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WATER-ABSORBING ROADS USING PERVIOUS CONCRETE: A CONCEPTUAL AND MODEL-BASED STUDY OF PERMEABLE PAVEMENT

Simran Alkunte[1], Vaishnavi Mangrule[2], Vaishnavi Jadhav[3], Rajshri Godale[4], Sakshi Shah[5]

[12345]*Student of B. Tech, Department of civil Engineering, Government College of Engineering, Shivaji University, Karad, Maharashtra, India.*

Abstract - *Conventional impervious pavement surfaces limit the direct infiltration of rainfall into the ground and can contribute to increased surface runoff, local water accumulation and pressure on urban stormwater drainage systems. Pervious concrete pavement offers an alternative surface system in which interconnected voids permit water to pass through the concrete layer and enter a permeable aggregate sub-base, where it may be temporarily stored and subsequently infiltrate into the underlying soil or be conveyed through a designed drainage arrangement. This paper presents a literature-supported conceptual study of water-absorbing roads using pervious concrete, based on an earlier student project, its physical exhibition model, project notes and a previously published overview of permeable pavement systems. The study describes the principle of pervious concrete, the functions of the pavement layers, relevant material considerations, potential applications, advantages and limitations. Published reviews identify the need to balance hydraulic performance with mechanical strength and durability, while also addressing clogging and maintenance. The physical model developed for the project illustrates a pervious concrete road surface, aggregate subbase, soil layer, adjacent green area and a proposed water storage arrangement. The model is illustrative and does not constitute a measured field or laboratory performance evaluation. No numerical test results are claimed in this paper. The study concludes that pervious concrete may be a useful stormwater-management component in suitable low- to moderate-traffic applications, provided that site soil, groundwater conditions, structural loading, drainage design and maintenance requirements are assessed before implementation.*

Keywords: Pervious concrete, permeable pavement, water-absorbing roads, stormwater management, infiltration, porous pavement, sustainable pavement.

1. INTRODUCTION

Road pavements provide essential connectivity for the movement of people and goods. Conventional concrete and bituminous surfaces are generally designed primarily to provide a safe, smooth and durable riding surface. Because these surfaces are comparatively impermeable, rainfall falling on them is commonly converted into surface runoff rather than infiltrating directly into the ground. In developed areas, the combined effect of roads, parking areas, footpaths and other hard surfaces can increase runoff volumes and contribute to local waterlogging where drainage capacity is insufficient.

Permeable pavement is an engineered surface system intended to allow water to pass through the pavement surface and into underlying aggregate layers. Three commonly discussed forms are pervious concrete, porous asphalt and permeable interlocking pavers. The present paper focuses on pervious concrete, which is produced with a connected pore structure. It typically uses coarse aggregate bound by cement paste, with little or no fine aggregate, so that interconnected voids remain within the hardened material [1,2].

The earlier student project titled “Water Absorbing Road by Permeable Concrete” explored this concept through a physical model. The model represented a road surface over an aggregate sub-base and soil layer, alongside a garden or green area and a proposed water-storage tank. The intention was to communicate how rainfall can move through a permeable surface rather than remaining entirely as surface runoff.

The objective of this paper is to consolidate the project concept with relevant published literature, explain the system components and identify the technical considerations that would govern practical application. The paper is not presented as a laboratory validation or a full pavement design.

1.1 PROBLEM STATEMENT

Impervious pavement surfaces can increase the amount of rainfall that becomes runoff. During intense rainfall, runoff may collect on road surfaces and contribute to waterlogging, while conventional drainage systems may require additional collection and conveyance infrastructure. A permeable pavement system may reduce direct surface runoff by allowing a portion of rainfall to enter the pavement structure. Its effectiveness, however, depends on the permeability of the surface and sub-base, the infiltration capacity of the underlying soil, groundwater conditions, rainfall characteristics, structural design and maintenance.

1.2 AIM

To study the concept, constructional arrangement and potential stormwater-management applications of pervious concrete as a water-absorbing road pavement.

