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Impact Assessment Of Workability And Strength Of Previous Concrete With Varying Coarse Aggregate

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Abstract
Pervious concrete is an eco-friendly construction material that helps in reducing urban flooding and protecting groundwater by allowing water to flow through its porous structure. This research investigates how different sizes of coarse aggregate affect the workability and strength of pervious concrete with focus on refining its mix design for practical use in city. The study examines the relationship between aggregate size and workability parameters such as slump and compacting factor and also compressive and flexural strength and permeability.
The research methodology involves creation of concrete samples with different aggregate sizes and then testing their workability, strength and permeability. The results show that smaller aggregate can improve compressive strength due to better bonding but at the cost of lower permeability. Larger aggregate can improve permeability but compromise strength. Medium size aggregate provides balanced performance in all the parameters tested.
This study highlights the trade-offs in pervious concrete design and offers valuable insights for enhancing its characteristics for specific use. By filling the gaps in existing research it helps in promoting sustainable urban growth by providing ways to manage stormwater and recharge groundwater. The study includes tables and figures to illustrate key findings including comparison of compressive strength across different aggregate sizes.
Keywords: *Workability, Slump, Compacting Factor, Vebe Time, Mix ratio*

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I. Introduction

Pervious concrete is a special type of concrete that consists of cement, coarse aggregate, water and very few or no fine aggregate. Its porous structure allows water and air to flow through it making it a good option for stormwater management. As cities grow the need for materials that can address environmental issues like flooding and depletion of groundwater resources becomes more pressing. Pervious concrete is a practical solution by allowing water to infiltrate the soil thereby reducing surface runoff and recharging groundwater. Pervious concrete is used in parking lots, walkways, driveways, low-traffic streets and other areas where stormwater management is critical. Its ability to mitigate urban flooding and recharge groundwater makes it a part of modern infrastructure. But we need to strike a balance between workability and strength for optimal performance. Workability is the ease of material to be handled and installed during construction and strength is the durability and load bearing capacity of the finished structure.

In cities like Mumbai and Chennai, flooding is a big problem, mainly because the drainage systems fail to function during heavy rains. This leads to huge economic losses and inconvenience to the people. Traditional drainage systems can’t handle the monsoon rains, hence the need for innovative solutions to manage stormwater and build urban resilience. One such solution is pervious concrete which allows rainwater to pass through its surface, thus reducing runoff and recharging groundwater.

This study focuses on the effect of different coarse aggregate sizes on workability and strength of pervious concrete. By fine tuning these parameters, the research aims to improve the material's use in urban development. The objective of this study is to improve the use of workability of sentences. The goals of this research are to study the effect of aggregate size on workability parameters like slump and compacting factor. Also to study the variation in compressive and flexural strength with different aggregate sizes. To study how aggregate size affects permeability and provide recommendations for mix design.

This document is divided into several sections. It starts with literature review which summarizes previous studies on pervious concrete. Then there is a section on materials and methods which explains the experimental procedure. The results and discussion section then analyzes the results on workability, strength and permeability. Finally the paper concludes with summary and references.

II. Literature Review

In recent years pervious concrete has gained popularity due to its potential to address environmental issues, especially in stormwater management and groundwater depletion. Researchers have studied various aspects of its mix design to improve properties like permeability, compressive strength, workability and durability.

In 1976 Malhotra significantly advanced our understanding of pervious concrete's properties and its applications. He emphasized the importance of water-cement (W/C) and aggregate-cement (A/C) ratios in optimizing porosity while maintaining structural integrity. His findings showed that although these ratios play a major role in compressive strength, pervious concrete generally has lower strength than conventional concrete due to its porous nature, as shown in **Table** 1.Recent studies have focused on the effect of coarse aggregate size on workability and strength of concrete. It has been found that smaller aggregates can improve compressive strength by increasing the bonding within the mix; but can reduce permeability due to lower void content. Larger aggregates can increase permeability by creating larger voids; but can reduce compressive strength due to weaker bond between particles.

