept for 24 hours and de-molded, and they were cured for 7 days and 28 days.

5. Result and Discussion:

Concrete cubes of standard IS size were cast during casting the cubes were mechanically vibrated using table vibrator. After the casting, the cubes were de-molded after a span of 24 hours and the specimens were subjected to curing for 7 days, 14 days and 28 days in tap water. After the completion of the curing process, the specimens were tested for compressive strength under the compression testing machine of 2000kn capacity as per the BIS: 516-1959. The maximum load at which the cracks developed was taken.

The compressive strength of concrete can be found by using the equation.

Ultimate compressive load (W) = Compressive Strength (N/mm^2) / Cross-Sectional Area of specimen (mm^2)

Fig -2: Compression Testing Machine

S. No.	Mix	Compressive Strength (KN/mm²) (7 Days)	Compressive Strength (KN/mm²) (14 Days)	Compressive Strength (KN/mm²) (28 Days)
1	M30 Conventional Mix	20.80	23.73	29.48
2	M30 Conventional Mix	20.10	24.54	28.21

Table -1: Compressive Strength of Conventional Concrete

Conventional reading (N/mm²)	No. of days	Replacement %	Reading after replacement of Pumice stone (N/mm²)
20.45	7 Days	8%	19.02
		16%	17.98
		24%	17.06
24.13	14 Days	8%	22.44
		16%	21.17
		24%	20.13
28.84	28 Days	8%	26.82
		16%	25.80
		24%	24.76

Table -2: Compressive Strength of Light Weight Concrete at Different Replacement

S. No	Mix	Weight of Cube Specimens (Kg)
1	M30 Conventional Mix	8.15
2	M30 (8% Pumice)	7.92
3	M30 (16% Pumice)	7.81
4	M30 (24% Pumice)	7.78

Table -3: Weight of Specimens

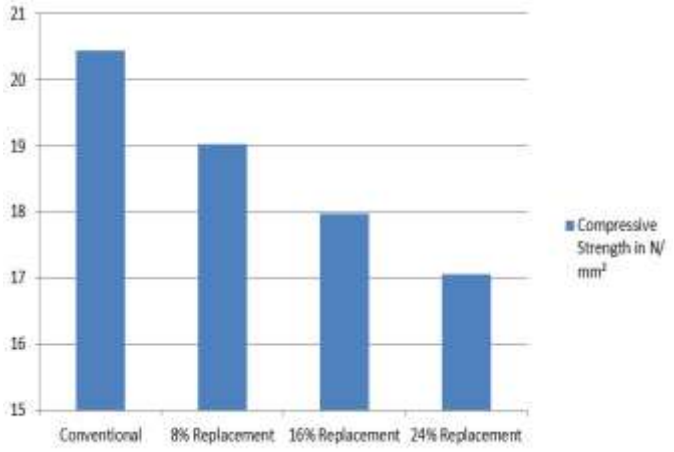


Fig -3: Compressive strength for M30 grade 7 days result of pumice stone

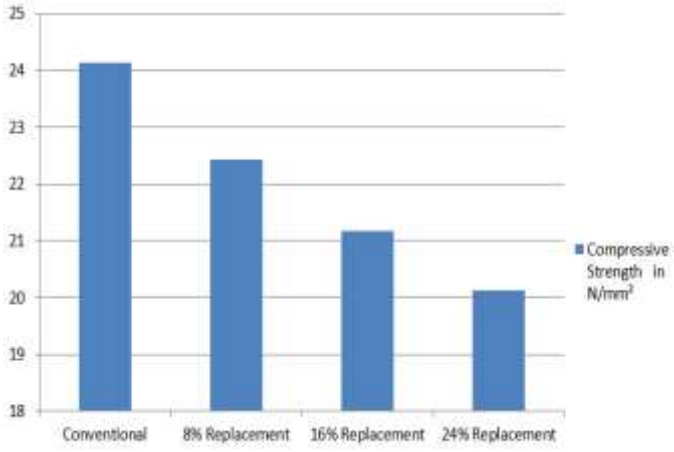


Fig -4: Compressive strength for M30 grade 14 days result of pumice stone

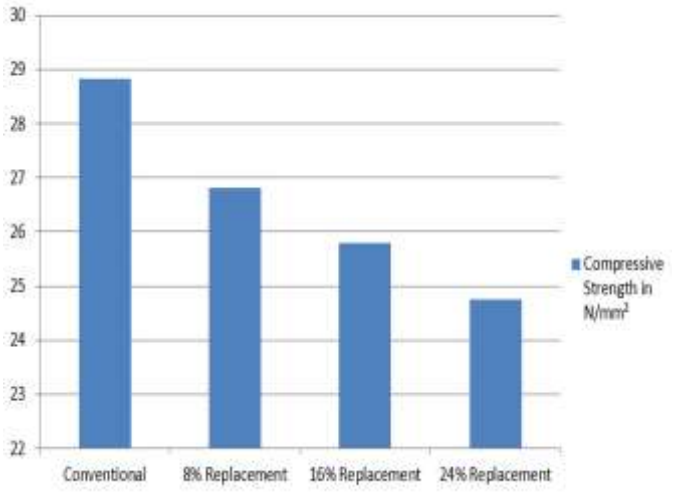


Fig -5: Compressive strength for M30 grade 28 days result of pumice stone

6. CONCLUSIONS

Based on the experimental study and the results obtained from the study following conclusion are made:

• The density of concrete is very much reduced as compared to conventional concrete, so the self-weight of the structure is also reduced.

• The density of concrete decreases as we increase the replacement percentage of normal coarse aggregate with pumice aggregate.

• The Pumice stone absorbs more water compared to the normal coarse aggregate, so to overcome this situation superplasticizers are used.

• By replacing 16% of normal coarse aggregate with pumice aggregate the compressive strength is promising.

• With the further increase in percentage replacement, the strength of concrete starts decreasing.

• The lightweight concrete can be used in wall paneling of non-load bearing type used in precast building.

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