Partial Replacement of Pumice Stone in Concrete As Coarse Aggregate Material

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Abstract. In design of concrete structures, concrete plays an important role in the contemporary background as raw material for construction has been decreased. Therefore construction industry has acquaint with novel methods by making use of the available waste material for partial replacement by using alternative aggregates instead of ordinary aggregates. In this study, pumice stone is used as replacement materials for concrete where it is found in the abyssal of the red clay or in deepest portion of the ocean, and partially replacing by Pumice, blends with cement. The physical, mechanical and durability properties of concrete was investigated by conduction compressive strength and tensile strength on the ordinary and replaced concrete with varied percentage of pumice from 5% to 30%. It’s observed that environmental and economical benefits can be achieved if waste materials can be used to replace the coarse aggregate in order to use the waste materials effectively in areas with abundant availability of materials. This thesis work on the effectiveness of partial substitutions of pumice for coarse aggregate in producing adequate strength gain. In the present thesis work comparison of fresh concrete and hardened properties of concrete for both conventional concrete and Replaced concrete for varying percentage of replacement of pumice stone to coarse aggregate and based on the experimental results, it's concluded that 25% partial replacement by pumice gives maximum compressive strength.

Index Terms— Pumice Stone. Conventional concrete, Replaced concrete, Fresh & hardened properties of concrete

1. Introduction
Concrete can be defined as composite material, composed of cement, aggregate, water and admixtures in required proportions. It is considered to be most important and useful materials for many constructional activities. The basic ingredients for a concrete are Portland cement, water, and aggregates. Concrete is generally considered to be the most widely used material on Earth. It can be easily moldable to any shape in the elastic stage. The relative quantity of the various ingredient in concrete controls the various properties of concrete both in wet stage and hardened stage. Aggregate is a broad category of coarse particulate material most widely used in constructional activities, which
includes sand, gravel, and crushed stone. Aggregate act as a reinforcement in a concrete contributing compressive strength to concrete. With the increasing urban development and population, demand of sustainable structures increased. However, by use of the waste materials, the environmental impact may be reduced. Sustainable by products from various industries reduces overall cost and energy. By incorporating industrial by products in concrete meet out the requirement of creating the environmental awareness in the society.

This research deals with the utilization of an alternative material, Pumice is a volcanic origin highly porous rock is used as light weight aggregate with water absorption 55%. Pumice is a color less or light grey colored coarse aggregate. The pumice bulk density is found to be 0.25 g/cm³. It exhibits excellent mechanical strength insulation properties due to low conductivity of heat. Due to a high melting point it acts as fire resistant. It can be used in high sound prone areas since it acts as sound proofing material.

Cement concrete is most widely used construction material throughout world as everyone are living in concrete era. Concrete is manufacture by mixing various ingredients such as cement, aggregates & water in different proportions. Concrete is one of complex construction material since it can be manufactured at a site its quality, properties and performance varies to a large extent

2. Literature Review

Nagaswaram Roopa, K. Supriya and P. Rasheed Khan (March 2017)[1], did the “experimental Study on Concrete by Partial Replacement of Coarse Aggregate with pumice”. The main objective of study is study M25 grade concrete by partially replacing cement with fly ash at different proportions 35%, 40% and partially replacing coarse aggregate with Pumice by 0.2%, 0.3% by weight respectively. It's observed that compressive strength increased from 33.25 N/mm² to 35.5 N/mm² at 35% partial replacement of cement by fly ash.

Vinod Goud, et al (2016)[2], did the investigation of partially replacing coarse Aggregate with pumice in Concrete and its effect. The research was done on M25 grade of concrete and the replacement of Coarse Aggregate with pumice was 10%, 20% and 30%. The 20% replacement of Coarse Aggregate with pumice shows good compressive strength for 28 days, after 20% of replacement strength compressive strength decreases.

Dr. G. Elangovan (2015)[3], Studied “partial replacement of coarse aggregate by pumice” using M20 grade of concrete. This study replaces Coarse Aggregate with pumice in varying percentages of 20%, 40%, 60% and 80% and. The study concluded that by replacing coarse aggregate by 60% with pumice , the maximum compressive strength of 23.5N/mm² was achieved and its percentage improvement was 47.28%. This experimental work proves that pumice is used as partially replacement alternative material for the coarse aggregate in concrete and makes the concrete more economical and eco-friendly concrete as well. [3]

3. Objectives of Present Thesis Of Work

☐ Basic tests on ingredients of concrete pumice as per IS code provision limits
☐ To check the properties of the conventional concrete and Replaced Concrete.
☐ To design a suitable concrete mix as per IS 10262:2016.
☐ To check the performance of fresh properties and hardened properties of conventional concrete and Replaced Concrete.

4. Materials and Methodology Cement(Is 1489-1991)

Cement is a folio material which is utilized in development activities, that ties all the constituents together. The most important types of cement are used as a component in the preparing the mortar for the brick masonry, and of concrete which is a combination of cement and an aggregate to form a strong building material is used in the present thesis work.
FINE AGGREGATES (IS 383:1970)
Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. Well graded river sand passing through 4.75 mm is used in current study. It is classified based soil grain size particles. Generally fine sand gathered river banks is in whitish grey.

