



Study On Compressive Strength Of Pervious Concrete: A Review

1.CHARU L. DURGE 2.LAXMI NAKADE 3.KHUSHI BAGDE 4.PURVE SAYARE
5.R.H.MOHANKAR

1,2,3,4,Students, 5Assistant Professor

Department of Civil Engineering
Priyadarshini J.L. College of Engineering, Nagpur, India

Abstract:

Pervious concrete, also referred to as permeable or porous concrete, is a highly porous material designed to facilitate water infiltration, making it a vital component in sustainable construction and stormwater management. This review paper analyzes the various factors that affect the compressive strength of pervious concrete, a characteristic that often limits its use in structural applications. We examine mix design parameters, aggregate characteristics, water-to-cement ratios, compaction techniques, curing methods, and the use of supplementary cementitious materials (SCMs) such as fly ash, silica fume, and slag. Furthermore, the paper addresses the inherent trade-offs between permeability and compressive strength, and highlights recent innovations aimed at enhancing compressive strength without compromising permeability. This comprehensive review lays the groundwork for future research and practical applications, focusing on improving the performance of pervious concrete for a broader range of civil engineering projects.

Keyword: - Pervious concrete, compressive strength, permeability, mix design, aggregate gradation, sustainability, fiber reinforcement, curing methods, SCMs.

1.Introduction:

Pervious concrete is becoming increasingly popular as a sustainable material due to its environmental advantages, particularly its capacity to reduce stormwater runoff by allowing water to pass through its structure. However, its lower compressive strength compared to conventional concrete limits its application in structural contexts. Compressive strength is essential for assessing the material's load-bearing

capacity and durability in pavement and other infrastructure projects.

The structural performance of pervious concrete is influenced by various factors, including mix design, aggregate size and gradation, the water-to-cement (w/c) ratio, as well as compaction and curing methods. This paper aims to review recent research on how these factors impact the compressive strength of pervious concrete, explore the balance between permeability and compressive strength, and evaluate recent advancements designed to improve compressive strength without sacrificing permeability.

2. Overview of Pervious Concrete:

Pervious concrete is distinct from conventional concrete primarily because of its high porosity, which usually ranges from 15% to 30%, enabling water to flow through it. This characteristic is achieved by utilizing a mix that contains little to no fine aggregates (such as sand), creating an

interconnected network of voids. The lack of fine materials notably decreases both the density and compressive strength of the concrete.

Applications of Pervious Concrete

Pervious concrete is mainly utilized in situations where effective water management is crucial. Key applications include:

- **Stormwater management systems:**

Pervious concrete facilitates groundwater recharge, alleviating the burden on urban drainage systems.

- **Parking lots and driveways:** Its capability to manage surface water efficiently makes it a popular option for low-traffic areas.

- **Sidewalks and pedestrian paths:** Pervious concrete minimizes puddling and promotes natural rainwater infiltration.

However, the lower compressive strength of pervious concrete restricts its use in high-traffic areas or load-bearing applications. Understanding the factors that influence compressive strength is vital for enhancing its functionality.

3. Factors Influencing Compressive Strength:

3.1. Mix Design:

The mix design of pervious concrete has a direct impact on its compressive strength and permeability. The basic components of pervious concrete include coarse aggregates, cement, and water, with little or no fine aggregates. The absence of fine particles (fines) results in a porous structure that enhances water permeability but reduces compressive strength.

3.1.1. Cement Content:

Higher cement content tends to increase the compressive strength of pervious concrete due to better bonding between the aggregates. However, excessive cement can reduce the material's permeability by filling voids meant for water infiltration. Studies indicate that a cement content of approximately 300-400 kg/m³ is optimal for achieving a balance between strength and permeability.

3.1.2. Water-to-Cement Ratio (w/c):

The water-to-cement ratio (w/c) is another critical variable in determining both strength and porosity. A low w/c ratio typically increases compressive strength but may hinder the workability of the mix, leading to difficulties in placing and compacting

the concrete. Conversely, a higher w/c ratio improves workability but weakens the bonding between cement paste and aggregates, reducing compressive strength. Optimal w/c ratios for pervious concrete typically range from 0.27 to 0.35, with adjustments depending on other mix variables.

3.1.3. Fine Aggregate Addition:

Although traditional pervious concrete mixes avoid the use of fine aggregates, some studies have explored the controlled addition of fines to enhance compressive strength without drastically affecting permeability. The addition of up to 5% fine aggregate has been found to marginally increase compressive strength while maintaining adequate porosity for stormwater infiltration.

3.2. Aggregate Properties:

3.2.1. Aggregate Size:

The size of coarse aggregates in pervious concrete has a significant impact on both its compressive strength and permeability. Larger aggregates create bigger voids, which improve permeability but can compromise compressive strength. In contrast, smaller aggregates offer more contact points between particles, enhancing the bond with the cement paste and increasing compressive strength. Most studies recommend using aggregate sizes between 6.35 mm and 19 mm for optimal performance regarding both strength and permeability.

