Advance Pavement Design for Sustainable Infrastructure

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Abstract

Pervious concrete is a sustainable material that offers numerous environmental benefits, including reduced stormwater runoff, groundwater recharge, and improved water quality. This paper discusses the properties of pervious concrete, such as compressive strength, split tensile strength, and permeability factor, and compares them to normal concrete. The use of pervious concrete in pavement design can significantly contribute to sustainable infrastructure development. This study highlights the advantages of pervious concrete, including reduced urban heat island effect, minimized road splashes, and improved skid resistance. The findings of this research can inform the design of sustainable pavements that mitigate the environmental impacts of urbanization.

Keywords

Pervious concrete, Sustainable infrastructure, Pavement design, Environmental benefits, Stormwater management.

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1. Introduction General:

Pervious concrete is a unique form of concrete with high porosity, designed specifically for applications that require effective water infiltration. Its unique structure allows rainwater and runoff to permeate directly through the surface, thereby reducing surface water accumulation and promoting groundwater recharge.

The cement paste coats the coarse aggregates, forming an interconnected void system that facilitates water flow through the slab. Due to its permeability, pervious concrete is commonly used in low-traffic areas such as parking lots, residential roads, pedestrian paths, and greenhouses. It is increasingly employed in sustainable construction practices as part of low-impact development (LID) strategies to improve water management and protect water quality.

Pervious concrete offers several environmental and sustainability advantages. These include noise reduction from tirepavement contact, decreased urban heat island effects, improved skid resistance, minimized surface splash, enhanced groundwater recharge, and reduced stormwater runoff. Additionally, its structure limits pollutant migration into groundwater and helps preserve local ecosystems.

pervious concrete is a high-porosity material composed of coarse aggregates, cement, and water, with minimal or no fine aggregates. Its unique composition allows for effective water infiltration, contributing to sustainable construction practices by reducing stormwater runoff and promoting groundwater recharge.

Fig. 1

Objectives:

- Formulate a durable PCC mix by incorporating various types of aggregates and adjusting fine aggregate content, aiming to optimize both mechanical strength and permeability.

- Incorporating M-sand as 15% of the fine aggregate in a PCC mix can be a viable option, potentially enhancing certain performance parameters like compressive strength and durability.

- Investigate how variations in the composition of pervious concrete influence its compressive strength, striving to enhance strength without compromising the material's permeability.

- Perform a series of laboratory tests on specifically prepared concrete specimens to evaluate properties such as specific gravity, water permeability, compressive strength, and infiltration capacity.

- Analyze how different types and proportions of fine and coarse aggregates affect the mechanical and hydraulic behavior of pervious concrete.

Advantages:

- By allowing water to infiltrate the ground, pervious concrete can decrease the scale and, in some cases, eliminate the need for traditional stormwater drainage systems.

- Facilitates the replenishment of groundwater levels through natural infiltration, supporting sustainable water resource management.

- Promotes the natural purification of runoff as water passes through soil layers, filtering out pollutants and contaminants.

- Reduces surface temperatures due to its lighter surface color, helping to alleviate the urban heat island effect.

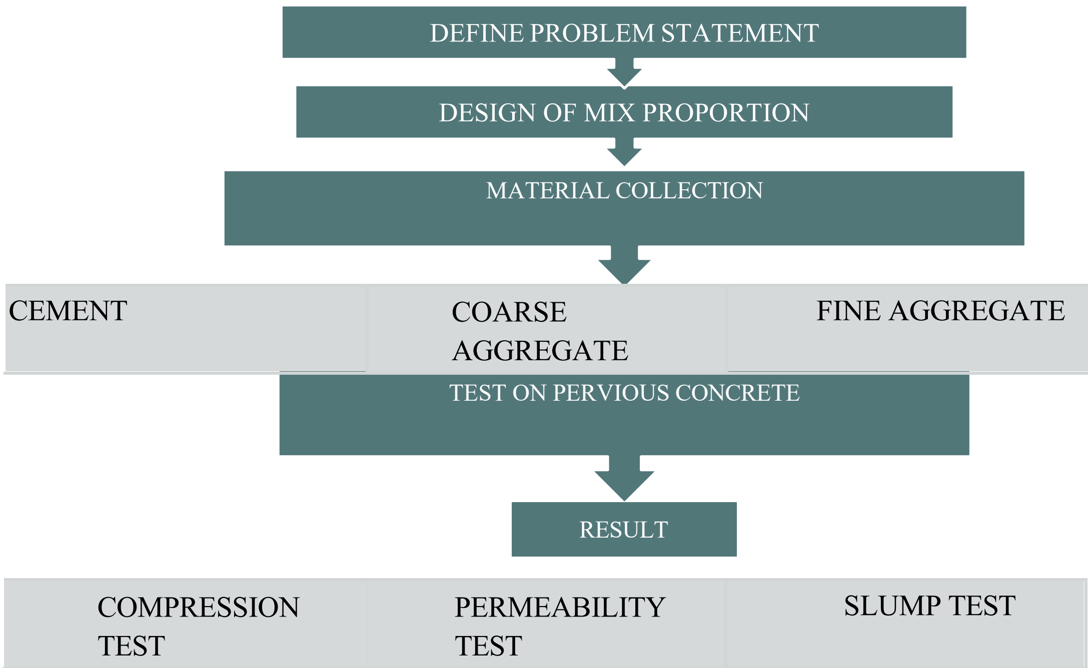
- Contributes to quieter pavements by minimizing tire-generated noise, enhancing the urban acoustic environment.

