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Study and Investigation on Pervious Concrete

Satish P. Deore[1], Mr. Raghav D. Vadje[2], Mr. Vishal S. Gosavi[3], Mr. Kailas A. Gaikwad[4]

[1]HOD, Department of civil engineering, Mahavir polytechnic, Nashik, Maharastra,422202 India
[2]Sr. Lecturer, Department of civil engineering, Mahavir polytechnic, Nashik, Maharastra,422202 India
[3] Lecturer, Department of civil engineering, Mahavir polytechnic, Nashik, Maharastra,422202 India
[4] Technical Assistant, Department of civil engineering, Mahavir polytechnic, Nashik, Maharastra,422202 India
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A B S T R A C T

Pervious concrete, a unique type of concrete, is composed of cement, coarse aggregates, water, and optionally, admixtures or additional cementitious materials. Due to the absence of fine aggregates, this concrete has a higher void ratio, allowing water to permeate through its structure. This characteristic gives pervious concrete other names, such as permeable or porous concrete.

Significant research has been conducted on pervious concrete. While it offers numerous benefits, its compressive strength is lower compared to traditional concrete due to its porosity and voids. Consequently, its use has been restricted, despite its advantages. If both the compressive and flexural strengths of pervious concrete can be enhanced, it could find broader applications. Presently, it is primarily used in areas with light traffic. With improvements, it could be applied to medium and heavy traffic pavements as well. In addition, pervious concrete helps in reducing surface water runoff, supports groundwater recharge, and optimizes land use.

The primary goal of this project is to enhance the strength properties of pervious concrete. However, it is crucial to maintain a balance between strength and permeability, as reducing permeability would compromise its core functionality.

Keywords: *Pervious concrete, Permeability, Compressive strength, Flexural strength, Surface runoff, Groundwater recharge, Strength properties etc.*

1. Introduction

1.1 The project focuses on the development of water-absorbent road surfaces using pervious concrete technology. Pervious concrete also referred to as permeable or porous concrete is designed to allow water to pass through its structure. This capability helps in managing storm water runoff by allowing it to seep into the ground, thus aiding groundwater recharge. The material consists primarily of coarse aggregates, cement, and water, without the use of fine aggregates, resulting in an interconnected void structure that promotes water permeability.

1.2 The project aims to enhance the strength properties of pervious concrete without significantly compromising its permeability. By optimizing the concrete mix, such as incorporating small amounts of fine aggregates and alternative cementitous materials like fly ash or rice husk ash, the team seeks to improve the compressive strength while maintaining the drainage capabilities crucial for storm water management.

1.3 The application of this material in road construction could help reduce urban flooding, alleviate heat island effects, and contribute to more sustainable infrastructure development, particularly in areas prone to heavy rainfall. This environmentally friendly approach not only provides a solution for water management but also optimizes land use by eliminating the need for traditional storm water retention systems.

1.4 Figures

Figure 1: pervious concrete cube blocks

Figure 2: pervious concrete beam

2. Literature Review

The development and application of pervious concrete have been extensively studied, revealing significant insights into its structural performance, environmental benefits, and potential applications.

1. **Structural Performance and Durability:**

Ajamu and Jimoh (2012) investigated the structural performance of pervious concrete, highlighting its effectiveness in stormwater management. They noted that while this material provides considerable environmental benefits, its compressive strength is often lower than required for high-traffic applications, limiting its broader use. Similarly, Schaefer et al. (2006) addressed concerns regarding the freeze-thaw durability of pervious concrete. Their research showed that adding fine aggregates or latex admixtures could enhance the material's strength and durability in harsh climates, suggesting that a carefully designed mix could overcome some of the traditional limitations associated with pervious concrete.

2. **Material Properties and Mix Design:**

The assessment of various aggregates in pervious concrete has also been a critical focus. Shah and Pitroda (2013) conducted a study assessing the use of gravel and other aggregates, emphasizing the need for a balance between permeability and strength. They found that the choice of aggregates significantly impacts the mechanical properties of pervious concrete. Furthermore, Tennis et al. (2004) developed guidelines for mix design, recommending a void content of around 20% to ensure sufficient infiltration while maintaining adequate strength. Their work indicates that the size and type of aggregates used play a vital role in the final performance of pervious concrete.

3. Environmental Impact and Applications:

Ghafoori and Dutta (1995) explored non-pavement applications for pervious concrete, demonstrating its utility in various construction scenarios where drainage is crucial. They pointed out that pervious concrete can serve not only as a pavement material but also as a solution for managing storm water in building sites. The environmental benefits of pervious concrete are further supported by its ability to recharge groundwater, reduce runoff, and improve water quality by filtering pollutants.

4. Use of Supplementary Cementitous Materials (SCMs):

Recent studies have investigated the incorporation of SCMs, such as fly ash and rice husk ash, to enhance the properties of pervious concrete. Schaefer et al. (2006) highlighted that the addition of fly ash not only improves the strength and workability of pervious concrete but also contributes to its sustainability by reducing the carbon footprint associated with cement production. Research has shown that up to 30% of Portland cement can be replaced with fly ash without significantly affecting the material's performance, allowing for more eco-friendly construction practices.

5. Challenges and Future Directions:

Despite the advances in research, challenges remain in the practical application of pervious concrete. Issues such as clogging, raveling, and maintenance during winter conditions have been noted as potential drawbacks. The American experience with pervious concrete is still developing, and additional research is necessary to establish best practices for construction and maintenance in various climates.

In conclusion, while pervious concrete demonstrates promising attributes for sustainable construction and effective storm water management, on-going research is crucial to overcome its limitations and enhance its applicability across diverse infrastructure projects. The incorporation of innovative materials and improved mix designs will likely play a vital role in expanding the use of pervious concrete in the future.