1.3 OBJECTIVES

- To explain the principle and pore structure of pervious concrete.
- To describe the functions of the pervious concrete surface, aggregate sub-base and underlying soil.
- To review published research concerning material properties, pavement performance and clogging.
- To document the physical model prepared to demonstrate the permeable pavement concept.
- To identify the potential applications, advantages, limitations and further testing required before field implementation.

2. LITERATURE REVIEW

2.1 PERVIOUS CONCRETE AS A PAVEMENT MATERIAL

Zhong, Leng and Poon [1] reviewed research and practical applications of pervious concrete as a sustainable pavement material. Their review considered pore-system characterization and its influence on mechanical, hydraulic and acoustic properties. The authors described pervious concrete as a promising paving material while identifying performance challenges and areas requiring further research.

Chandrappa and Biligiri [2] reviewed the use of pervious concrete in sustainable pavement applications, with particular attention to low-volume roads. Their work considered material characteristics, durability, field performance and environmental and economic aspects. The review indicates that pavement suitability cannot be determined from permeability alone; mechanical performance and durability also need consideration.

2.2 MIXTURE OPTIMISATION AND PERFORMANCE BALANCE

AlShareedah and Nassiri [3] reviewed pervious concrete mixture optimization, physical and mechanical properties, and pavement design. Their discussion covers mixture composition, characterization methods, waste materials, mechanical performance and pavement design. A central design consideration is the balance between a connected pore structure that supports water movement and a sufficiently strong cementitious skeleton that can resist applied loads.

Cui et al. [4] reviewed the effects of aggregate characteristics, particle size, water–cement ratio, additives, admixtures, mixture proportions and preparation methods on pervious concrete. Their review highlights that these variables influence porosity, permeability and mechanical performance. It also identifies continuing issues in the correlation between influencing factors and the reliability of preparation and testing methods.

2.3 CLOGGING AND MAINTENANCE

Sandoval et al. [5] conducted a systematic literature review of clogging in pervious concrete. Clogging occurs when sediments and other particles obstruct the connected pore network, reducing hydraulic performance. Their review discusses the relationship between pore obstruction, porosity change, permeability loss and the effectiveness of cleaning methods. This evidence makes maintenance a design consideration rather than an afterthought.

The uploaded IRJET paper by Wagh et al. [6] also discusses the accumulation of debris and residue within the void structure of permeable pavement. It describes routine maintenance and rehabilitation approaches, including vacuum cleaning and targeted cleaning of clogged areas. The paper further identifies clogging, specialized construction practices, limitations under heavy traffic and high-groundwater conditions as issues requiring attention.

2.4 PERMEABLE PAVEMENT SYSTEMS AND STORMWATER MANAGEMENT

The uploaded IRJET paper [6] distinguishes among pervious concrete, porous asphalt and permeable pavers. It describes pervious concrete as a material with little or no fine aggregate, allowing water to pass through connected voids. It also discusses porous asphalt and permeable interlocking pavers as alternative permeable surface systems. The paper outlines the use of geotextiles to limit migration of subgrade fines into a stone recharge bed and describes a clean, uniformly graded aggregate layer as part of a permeable pavement structure.

Antunes, Ghisi and Thives [7], as cited in the uploaded IRJET paper, examined life-cycle assessment literature for permeable pavements and compared environmental performance considerations associated with construction, maintenance and disposal. This wider perspective is relevant because the environmental value of a pavement system should be considered over its service life, not solely from its initial infiltration function.

2.5 FINDINGS FROM THE EARLIER STUDENT PROJECT

The earlier project material supplied for this paper describes a physical demonstration model with a pervious concrete road surface, aggregate sub-base, soil layer, a garden or forest area and a water-storage tank. The accompanying poster identifies the principle, introduction,

applications and advantages of water absorbing roads. The model is intended to demonstrate the pathway by which water may pass through the pavement and aggregate layer towards the underlying ground or a collection arrangement.

