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# Performance of Pervious Concrete with Rice Husk Ash and Perlite Stone

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**ABSTRACT**
Pervious concrete is an environmentally sustainable material known for its ability to allow water to pass through, thereby reducing surface runoff and aiding groundwater recharge. However, its high porosity often results in lower compressive strength compared to conventional concrete. This study aims to enhance the performance of pervious concrete by partially replacing cement with Rice Husk Ash (RHA)and coarse aggregates with Perlite stone. RHA, an agro-industrial by-product with pozzolanic properties, and Perlite, a lightweight, porous volcanic material, were chosen for their environmental and structural benefits. The mix design followed a 1:4.5 cement-to-aggregate ratio with a constant water-cement ratio of 0.45. RHA was used in varying proportions (4%, 6%, 8%,10%) while Perlite stone was replaced as 10% by weight of the aggregate in all mixes. The concrete specimens were tested for compressive strength and permeability after a 28-day curing period. Results showed that permeability increased with 6 % RHA content and 10% Perlite, whereas compressive strength reduced as RHA content increased. The optimal balance was found at 6% RHA and 10% Perlite offering adequate strength and permeability. This study demonstrates that incorporating RHA and Perlite in pervious concrete enhances sustainability while maintaining functional performance, making it suitable for eco-friendly pavements and drainage systems.

**Keywords:** Pervious concrete, Rice Husk Ash (RHA), Perlite stone, Compressivestrength, Permeability, Sustainable construction, Cement replacement, Drainage pavement.

## 1. Introduction:

Pervious concrete is a green construction material that allows water to pass through it, helping to reduce surface runoff and enhance groundwater recharge. Pervious concrete is characterized by its high porosity, but this makes the material weaker compared to conventional concrete. Pervious concrete is the focus of this research with the incorporation of Rice Husk Ash (RHA) and Perlite stone with an attempt to enhance its performance. RHA is produced as a rice milling waste product and has the pozzolanic nature that allows partial substitution for cement while being used in the mixture. Perlite stone is a lightweight volcanic material used as a partial replacement for coarse aggregates. Concrete samples with different proportions of RHA (4%, 6%, 8%, and 10%) and a fixed 10% of Perlite were produced. Compressive strength and permeability tests of the concrete samples were carried out after 28 days of curing. The results seek to establish a balanced mix with appropriate strength and permeability for environmentally friendly concrete applications for pavements and water drainage systems.

### 1.1. Aim and objectives

**Aim:** To develop and analyze pervious concrete by partially replacing cement and aggregates with RHA and Perlite Stone.

**Objectives**:
To study the properties of perlite stone and rice husk ash.
To determine the permeability & compressive strength with partial cement replacement with Rice husk ash (RHA) and Coarse aggregate with Perlite stone.

## 2. Materials

This study on pervious concrete utilized five key materials: Ordinary Portland Cement (OPC), coarse aggregates, Rice Husk Ash (RHA), Perlite stone, and potable water. Each material played a specific role in achieving the desired balance between compressive strength and permeability, and all were carefully selected and tested before use.

1. Ordinary Portland Cement (OPC): The main binder in the concrete mixture was OPC. Its hydration process gives it strength and durability. The grade that was utilized met all applicable IS requirements. In order to evaluate the performance and environmental benefits, rice husk ash (RHA) was used partially as replacement of the cement in this study.

2. Coarse Aggregates: The main structural component of the concrete was crushed stone aggregates suitable size (12.5mm -20mm) and grading. The aggregates helped the mix have load-bearing capacity and strength. Fine aggregates (sand) was not used in the mix to preserve the necessary porosity for pervious concrete.

3. Rice Husk Ash (RHA): Rice husks, a common agricultural waste, are burned under controlled conditions to produce RHA, a fine, grey powder. It has pozzolanic qualities due to its high silica content (85–95%), which enables it to react with cement's calcium hydroxide to create more binding compounds. Cement was substituted with RHA at different weight percentages: 4%, 6%, 8%, and 10%.

Figure 1: Rice Husk Ash

Figure 2: Perlite Stone

4. Perlite Stone: The volcanic mineral perlite is white, light, and expands when heated. With a porosity of about 90%, it is extremely porous and perfect for increasing the water permeability of concrete. Perlite was used in this study to replace 10% of the coarse aggregate in all mix proportions. Perlite's low unit weight and 0.28 specific gravity helped create lighter concrete with improved drainage qualities.

5. Water: For mixing and curing, potable tap water was utilized. It complied with construction use standards and was pure. To guarantee consistency in workability and strength development, a constant water-to-cement ratio (W/C) of 0.45 was kept throughout all mixes.