3. Material Used:

The materials used for the project on Pervious Concrete are detailed as follows:

1. Cement:

The primary binder for the concrete mix. Different types of cement can be used, but Ordinary Portland Cement (OPC) is common. It has various compositions that can affect the concrete's properties.

Figure 3: Ordinary Portland cement

2. Coarse Aggregates:

These are larger particles (greater than 4.75 mm) that form a significant part of the concrete mix (up to 80%). Typical sizes used range from 9.5 mm to 19 mm. The aggregates can be sourced from gravel or granite.

Figure 4: Ordinary Portland cement

3. Fine Aggregates:

Pervious concrete usually contains little to no fine aggregates. However, for strength improvement, a small quantity of fine aggregates may be added (5-10% of coarse aggregates).

Figure 5: Ordinary Portland cement

4. Water:

Essential for hydration of the cement. The water-to-cement ratio is crucial, typically kept between 0.27 and 0.34 to achieve the desired strength and permeability.

5. Supplementary Cementitous Materials (SCMs):

Materials like fly ash and rice husk ash can be added to replace a portion of the cement (typically around 10%). These materials enhance durability and reduce permeability.

Figure 6: Ordinary Portland cement

6. Chemical Admixtures:

Admixtures such as water reducers or retarders may be used to improve the workability and performance of the concrete mix.

4. Mix Design of Pervious Concrete

Typical Mix Design of Pervious Concrete of M 30

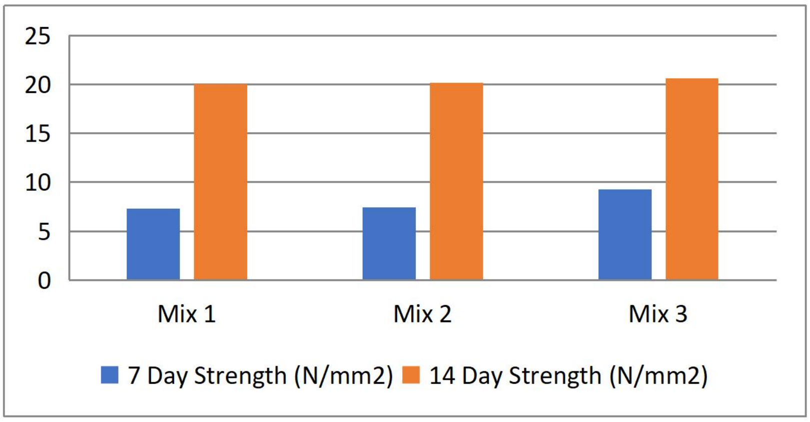
1. Cement (OPC or blended): 415 kg/m³
2. Coarse Aggregate: 1250 kg/m³
3. Water-Cement Ratio (by mass): 0.3 to 0.4
4. C:S:A = 1:0:3.01
5. For strength improvement, a small quantity of fine aggregates may be added (5-10% of coarse aggregates).

5. Test Results

1. Compressive Strength Test:

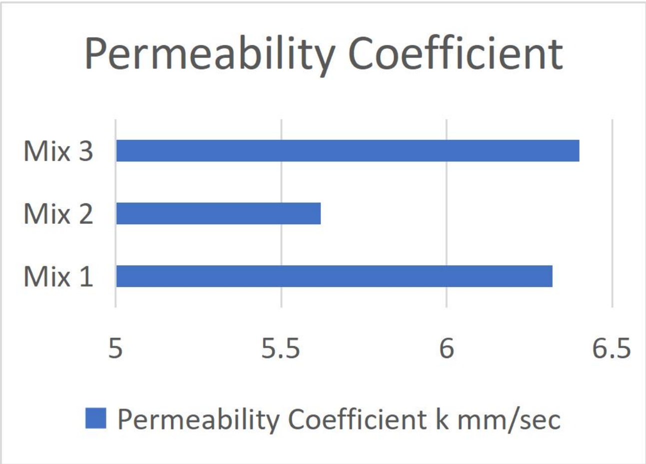
A test specimen measuring 150 mm x 150 mm x 150 mm was prepared and subjected to testing with a compressive testing machine. Compressive strength tests were conducted at 7 and 28 days.

Mix	W/C Ratio	Day of Curing	
		7 day	28 day
1	0.40	7.30 N/mm2	20.01 N/mm2
2	0.35	7.40 N/mm2	20.14 N/mm2
3	0.30	9.25 N/mm2	20.58 N/mm2



2. Falling Head Method:

Mix	Permeability Coefficient k mm/sec
1	6.32
2	5.62
3	6.4



6. Conclusions

Pervious concrete offers a sustainable solution for storm water management, addressing issues related to urban flooding and groundwater depletion. While it typically has lower strength than conventional concrete, optimizing its mix design with Coarse aggregates and appropriate water-cement ratios can enhance both its strength and permeability. This makes it suitable for various applications, such as parking lots and sidewalks.

The adoption of pervious concrete in urban areas can significantly reduce runoff and environmental pollution, contributing to sustainable urban infrastructure. Future research should focus on improving its durability and maintenance, particularly in harsh weather conditions, to enhance its acceptance and effectiveness as a key component in urban planning

7. Future Scope

- Pervious concrete was widely used in the past due to limited cement availability.
- Its significance declined with the increased production of cement in large quantities.
- Recently, the popularity of pervious concrete has surged because of its numerous advantages.
- Urban areas worldwide have transformed into "concrete jungles," making storm water management a significant challenge.
- Pervious concrete can aid in recharging groundwater and improving storm water disposal.
- To address these challenges and protect communities in flood-prone areas, pervious concrete presents an effective solution for the future.

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