Table1: Relationship b/w Strength and W/C & A/C Ratios (Aggregate‖Gravel‖)

Aggregate Cement Ratio (A/C)*	Water Cement Ratio (W/C)**	Age of Test (Days)	Density (Kg/m^3)	Cement (Kg/m^3)	Compressive Strength (MPa)
6	0.38	3	2015.12	258.66	8.928
		7	2008.71	258.66	11.445
		28	1999.10	258.66	14.341
8	0.41	3	1922.22	193.40	5.860
		7	1914.21	193.40	7.273
		28	1912.60	193.40	9.411
10	0.45	3	1869.35	154.84	4.309
		7	1864.55	154.84	5.377
		28	1861.34	154.84	6.998

Source: Malhotra (1976), ACI Journal, Vol. 73, Issue 11 , p 633.

*A/C Ratios are by volume.

**W/C Ratios are by weight.

A thorough study of different mix designs has shown that there is a fine balance to be achieved to improve pervious concrete. Variations in water-cement (W/C) ratios, aggregate-cement (A/C) ratios, aggregate size distribution and compaction method have all been found to have significant effect on workability, strength and permeability as shown in **Table** 2. But achieving the right balance is a difficult task as these parameters often conflict with each other.

A study of different mix designs has shown the delicate balance required to improve pervious concrete. Variations in water to cement (W/C) ratio, aggregate to cement (A/C) ratio, aggregate size distribution and compaction methods have all been proven to have a significant effect on workability, strength and permeability as shown in **Table** 2. But achieving the right balance is a difficult task as these factors often conflict with each other.

While research has been done on individual factors like W/C ratio or aggregate type, there is still a gap in our understanding of how different sizes of coarse aggregates affect the three important properties—workability, strength and permeability. This study aims to fill this gap by thoroughly studying how aggregate size affects these interconnected properties.

Table 2: Relationship between 28 Day Compressive Strength and Grading (Water Content = 0.36)

Grading	Aggregate Cement Ratio (A/C) by volume	Unit Weight (Kg/m^3)	CompressiveStrength (MPa)
A	8	1909.40 1870.96 1858.14 1813.29	8.480 6.722 7.515 5.619
B	9	1883.77 1819.70 1800.47	7.170 5.688 5.136
C	7	1877.36 1851.73 1826.10 1826.10	8.825 7.101 6.894 6.550

Source: Malhotra (1976), ACI Journal, Vol 73, Issue 11, p 634

III. Materials And Methods

Materials Used

Ordinary Portland Cement (OPC) is used as the binder in this study due to its availability. For this study, limestone aggregates with sizes ranging from 3/8" to 3/4" were chosen because of their good handling properties. Clean water was used for hydration and optional admixtures to improve workability.

Experimental Design

Concrete samples were made using different sizes of coarse aggregates: small (3/8"), medium (1/2") and large (3/4"). Consistent mixing method was applied to ensure even distribution of materials in each sample. The mixing was carefully managed to avoid segregation or uneven distribution which could affect the test results.

Workability Tests

To evaluate workability, slump tests were conducted to measure consistency during placement (as shown in Figure 1), and compacting factor tests to measure the ease of compaction under controlled conditions

Strength Tests

Compressive strength tests were conducted to determine the load bearing capacity under axial stress (with compressive strength data in Table 3). Flexural tests were also conducted to analyze tensile behavior which is important for pavement applications. Permeability tests were also done to measure water infiltration rate through the porous structure of each sample.

IV. Results And Discussion

This section will present the experimental results, showing how different coarse aggregate sizes affect the workability, strength and permeability of pervious concrete. Tables and figures will be used to summarize the results. Performance of pervious concrete will also be compared with conventional concrete, highlighting the trade-offs between workability, strength and permeability.

Workability Analysis

Workability of pervious concrete mixes was tested through slump test and compacting factor test. Results showed that aggregate size had significant effect on workability. Smaller aggregates gave lower slump values indicating less consistency and flowability due to decrease in void content. As mentioned earlier water can seep into the ground and groundwater can replenish over time as the Pervious asphalt allows air and water to pass through keeping the underlying soil moist. Larger aggregates gave higher slump values but compromised uniformity during placement. **Table 3** shows the slump test results for different aggregate sizes with slump values ranging from 0 mm for smaller aggregates to 175 mm for larger ones.