## 3. Experimental Work:

Using perlite stone and rice husk ash (RHA) as partial substitutes for cement and coarse aggregates, respectively, an experimental study was carried out to evaluate the performance of pervious concrete. After 28 days of curing, the emphasis was on assessing permeability and compressive strength.

**Material Testing:** The physical and chemical characteristics of every material were examined. Perlite's porosity, unit weight, and specific gravity were tested, while RHA's silica content and fineness were assessed. Coarse aggregates and cement fulfilled IS requirements.

**Mix Design:** A consistent water-to-cement ratio of 0.45 and cement-to-aggregate ratio of 1:4.5 was adopted. Perlite continuously replaced 10% of coarse aggregate by weight in all mixes, while RHA was as cement replacement at 4%, 6%, 8%, and 10%.

**Casting of Specimens:** Concrete cubes measuring 150 mm x 150 mm x 150 mm were mixed by hand. To preserve porosity, no vibration was used. To guarantee correct placement, light tamping was done.


Figure 3: Concrete mixture


Figure 4: Concrete placed into cube moulds

**Curing:** To encourage hydration and pozzolanic activity, specimens were demolded after 24 hours and cured in water for 28 days.

### 3.1. Compressive Strength Test:

1. Standard Followed: IS 516:1959
2. Apparatus: Universal Testing Machine (UTM)
3. Procedure:
   - The cube was placed centrally on the compression testing platform.
   - Load was applied gradually until failure.

Figure 5: Compressive Strength Test (UTM)

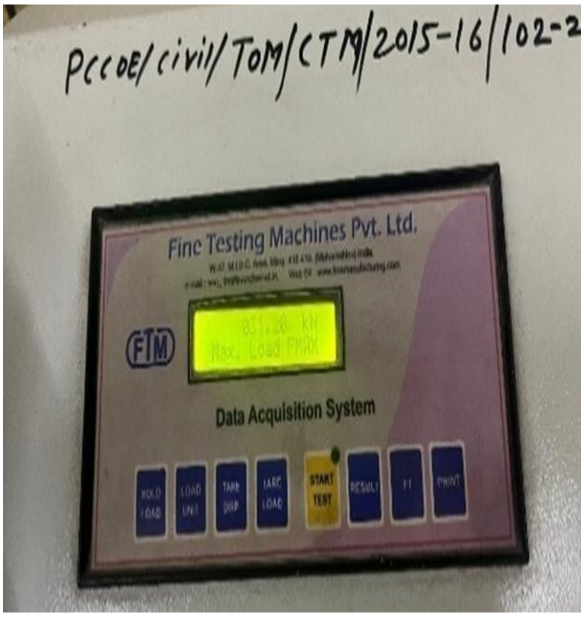

Figure 6: Test Reading

### 3.2. Permeability Test:

1. Objective: Measure the rate at which water can pass through the concrete.
2. Constant Head permeability test was adopted

Figure 7: Permeability Test

## 4. Result and Discussion:

### 4.1. Compressive Strength Results

Table 1: Compressive Strength Results

| Sr .No. | RHA | Perlite stone | Compressive strength (MPA) |
|---|---|---|---|
| 1 | 4 % | 10 % | 1.97 |
| 2 | 6 % | 10 % | 1.93 |
| 3 | 8 % | 10 % | 1.90 |
| | | | |