3.2.2. Aggregate Gradation:

Aggregate gradation is crucial to the performance of pervious concrete. Uniformly graded aggregates result in higher void ratios, which increases permeability but reduces compressive strength. Conversely, well-graded aggregates can fill some of the voids, thereby improving compressive strength while slightly decreasing permeability.

3.3. Compaction Methods:

Proper compaction is crucial to achieving the desired balance between compressive strength and permeability in pervious concrete. Insufficient compaction leads to larger voids and reduced strength, while excessive compaction decreases permeability by closing off too many voids. Mechanical compaction methods, such as using vibratory or roller compactors, are commonly employed to achieve uniform results.

3.3.1. Mechanical Compaction:

Research suggests that mechanical compaction, such as vibrating or roller compaction, leads to more consistent results in terms of compressive strength and permeability. Too much compaction, however, may compromise the porous structure, reducing the permeability.

3.4. Curing Methods:

Curing is vital for the hydration of cement and the development of compressive strength. Given its porous nature, pervious concrete tends to lose moisture quickly, which can adversely affect the hydration process and, consequently, its strength. Moist curing techniques, such as covering the concrete with wet burlap or continuously spraying it with water, have been shown to significantly enhance the compressive strength of pervious concrete.

3.4.1. Moist Curing:

Moist curing methods help retain water in the concrete for extended periods, allowing the cement to fully hydrate. This process leads to improved bonding between the aggregates and the cement paste, resulting in increased compressive strength.

3.4.2. Air Curing:

Air curing, in which the concrete is allowed to cure in ambient conditions without additional moisture, generally results in lower compressive strength due to the rapid loss of water essential for hydration.

3.5. Supplementary Cementitious Materials (SCMs):

The use of supplementary cementitious materials (SCMs) such as fly ash, slag, and silica fume has been extensively researched as a means to enhance the compressive strength of pervious concrete. These materials improve the binder matrix by reacting with calcium hydroxide generated during cement hydration, leading to the formation of additional calcium silicate hydrate (C-S-H), which boosts the overall strength and durability of the concrete.

3.5.1. Fly Ash and Slag:

Fly ash and slag are commonly used SCMs that contribute to the long-term compressive strength of pervious concrete. Fly ash enhances workability and lowers water demand, while slag improves the

durability of the binder matrix. However, careful management of their usage is crucial, as excessive amounts can negatively affect permeability by reducing porosity.

3.5.2. Silica Fume:

Silica fume is a highly reactive pozzolan that significantly enhances the compressive strength of concrete by filling voids and increasing the density of the binder matrix. In pervious concrete, while silica fume can improve strength, its excessive use may compromise permeability.

4. Trade-offs Between Permeability and Compressive Strength:

One of the main challenges in designing pervious concrete is achieving a balance between permeability and compressive strength. While the primary role of pervious concrete is to facilitate water infiltration, adequate compressive strength is essential for its use in load-bearing applications. Typical compressive strength values for pervious concrete range from 3.5 MPa to 28 MPa, which is significantly lower than that of conventional concrete.

4.1. Permeability Requirements:

The permeability of pervious concrete is determined by its void structure, which is influenced by factors such as aggregate size, gradation, and compaction methods. While higher permeability is desirable for effective stormwater management, it often comes at the expense of reduced compressive strength.

4.2. Strategies to Enhance Compressive Strength Without Compromising Permeability:

Several strategies have been suggested to optimize the balance between permeability and compressive strength:

- **Optimizing Aggregate Size and Gradation:** Using smaller or blended aggregates can enhance compressive strength without significantly diminishing permeability.
- **Using SCMs:** Incorporating supplementary cementitious materials (SCMs) like fly ash, slag, or silica fume can improve the compressive strength of pervious concrete while having a minimal effect on its permeability.
- **Fiber Reinforcement:** Adding fibers, such as polypropylene or steel, can increase both the tensile and compressive strength of pervious concrete while preserving its permeability.

5. Recent Advances in Improving Compressive Strength:

5.1. Polymer Modifications:

Polymer-modified pervious concrete has demonstrated potential in increasing compressive strength by improving the adhesion between the aggregates and cement paste. However, the high cost of polymer additives restricts their extensive use in commercial projects.

5.2. Fiber Reinforcement :

The addition of fibers like polypropylene, steel, or glass to pervious concrete has been shown to notably enhance both tensile and compressive strength. Fiber reinforcement also aids in controlling crack propagation, which increases the durability of pervious concrete under load conditions.

6. Conclusion:

The compressive strength of pervious concrete is a key factor limiting its wider use in structural applications. Various elements, including mix design, aggregate characteristics, compaction methods, curing processes, and the use of supplementary cementitious materials (SCMs), greatly impact the compressive strength of the material. Achieving the optimal balance between permeability and compressive strength remains a major challenge. Recent innovations, such as polymer modifications and fiber reinforcement, offer promising solutions to this issue.

Future research should aim at optimizing these factors to create pervious concrete mixtures with improved compressive strength and durability, while preserving their critical permeability properties. These advancements could greatly extend the application of pervious concrete in load-bearing and structural roles, contributing to more sustainable construction practices.

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This review paper offers an in-depth analysis of the factors influencing the compressive strength of pervious concrete and highlights recent innovations designed to enhance its performance in structural applications.