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AN EXPERIMENTAL STUDY TO REDUCE SELFWEIGHT OF CONCRETE USING PUMICE STONE AS COARSE AGGREGATE

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ABSTRACT

The study looks at the usage of pumice aggregate in certain types of concrete, such as lightweight concrete (natural aggregate). The high self-weight of conventional concrete is one of its drawbacks. Due to its high self-weight, it will be an uneconomical structural material to some extent. To minimize dead loads and enhance thermal insulation, lightweight concrete with a low density is utilized. It has a reduced density since it is used as a partial replacement for coarse aggregate in concrete. Using mix M_{30} with poly carboxyl ether addition, this study compared conventional concrete to low-weight aggregate concrete. Pumice is used to partly replace coarse aggregate in lightweight concrete at different percentages ranging from 20% to 100%. The objective of this research is to determine which of the above-mentioned alternatives is the best replacement by evaluating the compression and split tensile strength characteristics of lightweight aggregate concrete. The results are compared to those of conventional concrete.

Keywords*: Pumice Aggregate, light weight concrete, low density concrete, light weight aggregate.*

1. INTRODUCTION

Because coarse aggregate is less costly than cement in the production of concrete, the most cost-effective approach is to utilize as much aggregate as feasible. The use of aggregates improves the volume stability and durability of the finished concrete[1]. An appropriate aggregate should

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provide the required characteristics in both fresh and hardened concrete[2]. Concrete is made up of cement, fine aggregate, coarse aggregate, and water, and it has a broad variety of strengths. Based on research that used pumice stone as a substitute material[3]. Pumice is a volcanic-derived natural aggregate produced when gases escape from the lava as it solidifies. Bubbles or air gaps develop as gases caught in molten lava flowing from volcanoes get trapped when it cools, giving pumice its cellular structure. The use of coarse aggregate rather than pumice stone is claimed to be a structural lightweight concrete option for lowering the self-weight of a structure[4-6]. The low density of pumice aggregate concrete is one of its most important benefits. Pumice stone is a light, low-specific-gravity aggregate. Water absorption is similar to coarse aggregate since it is a very porous substance[6-8]. Pumice is used in place of coarse material, while sand is used in place of fine aggregate. Pumice is a floatable light grey or colorless coarse aggregate. The density of pumice is 0.25 g/cm^3. The specific gravity of pumice aggregate is low, and it is thermally insulating.

2. OBJECTIVE AND SCOPE OF THE STUDY

- To investigate whether lightweight pumice stone concrete might be utilized in structural applications.
- The compressive and split tensile strengths of lightweight concrete having a density of less than 1800kg/m^3 were measured.
- The main objective of this study was to see how lightweight aggregate (pumice) and conventional concrete affected the 7th and 28-day compressive strength of natural aggregate replacements (20%, 50%, 80%, and 100%). It contributes to the reduction of dead load, the acceleration of building, and the reduction of transportation and handling expenses. When there is poor soil and tall structures, the weight of the building on the foundation is a significant problem in design.

3. METHODOLOGY

Literature reviews on pumice stone were gathered, and preparatory work was carried out based on the findings of the literature survey. Pumice stone collecting was one of the tasks completed. Concrete materials such as coarse aggregate, fine aggregate, and cement were collected. Basic tests on fine aggregate, coarse aggregate, cement, and pumice stone were undertaken to determine their suitability for concrete production. The qualities of fine and coarse aggregates are determined through sieve analysis of fine and coarse aggregates, as well as cement testing. The purpose of this study is to look at the strength-related properties of concrete of the M30 grade. Mix design according to IS code established the amounts of elements in the control concrete of grade M_{30}. To cast the specimen, moulds were created. Moulds of size 150 x 150 x 150mm and cylinder moulds of size 150 x 300mm were cast to partially replace coarse aggregate (20%, 50%, 80%, 100%). After 7 days and 28 days of curing, the cast samples were evaluated. Casted concrete was used to assess compressive strength and split tensile strength. The conclusion was reached once the results were acquired.