| | | | |
|---|---|---|---|
| 4 | 10 % | 10 % | 1.74 |

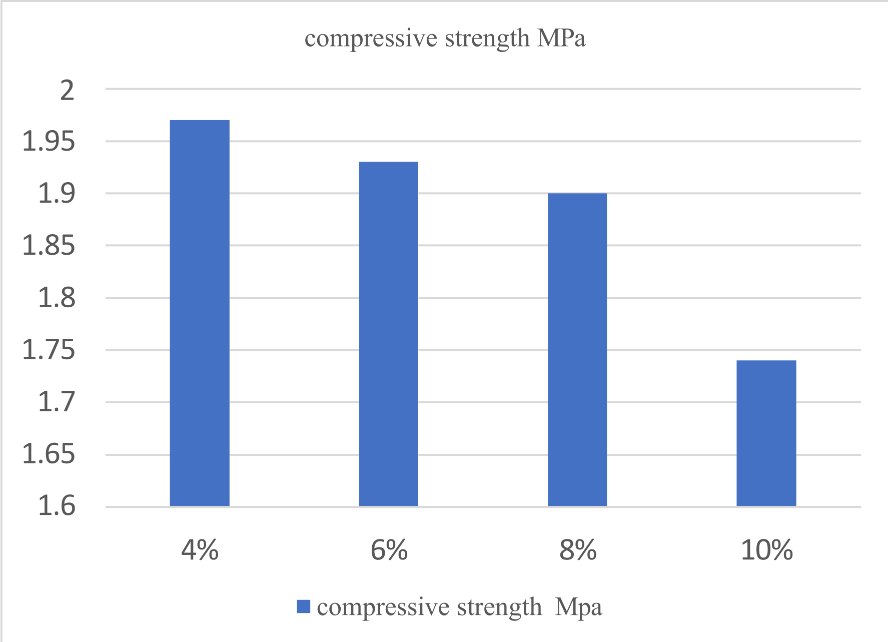


Figure 8: Compressive Strength

**Observations:**

1. The highest compressive strength (1.97 MPa) was achieved at 4% RHA, suggesting that limited RHA enhances strength due to pozzolanic reaction.
2. Beyond 6% RHA, strength gradually declined due to reduced cement content and weaker bonding.
3. Even at 10% RHA, the strength remained acceptable for low-load applications.

## 4.2. Permeability Test Results

Table 2:Permeability Test Results

| Sr .no | % of RHA | % of Perlite stone | Permeability cm/sec |
|---|---|---|---|
| 1 | 4 % | 10 % | 0.026 |
| 2 | 6 % | 10 % | 0.063 |
| 3 | 8 % | 10 % | 0.045 |
| 4 | 10 % | 10 % | 0.039 |

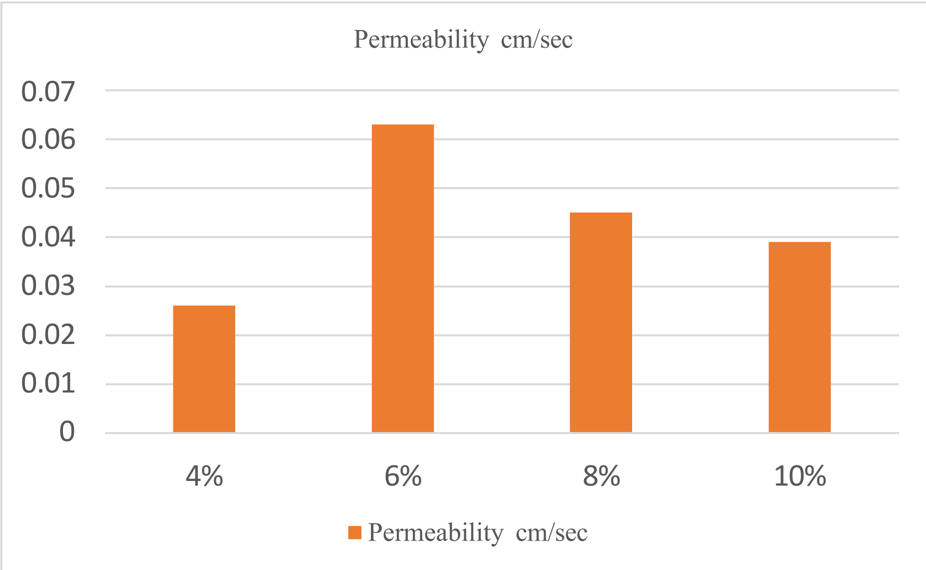

Fig 9: Permeability Bar Graph

**Observations:**

1. Maximum permeability was observed at 6% RHA and 10% Perlite.
2. Increased RHA up to 6% improved porosity and water infiltration.
3. Further increases showed minimal gains or slight declines due to finer ash particles partially filling pores.

## 5. Discussion:

The findings demonstrate how compressive strength and permeability are affected when RHA and Perlite are used in place of cement and aggregate, respectively. The pozzolanic reaction caused the compressive strength to in crease for 4 % replacement of RHA, but decreased for replacement beyond 6% of RHA. With the addition of RHA, permeability increased and peaked at 6% as finer ash particles added to the pore structure without causing undue clogging.

Since Perlite is porous, its permeability was continuously improved by a 10% replacement. With a realistic balance of sufficient strength (1.93 MPa) and high permeability (0.063 cm/sec), the best overall performance was obtained at 6% RHA and 10% Perlite. For non-structural, environmentally conscious concrete applications, this mix is can be preferred.

**Conclusion:**

1. Permeability of pervious concrete increased significantly with the addition of 6% Rice Husk Ash (RHA) and 10% Perlite stone, reaching a peak of 0.063 cm/sec, making it most effective for water drainage at this combination.
2. Compressive strength showed a gradual decrease with increasing RHA content.
3. An optimal balance between permeability and strength is achieved at 6% RHA and 10% Perlite stone, offering a practical mix for applications where moderate strength and high drainage are required.
4. Incorporating RHA and Perlite not only improves sustainability by utilizing waste and lightweight materials but also enhances the functional performance of pervious concrete for eco-friendly pavements and drainage systems.

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