Table3. Slump Test Results and uses

Degree of workability	Slump		Compacting Factor	Use for which concrete is suitable
	mm	in		
Very low	0-25	0-1	0.78	Very dry mixes; used in road making. Roads vibrated by power operated machines.
Low	25-50	1-2	0.85	Low workability mixes; used for foundations with light reinforcement. Roads vibrated by hand operated Machines.
Medium	50-100	2-4	0.92	Medium workability mixes; manually compacted flat slabs using crushed aggregates. Normal reinforced concrete manually compacted and heavily reinforced sections with vibrations.
High	100-175	4-7	0.95	High workability concrete; for sections with congested reinforcement. Not normally suitable for vibration

Compacting factor test showed that mixes with smaller aggregates had better compacting factors indicating easier compaction. Larger aggregates had lower compacting factors indicating more effort is required to achieve sufficient compaction. Summary of compacting factor test results for different aggregate sizes is given in **Table 1**.

Strength Analysis

Tests were conducted on compressive strength and flexural strength to evaluate the mechanical properties of pervious concrete mixes with different aggregate sizes. Results showed that aggregate size had significant effect on strength characteristics of concrete. Generally mixes with smaller aggregates had higher compressive strength due to better bonding within the concrete matrix. As aggregate size increased compressive strength tended to decrease because larger aggregates had fewer contact points and weakened the bonding between particles.

Flexural strength followed the same trend as compressive strength. Smaller aggregates gave higher flexural strength while larger aggregates gave lower flexural strength. Summary of compressive and flexural strength test results for different aggregate sizes after 28 days of curing is given in **Table 2.**

Permeability

Tests were also conducted to evaluate the permeability of pervious concrete mixes with different aggregate sizes. Results showed that aggregate size had significant effect on permeability. Larger aggregates improved permeability by increasing void content and forming larger interconnected pores. But excessive voids can compromise the structural integrity and strength of the concrete. The solid black-top surface can withstand vehicle traffic as mentioned in the document.

Smaller aggregates gave lower permeability due to lower void content and smaller pore size. Medium sized aggregates gave the best permeability performance as it provided good balance between void content and pore size for water infiltration.

Comparative Analysis

When comparing previous concrete to regular concrete, it was found that previous concrete has better permeability but lower compressive strength. The high porosity of previous concrete allows for fast water infiltration, good for stormwater management. But this porosity reduces its load bearing capacity compared to regular concrete. As stated in the summary, previous concrete is made up of aggregates, bonding agents, water and no sand which creates an open-cell structure that allows water and air to pass through. So careful consideration is needed when using previous concrete for specific applications. As noted by Malhotra (1976) even with ideal proportions previous concrete may not achieve compressive strength characteristics of regular cement.

The balance between workability, strength and permeability was evident in all mix designs. It is important to optimize aggregate size to achieve the desired balance of these properties for successful use of previous concrete in various applications. The document also mentioned that previous concrete materials can absorb heat and the black-top can affect the temperature and moisture of the earth's surface and help mitigate the urban heat island effect.

V. Conclusion And Recommendations

Summary of Key Findings

The experimental results showed the significant effect of coarse aggregate size on the workability, strength and permeability of previous concrete. Key findings:

- Smaller aggregates increase compressive and flexural strength but decrease permeability.
- Larger aggregates increase permeability but decrease strength.
- Medium aggregates provide the best balance between strength and permeability.
- Aggregate size should be chosen according to application needs.

Practical Implications

Previous concrete is a sustainable solution for stormwater management and groundwater recharge in urban areas. It can help reduce urban flooding, surface runoff pollution and environmental sustainability.

Limitations

This study only looked at the effect of aggregate size on the properties of previous concrete using specific materials and mix design. Results may vary with different aggregates, cement, admixtures and environmental conditions. More research is needed to test the long term durability and performance of previous concrete under different conditions.

Future Research

Future studies should:

-Look at different types of aggregates on previous concrete properties.
-Use recycled aggregates in previous concrete mixes.
-Test previous concrete in different environmental conditions.

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