COARSE AGGREGATES (IS 383:1970)
Aggregates are passive coarse materials which includes sand, gravel and crushed stone is an essential ingredient in concrete. For a concrete mix design aggregates need to be clean, hard, strong and particles should be free of chemicals or coatings of clay that may weakens the concrete. Aggregates influences both freshly mixed and hardened properties and overall economy cost of concrete per cubic meter.

Pumice
Pumice is a material created by the arrival of gases during the cementing of magma. The cell structure of pumice is made by the development of air pockets or air voids when gases are trapped in the liquid magma spilling out of volcanoes become caught on cooling. Cells are lengthened and corresponding to each other and sometimes interconnected. Volcanic pumice (VP) utilizes to create lightweight cement. Up until now, utilization of pumice was reliant on accessibility and constrained to the nations where it is locally accessible or handily imported palatable cement [9] which is a few times lighter than ordinary cement having great protecting attributes with high assimilation and shrinkage can be fabricated utilizing VP. These materials can likewise improve the sturdiness of cement and the pace of addition in quality and can likewise lessen the pace of freedom of warmth, which is valuable for mass cement. Far reaching research had been completed in the past on the utilization of FA, pulverized-fuel debris (PFA), impact heater slag, rice husk debris, silica seethe, and so on.

5. Mix Design Proportion
Cement = 492.5 kg/m³ Water = 197 kg/m³
Fine aggregate = 598.17 kg/m³ Coarse aggregate = 1067 kg/m³ Water cement ratio = 0.45
Final proportion = 1:1.21:2.1:0.45

6. Results and Discussion of Fresh Concrete & Hardened Concrete
Consistence of fresh concrete is determined by conducting Slump Cone Test. The below table 1 indicated the variation of workability of conventional concrete of grade M30 and concrete replaced with pumice stone.
Fig. 2 Variation of Slump

Table 1 Slump value for varying Percentage

| Percentage Replacement of Pumice stone | Slump in mm |
|---------------------------------------|-------------|
| 0%                                    | 85          |
| 5%                                    | 82          |
| 10%                                   | 85          |
| 15%                                   | 89          |
| 20%                                   | 90          |
| 25%                                   | 96          |
| 30%                                   | 98          |

Properties Of Hardened Concrete

The compressive loading test on concretes cubes were conducted in a compressive testing machine of capacity. The test was performed on 150mmx150mmx150mm cube specimen at 14 and 28 days and also split partial replacement of course aggregates by pumice stone at 14 and 28 days respectively is shown in fig 3. It's observed that compressive strength of concrete increases up to 25% replacement and then decreases for 30% since, the hydration of cement is an exothermic reaction. High amount of heat is developed during mixing of concrete. The strength decreases with variation of pumice due to heat of hydration takes place.

Table 2 Compressive Strength for 14 and 28 Days of curing

| % Replacement of pumice stone | 14 days average Compressive strength (N/mm²) | 28 days average Compressive strength (N/mm²) |
|-------------------------------|---------------------------------------------|---------------------------------------------|
| 0%                            | 19.24                                       | 33.68                                       |
| 5%                            | 17.33                                       | 32.22                                       |
| 10%                           | 18.44                                       | 32.8                                        |
| 15%                           | 19.33                                       | 33.55                                       |
| 20%                           | 19.91                                       | 34.22                                       |
| 25%                           | 17.33                                       | 35.06                                       |
| 30%                           | 16.66                                       | 34.00                                       |
Fig. 3 Compressive Strength variation for 14 Days & 28 Days curing

Table 3 Split Tensile strength

| % Replace ment of pumice stone | 14 days average Split tensile strength (N/mm²) | 28 days average Split tensile strength (N/mm²) |
|-------------------------------|-----------------------------------------------|-----------------------------------------------|
| 0%                            | 3.03                                          | 4.09                                          |
| 5%                            | 2.18                                          | 3.18                                          |
| 10%                           | 2.23                                          | 3.36                                          |
| 15%                           | 2.29                                          | 3.53                                          |
| 20%                           | 2.00                                          | 3.79                                          |
| 25%                           | 1.78                                          | 3.39                                          |
| 30%                           | 1.71                                          | 3.18                                          |

Fig. 4 Split tensile Strength variation for 14 Days & 28 Days Curing
The tensile strength test was performed for cylindrical specimens of 150x300mm size, the test specimens were placed between two platens with two pieces of 3mm thick and The Split tensile strength of concrete is found to be increasing up to 10% partial replacement and then after decreases for both 20% and 30%

7. Conclusion

From the experimental results basic test on cement, sand, coarse aggregate and pumice are acceptable as per the IS code provisional limits.

For all the varying percentage of Pumice by 5%, 10%, 15%, 20%, 25%, 30% gives optimum recommended slump value for the structural concrete.

Compressive strength for M30 grade conventional concrete 33.68 N/mm² and replacement of Pumice up to 25% gives optimum compressive strength of 35.06 N/mm². From the result we can conclude that allowable percentage of replacement

Table 3 shows the results split tensile Strength on 14 and 28 Days of curing

Pumice is up to 25% Split tensile strength for M30 grade conventional is 4.09MPa based on the result obtained 25% of replacement of Pumice gives optimum tensile strength of 3.39MPa.

From this study we can conclude that upto 25% percentage of Pumice to coarse aggregate. Based on the results of slump values for various percentages from 0 to 35% of Pumice replacement is constantly increasing so the workability increases and also strength of concrete decreases

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