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LITERATURE REVIEW ON MODIFIED DOTCON-BASED PERMEABLE PAVEMENT SYSTEM FOR URBAN FLOOD MITIGATION AND RAINWATER HARVESTING

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Abstract: Rapid urbanisation and the increase in impervious surfaces have affected the natural movement of rainwater, contributing to surface runoff, water accumulation and urban flooding. Permeable pavement systems have been studied as an alternative to conventional impermeable pavement because they allow rainwater to pass through the pavement structure and enter the underlying layers. Pervious concrete and permeable pavement systems also provide opportunities for stormwater management, groundwater recharge and rainwater harvesting. The literature reviewed in this paper covers the hydrological performance of permeable pavements, mechanical properties of pervious concrete, pavement design under traffic loading, rainwater harvesting systems and water-quality performance. The reviewed studies indicate that pavement performance depends on the properties of the surface layer, aggregate base and sub-base, underlying soil, and the provision of suitable drainage and storage arrangements. The literature also identifies the importance of balancing permeability and structural strength and considering clogging and maintenance during pavement design. The present project proposes a modification of the DOTCON-based permeable pavement concept by incorporating an additional rainwater collection, filtration and storage arrangement. The proposed modification aims to collect a portion of the water passing through the pavement and make it available for potential non-potable reuse while retaining the stormwater-management function of the pavement. This review provides the technical background and identifies the research requirements for evaluating the proposed system.

Keywords: Permeable pavement, DOTCON, pervious concrete, stormwater management, rainwater harvesting, filtration, water storage, urban flooding.

I. INTRODUCTION

Urban development has increased the area covered by conventional concrete, asphalt and other impermeable surfaces. These surfaces restrict the infiltration of rainwater into the ground and increase the quantity of surface runoff. During heavy rainfall, increased runoff can contribute to waterlogging and urban flooding.

Permeable pavement is one of the techniques considered for managing stormwater at or near the location where rainfall occurs. Unlike conventional pavement, permeable pavement allows water to pass through its surface and enter the pavement layers. Depending on the pavement configuration and site conditions, the water may infiltrate into the subgrade, remain temporarily stored within the aggregate layers or be directed towards a drainage system.

Pervious concrete is one type of permeable pavement material. It contains interconnected voids that allow water to pass through the concrete structure. Its hydraulic performance is associated with its pore structure and porosity, while its mechanical performance depends on factors such as aggregate characteristics, binder content, mix proportions and compaction.

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Research has also investigated the integration of permeable pavement with rainwater harvesting systems. Such arrangements provide an opportunity to collect stormwater instead of allowing all the water to infiltrate into the ground or leave the site as runoff.

The present project focuses on a modified DOTCON-based permeable pavement system. The proposed modification includes an additional arrangement for collecting, filtering and storing rainwater. The literature review examines the existing research and technical information relevant to this proposed system.

II. REVIEW OF LITERATURE

A. Research on Pervious Concrete as a Sustainable Pavement Material

Zhong, Leng and Poon reviewed the research and practical applications of pervious concrete as a sustainable pavement material. Their review discusses the material's pore structure, hydraulic characteristics, mechanical properties and applications in stormwater management.

The study explains that pervious concrete contains interconnected pores that allow water to pass through the pavement. The presence of these pores is important for permeability, but it also influences the mechanical behaviour of the concrete. The review discusses different approaches used to improve the strength of pervious concrete, including modifications to the aggregate-to-binder ratio and the incorporation of additional materials.

The paper reports that conventional pervious concrete with porosity between approximately 15% and 30% has compressive strength values ranging from approximately 7 MPa to 25 MPa in the literature reviewed. It also discusses studies reporting higher strengths through different mix-design and material-modification approaches.

This review is relevant to the present project because the proposed pavement must provide sufficient water movement while maintaining the required structural performance. [1]

B. Mechanical Properties of Pervious Concrete

Chen, Wang and Liang investigated the mechanical properties of pervious cement concrete, including compressive strength, flexural strength, fracture energy and fatigue behaviour. Their study considered pervious concrete modified using supplementary cementitious materials and polymer-based modification.

The research indicates that the mechanical behaviour of modified pervious concrete differs according to the type of modification used. The study also reports that polymer-intensified pervious concrete showed higher flexural strength and a higher flexural-to-compressive strength ratio than supplementary-cementitious-material-modified pervious concrete at the same porosity level.

The authors also examined fracture behaviour, which is important when considering the performance of pavement materials under loading.

The findings indicate that the mechanical evaluation of pervious concrete should not be limited to compressive strength alone. Flexural behaviour and other mechanical properties are also relevant when assessing pavement performance.

For the present project, this research provides a basis for considering the structural behaviour of the modified pavement along with its permeability. [2]

C. Influence of Water-Cement Ratio and Aggregate Size on Pervious Concrete

Neamitha and Supraja studied the influence of water-cement ratio and aggregate size on the properties of pervious concrete. The study considered five water-cement ratios: 0.28, 0.30, 0.32, 0.33 and 0.34, along with two single-sized aggregates of 10 mm and 12.5 mm.