The supplied project notes mention cement, coarse aggregate and water as the basic constituents of pervious concrete and list trial proportion labels of 1:4, 1:5, 1:6 and 1:7, together with a water–cement ratio range of 0.28–0.40 and a void-content range of 15– 30%. These figures are retained here as values appearing in the supplied project material, not as validated mix designs or measured outcomes. The available evidence does not establish the aggregate grading, batching basis, specimen dimensions, curing regime, test standards or measured results associated with those values. They must therefore be verified against the original laboratory record before being used as experimental data.

2.6 RESEARCH GAP

The reviewed literature establishes the potential of pervious concrete for permeable pavement and stormwater management, but also shows that performance depends on interacting material, structural and site variables. A key challenge is balancing permeability with strength and durability. Clogging can further reduce infiltration over time. The earlier project model communicates the pavement layer concept, but the material currently available does not include documented laboratory results or field monitoring. Accordingly, the present study identifies a need for a future experimental programe that measures infiltration or permeability, void content, compressive strength and clogging-related performance for clearly documented mixtures and site conditions.

3. MATERIALS

3.1 PERVIOUS CONCRETE SURFACE

Pervious concrete is a cement-based concrete with a relatively open pore structure. Coarse aggregate particles are bonded by cement paste while a connected void network is retained. Unlike conventional dense concrete, fine aggregate is commonly reduced substantially or omitted. The pore network allows water to pass through the pavement surface, but the same structure can reduce the effective load-bearing area and make mixture production more sensitive to batching, placement, compaction and curing [1,3,4,6].

3.2 AGGREGATE SUB-BASE / STONE RESERVOIR

The aggregate sub-base provides support beneath the permeable surface and may provide temporary storage space for infiltrated water. The uploaded IRJET paper describes clean, uniformly graded crushed stone for the stone recharge bed and notes the importance of limiting excessive fines that may migrate into or clog the void structure [6]. The thickness and gradation of the sub-base must be designed for the expected loading, storage requirement, soil conditions and drainage objective; no design thickness is established by the supplied model.

3.3 GEOTEXTILE AND SEPARATION CONSIDERATIONS

The uploaded IRJET paper describes non-woven geotextile filter fabric as a means of limiting migration of subgrade fines into the stone recharge bed [6]. Whether a geotextile is appropriate, and where it should be placed, depends on the design objective and soil conditions. A poorly selected or incorrectly placed separator can interfere with infiltration or create a maintenance issue; it should not be specified without a project-specific design.

3.4 SOIL / SUBGRADE

The underlying soil receives infiltrated water where the soil has adequate infiltration capacity and where groundwater and contamination conditions permit. The model labels this bottom layer as the soil layer. In practice, soil infiltration characteristics, seasonal groundwater level, slope, risk of groundwater contamination and the need for an underdrain or lined storage arrangement must be assessed. Where the subgrade infiltrates slowly or groundwater is shallow, water may need to be stored temporarily and conveyed through a designed outlet rather than assumed to recharge groundwater.

3.5 WATER STORAGE ARRANGEMENT AND ADJACENT GREEN AREA

The physical model includes a labelled water-storage tank and a garden or forest area. These elements illustrate possible integration of permeable pavement with local water management and landscaping. The model does not demonstrate a quantified tank capacity, actual collection efficiency, irrigation demand or measured groundwater recharge. Such performance would require a defined hydraulic layout and monitoring.