4. EXPERIMENTAL INVESTIGATIONS

4.1 Materials

Cement

The cement used in this experiment was Ultra-tech cement' 43 grade OPC cement. The fundamental properties were assessed, and the specific gravity of cement was found to be 3.15, with starting and final setting times of 40 and 595 minutes, respectively.

Fine aggregate

To eliminate stones, fine aggregate is sieved with a 4.75mm sieve. Fine aggregate has a specific gravity of 2.60 and a fineness modulus of 2.78. It confirms the requirements of IS 383-1970 zone II, as illustrated in fig 1.

Fig 1 Fine Aggregate

Fig 2 Coarse aggregate

Coarse aggregate

All Samples will be cast using crushed granite aggregate with a specific gravity of 2.74 and retained through a 20mm sieve. As demonstrated in fig 2, it has a fineness modulus of 7 and water absorption of 4.4%.

Pumice aggregate

Pumice stone is a natural lightweight aggregate generated when molten volcanic materials cool rapidly. As seen in fig 3, pumice is created after the eruption of viscous magma that is primarily siliceous and rich in dissolved volatile components, particularly water vapor. Only mechanical manipulation, crushing, and screening are used to treat them. With lighter equipment, a larger amount of concrete may be handled with less wear and tear on the equipment. Light and airy The live load of formwork and falsework is also reduced with pumice concrete. When comparing water absorption, coarse aggregate outperforms pumice aggregate by 4.4 to 11.1%. As demonstrated in table 1, pumice aggregate absorbs more water than the conventional aggregate. As a result, soak the pumice aggregate in water for 24 hours before using it. Pumice Aggregate has a specific gravity of 0.90.

Table 1. Water Absorption of coarse and pumice aggregate

SL.NO	Determination no	Coarse aggregate	Pumice aggregate
1	Weight of saturated surface-dried sample(a)g	107	50
2	Weight of oven-dried sample(b)g	102	45
3	Water absorption %	4.4	11.1

Fig 3 Pumice Aggregate

Poly carboxyl ether

Poly carboxyl ether-based superplasticizers are a new generation of this type of admixture (PCES). Due to their chemical nature, which allows for effective particle dispersion, they allow for a water reduction of up to 40% with a relatively modest dosage (0.3 percent - 1.5% by cement weight). Poly carboxyl ether has a specific gravity of 1.08.

4.2 Design Mix

M_{30} grade with the nominal mix as per IS 456-2000 and IS 10262:2009 was employed in this study. For concrete mix, use a weight-to-volume ratio of 0.42 and a water-to-cement ratio of 0.42. This variable specifies the study mix. Table 2 shows the density of lightweight concrete at 1500 kg/m3 and the density of regular concrete at 2400 kg/m3. Combine the ingredients in a proportional mix.

Table 2 Mix Proportion (kg/m^3)

Mix Id	Proportion (C:FA:CA:PA)	Cement	Fine aggregate	Coarse aggregate	Pumice aggregate
P 0%	1:2.18:3.86:0	335	733	1295	0
P 20%	1:2.18:3.09:0.25	335	733	1036	85.08
P 50%	1:2.18:1.93:0.63	335	733	647.5	212.7
P 80%	1:2.18:0.77:1.01	335	733	259	340.32
P 100%	1:2.18:0:1.26	335	733	0	425.4

4.3 Preparation of Test Specimens

Cubes of standard size 150 mm x 150 mm x 150 mm were used to determine compressive strength. There was a total of 30 cubes cast, with 6 cubes for each mixing ratio. The compressive strength was determined using 30 cubes. The specimens were maintained for 24 hours after casting and then remoulded. They were cured for 7 and 28 days, respectively. Similarly, the split tensile strength Compressive test was performed on a 150mm x 300mm cylinder.