- Decreases the likelihood of hydroplaning and surface water accumulation, leading to safer driving and walking conditions.

- Can replace or reduce reliance on costly infrastructure such as storm sewers and retention basins, leading to potential cost savings.
- Increases usable parking space by eliminating the need for separate water retention areas, optimizing land use.

- Expands the total permeable surface area, which can contribute to meeting regulatory or environmental credits.

2. Methodology:



3. Materials, Properties, and Mix Design:

Laboratory testing provides the necessary data to ensure that materials used in concrete mixes are of the required quality and conform to standards. This process is fundamental for designing concrete mixes that achieve the desired performance characteristics, including strength and durability.

Ordinary Portland Cement (OPC), Coarse Aggregates, Fine Aggregates, Water.
The calculated mix ratios are presented in tabular form, ensuring the desired balance of strength, workability, and durability.

Cement	Water	Fine Aggregate	Coarse Aggregate
1	0.4	0.5	3

4. Test and Result

4.1 Slump Test:

Table: Slump Test Results

Water/Cement ratio	Slump in mm
0.4	80

4.2 Compression Test:

Compression tests were conducted on concrete cube specimens measuring (150 × 150 × 150) mm at various curing intervals specifically after (3, 7, 14, 21,28) days. Two different curing methods were employed: water curing and carbon curing.Compressive strength=[P/(150x150)] N/mm2

Table: Compressive Test Results

No of Days	Compressive Strength (N/mm^2)
7	9.3
14	11.6
28	15.4

4.3 Permeability Test:

Quantity of water flows under a given hydraulic gradient through a concrete block of known dimensions and cross-sectional area in each time. water is allowed to flow through cylindrical sample of a concrete block under a constant head.

Table: Permeability Test Results

Sr. no.	Water in ml	Infiltration rate
1	100	12.9 sec
2	100	12.3 sec
3	100	12.1sec

5. Conclusion:

The previous concrete has less strength than conventional concrete by 14.5% for M20.

Similarly, the split tensile strength values are also comparatively lower than the conventional concrete by 30%.

The smaller size of the coarse aggregate should be able to produce a higher compressive strength and at the same time produce a higher permeability rate.

The mixtures with higher aggregate/cement ratio considered to be useful for pavement that require low compressive strength.

The findings of this study indicate that no-fines concrete exhibits a higher coefficient of permeability compared to conventional concrete. This enhanced permeability allows for effective stormwater infiltration, aiding in groundwater recharge. Consequently, it is particularly suitable for applications in parking areas and residential zones with low to moderate vehicular traffic.

Sustainable construction practices. By omitting fine aggregates, this concrete type reduces the consumption of natural resources and minimizes environmental impact.

Pervious concrete is a cost-effective and environmentally friendly solution that supports sustainable construction. Its ability to capture stormwater and recharge groundwater while reducing stormwater runoff enables pervious concrete to play a significant role. Due to its potential to reduce runoff, it is commonly used as a pavement material. A smaller size of coarse aggregate can produce higher compressive strength while maintaining a higher permeability rate. Mixes with higher aggregate-to-cement ratios, low compressive strength and high permeability rates.

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