Ratio	% Material Used				
PERVIOUS CONCRETE MIX (CEMENT & AGGREGATE)	Cement	Aggregate 20mm-12.5mm	Aggregate 12.5mm-9.5mm	Aggregate 9.5mm-4.75mm	Admixture
A1(1:4)	20	56	24	0	0
A2(1:5)	16.67	50	33.33	0	0
A3(1:6)	14.28	51.42	34.3	0	0
A4(1:6.5)	13.33	69.34	17.33	0	0
A5(1:7)	12.5	52.5	35	0	0
A6(1:6)	14.26	60	12.8	12.8	0.14

4. WORKING PRINCIPLE

The proposed system operates through a sequence of surface entry, movement through connected pores, temporary storage within the aggregate sub-base and subsequent infiltration or controlled discharge. During rainfall, water enters the pervious concrete surface through its interconnected voids. It then moves into the open-graded aggregate sub-base, where it may be temporarily detained. Depending on the permeability of the subgrade and the overall drainage design, water may infiltrate into the soil, be directed to a storage facility or be discharged through an underdrain.

1. Rainfall reaches the pervious concrete pavement surface.
2. Water enters the interconnected voids in the concrete.
3. Water moves into the aggregate sub-base or reservoir layer.
4. Water is temporarily stored and then infiltrates into suitable underlying soil, or is conveyed to a designed storage / drainage outlet.
5. Routine inspection and cleaning are required to reduce sediment accumulation and preserve the connected pore network.

title as a simple description. Technically, the system is better described as a permeable pavement: water passes through connected voids and is managed by the underlying pavement and drainage layers. It is not necessarily absorbed by the concrete as a sponge-like material.



Figure A1. Project team with the water-absorbing road model during the exhibition.

5. METHODOLOGY

5.1 STUDY DESIGN

This paper adopts a literature-supported conceptual and model-based approach. It consolidates the supplied project poster, working-model photographs, handwritten notes and the uploaded IRJET paper with selected peer-reviewed review literature. The purpose is to explain the system and evaluate its potential and constraints at a conceptual level.

5.2 MODEL DESCRIPTION

The physical model is divided into a permeable road section and an adjacent water-management / built-up section. The road section visibly represents a surface layer, coarse aggregate sub-base and soil layer. The model also shows a planted garden or forest area. The adjacent section contains a building representation and a labelled water-storage tank. The model is a visual demonstration of the proposed arrangement and not a scaled engineering prototype with calibrated hydraulic properties.



Figure A2. Exhibition working model showing the pervious road surface, aggregate sub-base, soil layer, green area and proposed water-storage tank and Project poster.

5.3 SCOPE AND EXCLUSIONS

No laboratory test procedure, specimen preparation record, measured infiltration result, compressive strength result, field trial, cost estimate or life-cycle calculation was supplied for verification. Therefore, these are not reported as completed methods or findings. The flexible-pavement notes supplied with the project are used only to clarify the general pavement functions of providing a safe riding surface and distributing wheel loads; the present study focuses on pervious concrete, which is not the same material system as a conventional flexible bituminous pavement.

6. DISCUSSION

6.1 POTENTIAL BENEFITS

The main potential benefit of pervious pavement is the reduction of direct surface runoff by allowing water to

enter the pavement structure. Where the sub-base and subgrade are suitably designed, this can help reduce local ponding and provide temporary stormwater storage. Infiltration may also contribute to groundwater recharge where subsurface conditions are appropriate. The uploaded IRJET paper discusses potential benefits related to runoff reduction, water quality, wet-weather safety and reduced demand on conventional drainage infrastructure [6]. These are potential system-level benefits and should not be interpreted as measured outcomes of the student model.

6.2 STRUCTURAL AND TRAFFIC

CONSIDERATIONS

A pavement must provide a safe, smooth and durable surface over its design life. It must also distribute vehicle loads through the pavement layers so that the subgrade does not undergo unacceptable deformation under repeated loading. These general pavement functions are stated in the supplied handwritten notes. For pervious concrete, the open pore structure creates a design trade-off: increasing void content may improve water movement but can reduce strength. Consequently, traffic category, layer thickness, aggregate properties, mixture design and construction quality must be considered together [2 4]. The supplied material does not establish suitability for heavy-traffic roads.