5. RESULT AND DISCUSSION

Compressive strength

The maximum stress a material can withstand under a pushing, crushing force is known as compressive strength. The material's breaking fracture under these stresses determines it. Specimens measuring 150 mm x 150 mm x 150 mm are utilized in this test. The compressive strength of concrete is defined as the ratio of the greatest load to the concrete cube's surface area. For each mixing ratio, three cubes were tested, and the average of the three specimens was used to determine the compressive strength, which was determined using compression testing equipment with a capacity of 2000 kN.

Table 3 compression test at 7 and 28 days

Mix Id	Compression strengthat 7 days	Compression strengthat 28 days
P0%	25.1	34
P20%	15.5	25
P50%	20.1	30.6
P80%	12.2	21.5
P100%	8.8	16.5

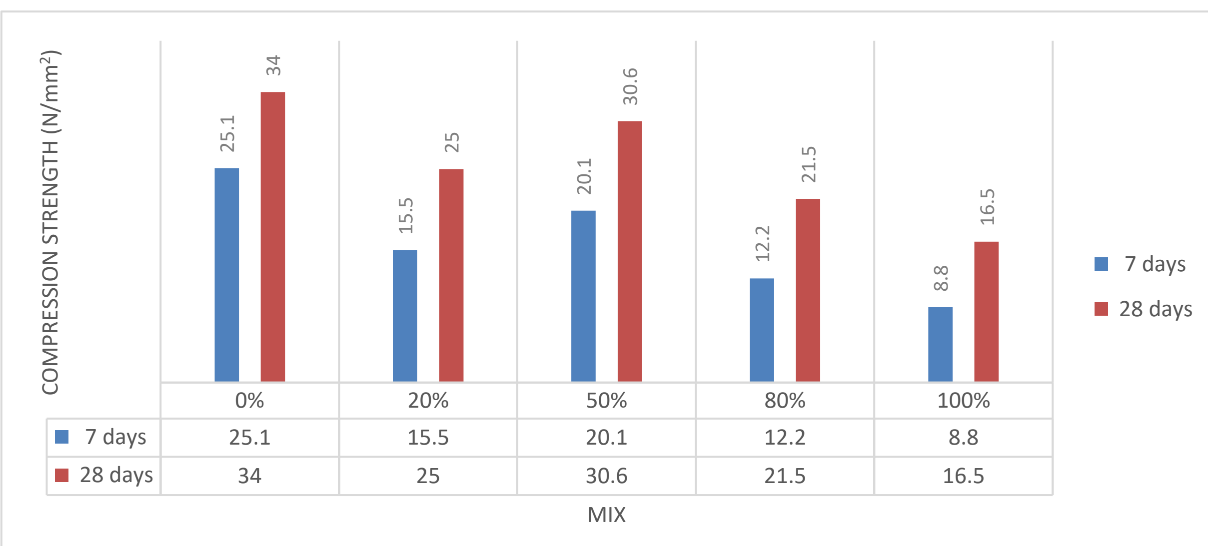

Fig 4 Compression strength test at 7 and 28 days

Split tensile strength of concrete

Lightweight concrete cylinders with a diameter of 150 mm and a height of 300 mm was casted. A table vibrator was used to mechanically vibrate the cylinders during casting. The specimens were de-moulded after 24 hours and cured in portable water for 7 days and 28 days. The cylindrical specimens were evaluated for split tensile strength after curing using compression testing equipment with a capacity of 2000kN. The average split tensile strength was computed using the calculation shown in table 4 using the ultimate load.

$$\text{Split tensile strength } (N/mm^2) = 2\,P/\pi\,L\,D$$

IS 5819: 1999 was used to conduct the split tensile strength test. Concrete prototypes with a diameter of 150 mm and a height of 300 mm were cast. At 7 and 28 days of age, the specimens were evaluated for split tensile strength using universal testing equipment.

Table 4. Split tensile strength at 7 and 28 days

Mix Id	Split tensile strengthat 7 days	Split tensile strengthat 28 days
P0%	2.56	3.78
P20%	1.63	2.80
P50%	2.21	3.17
P80%	2.01	2.36
P100%	1.21	2.08

Fig 5 Tested specimens

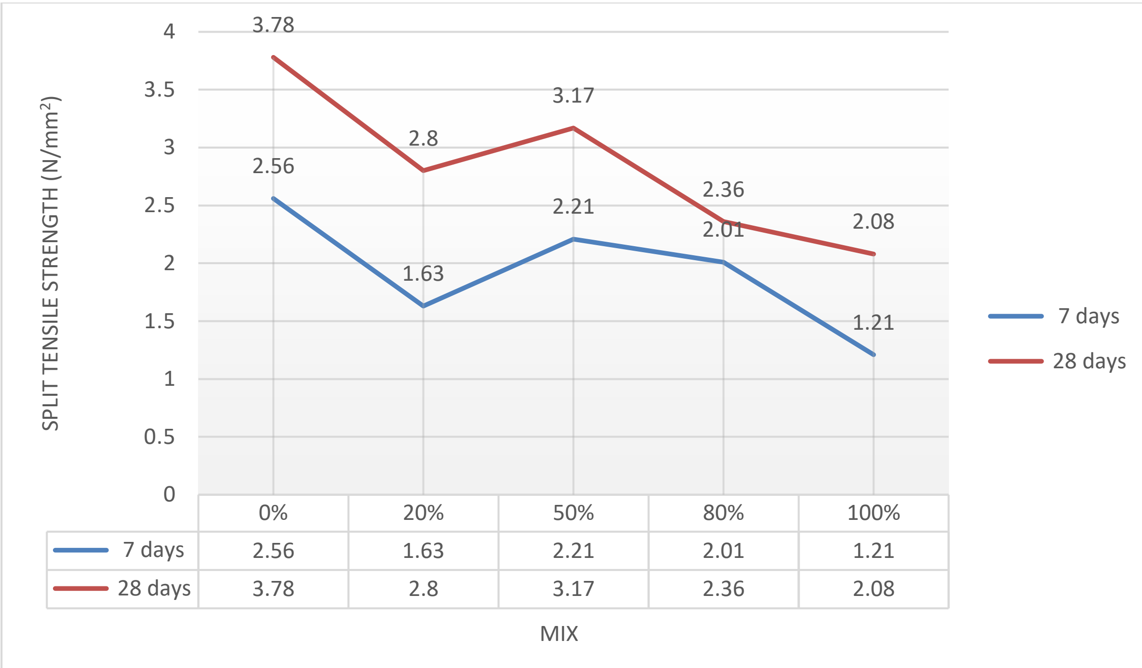

Fig 6 Split Tensile Strength test at 7 and 28 days

6. CONCLUSION

The observations and conclusions gained from the current study are based on experimental investigations into the compressive strength and split tensile strength of concrete. The compression and split tensile strength of the concrete is compared to that of conventional concrete with varying percentages of coarse aggregate replaced with pumice (20 percent, 50 percent, 80 percent, and 100 percent). The strength of concrete with 50% pumice replacement is comparable to conventional concrete. When 50% of the Pumice is replaced with coarse aggregate, the maximum strength value is reached. The difference between lightweight concrete with a density of 1500kg/m^3 and ordinary concrete with a density of 2400kg/m^3 must be highlighted. The increased use of pumice stones will have a negative impact on concrete strength (strength decreases). Since pumice stone absorbs more water than the nominal coarse aggregate, superplasticizers are used to combat this issue. The replacement of regular aggregate with pumice aggregate by 20%, 80%, and 100% results in the lowest compressive strength and the lightest concrete. As a result, 50 percent of the replacement can be used for structural purposes. Only 20%, 80%, and 100% replacement can be employed for non-structural purposes.

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