6.3 CLOGGING AND MAINTENANCE

Sediment, dust, organic matter and other debris can block surface openings and connected pores. As clogging progresses, infiltration capacity may decrease. The literature identifies clogging as a significant long-term hydraulic concern and discusses cleaning methods as a means of recovering some permeability [5,6]. A practical installation therefore needs a maintenance plan, control of sediment sources and periodic inspection. Maintenance frequency should be determined from site conditions and observed performance rather than assumed from a generic schedule.

6.4 SITE SUITABILITY AND GROUNDWATER PROTECTION

Permeable pavement is not universally suitable. Low permeability soils, shallow groundwater, contaminated runoff, high sediment loads, steep slopes and particular traffic demands can affect feasibility. In some settings, an under drained or lined system may be preferable to direct infiltration. The design must also consider whether infiltrated runoff could mobilize pollutants into groundwater. Site investigation and drainage design are therefore essential before implementation.

6.5 RBI GRADE-81 SUPPLEMENTARY MATERIAL

The supplied presentation images include information about RBI Grade-81, described in that material as a pavement material and natural soil stabilizer, along with examples of road projects and equipment. This technology concerns soil stabilization and should not be conflated with pervious concrete. The supplied images do not establish that RBI Grade-81 was used in the student model or in the pervious concrete mixture. It is therefore not treated as a constituent, test variable or performance result in this paper.

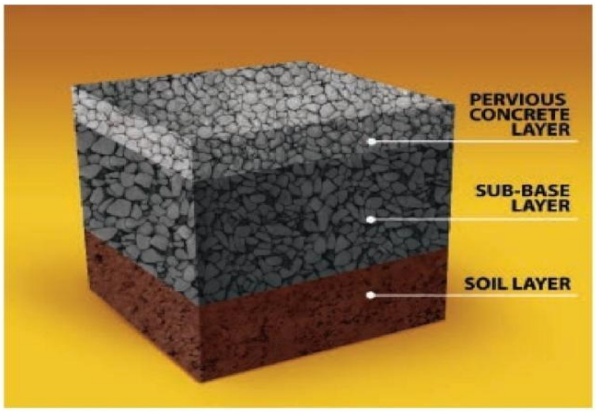

Figure A3. Conceptual pavement cross-section showing the pervious concrete layer, sub-base layer and soil layer

7. FUTURE SCOPE

A future experimental study may prepare pervious concrete specimens using documented aggregate grading, binder content and water cement ratio. Each mixture should be identified by its exact mass proportions and preparation procedure. Relevant tests may include fresh mixture workability or consistency observations, hardened density, void content, water permeability or infiltration, compressive strength and, where feasible, abrasion and clogging-related evaluation. The test methods, specimen dimensions, curing conditions, number of replicates and applicable standards should be stated. A small pavement-bed trial could further examine the combined behavior of the surface, aggregate reservoir and subgrade. Field monitoring should measure rainfall, inflow, outflow, water level and maintenance-related changes if runoff reduction or storage performance is to be quantified.

A comparative study between conventional concrete / bituminous pavement and pervious concrete may be considered only when comparable design traffic, layer configurations, drainage assumptions and evaluation periods are defined. Cost and environmental claims should be supported by quantity estimates and lifecycle boundaries.

8. CONCLUSION

Pervious concrete is a permeable pavement material designed with interconnected voids that allow rainfall to pass through the surface and enter the underlying pavement structure. The literature reviewed in this paper identifies its potential role in stormwater management and sustainable pavement applications, while emphasizing the need to balance permeability with strength, durability and long-term maintenance. The earlier student project communicated this concept through a physical model representing a pervious concrete road surface, aggregate sub-base, soil layer, green area and proposed water-storage tank.

The project material supports a conceptual explanation of how a permeable pavement system may manage rainfall; it does not, by itself, establish measured reductions in flooding, improved groundwater levels or structural adequacy for a particular traffic category. Clogging, subgrade permeability, groundwater conditions, pollutant risks, traffic loading and construction quality remain important considerations. The project therefore provides a useful educational and conceptual foundation, while laboratory testing and site-specific engineering design are required before practical performance can be claimed.

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