The research examines how variations in mix proportions and aggregate size affect the properties of pervious concrete. These parameters are important because the concrete must maintain interconnected voids for water movement while providing sufficient bonding between aggregate particles.

The study is relevant to the present project because the concrete or permeable surface component must be selected with consideration of both hydraulic and mechanical requirements. Mix proportions and aggregate characteristics should therefore be considered during the development and testing of the proposed pavement system. [3]

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D. Hydrological Performance of Permeable Pavements

Abbondati presented a systematic literature review of the hydrological performance of porous pavements for stormwater management and pollution control.

The review discusses the role of porous pavement systems in managing stormwater through infiltration and temporary storage. The hydrological performance of these systems depends on their ability to receive rainfall, transmit water through the pavement structure and manage the water entering the underlying layers.

Madrazo-Uribeetxebarria and co-authors investigated the hydraulic performance of permeable pavements on a layer-by-layer basis. Their research considers the hydraulic contribution of the different pavement layers rather than treating the pavement as a single uniform structure.

This layer-based approach is important because the surface, aggregate layers and underlying soil have different functions within the pavement system. The overall hydraulic performance depends on the combined behaviour of these components.

For the present project, the research supports the need to consider the complete pavement cross-section. The proposed collection and filtration arrangement should be evaluated in relation to the movement of water through each layer. [4], [5]

E. Structural and Hydrological Design of Permeable Pavements

Hein, Swan and Schaus discussed the structural and hydrological design of permeable pavements. Their work considers the pavement's ability to carry loading while also providing stormwater-management functions.

Permeable pavement design requires consideration of the materials used in the surface, base and sub-base layers. The pavement structure must be suitable for its intended application and should provide adequate hydraulic capacity.

Shackel examined the design of permeable paving subjected to traffic. The paper identifies that permeable paving must be designed not only to carry traffic but also to manage runoff, infiltration and pollutant transport. It discusses the additional design considerations associated with permeable pavement compared with conventional pavement.

These studies are relevant to the proposed DOTCON-based system because the addition of rainwater collection and filtration components should not compromise the pavement's structural function. The intended loading condition, pavement layers and material characteristics must be considered during design. [6], [7]

F. Performance Evaluation of Pervious Concrete Pavement

The technical brief titled *Performance Evaluation of Permeable Pavements* discusses the evaluation of permeable pavement performance. It provides a technical reference for considering the pavement's stormwater-management function and performance.

Performance evaluation is important because the initial permeability of a pavement does not by itself establish its long-term suitability. The pavement should be evaluated under relevant site and operating conditions.

For the present project, performance evaluation should consider water infiltration, water movement through the layers, storage behaviour and structural performance. These parameters can help determine whether the proposed modification provides the intended hydraulic function without adversely affecting the pavement structure. [8]

G. Permeable Pavements Integrated with Rainwater Harvesting

Gomez-Ullate and co-authors presented the design and construction of an experimental pervious paved parking area for harvesting reusable rainwater.

This work is particularly relevant because it connects permeable pavement construction with the collection of water for potential reuse. It demonstrates the research importance of considering rainwater harvesting as part of the pavement system rather than treating pavement infiltration and water collection as entirely separate functions.

The work provides a basis for studying how water passing through a paved surface can be managed for collection. In the present project, this concept is extended through a proposed additional filtration and storage arrangement associated with a DOTCON-based pavement.

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The proposed modification should be evaluated to determine how much water can be collected, how effectively it can be filtered and whether the collection arrangement affects the hydraulic and structural behaviour of the pavement. [9]

H. Water Quality Performance of Permeable Pavement and Stormwater Harvesting

Winston, Arend, Dorsey and Hunt studied the water-quality performance of a permeable pavement and stormwater-harvesting treatment-train stormwater-control measure.

The study is relevant because rainwater harvesting involves more than collecting water. The quality of the collected water is also important when considering its intended use.

Permeable pavement and associated treatment components may influence the quality of stormwater passing through the system. Therefore, water-quality evaluation should be considered when a pavement system is designed to collect water for reuse.

For the present project, the proposed filtration arrangement should be evaluated separately from the pavement's infiltration performance. The quality of collected water should be tested before making claims about its suitability for any particular reuse application. [10]

I. Rainwater Harvesting for Sustainable Water Supply

Rahman and co-authors investigated the sustainability of rainwater harvesting systems in terms of water quality. Their research highlights the importance of considering water quality as part of rainwater harvesting system performance.

Rodrigues, Formiga and Milograna reviewed integrated systems for rainwater harvesting and greywater reuse as urban water-management strategies. Their review discusses decentralised approaches for managing water resources and reducing dependence on conventional water supplies.

These studies provide supporting information for the rainwater-harvesting component of the present project. The proposed pavement system is intended to collect rainwater and store it for potential non-potable use. However, the actual suitability of the collected water depends on the results of water-quality testing and the requirements of the intended use. [11], [12]

J. Stormwater Management through Permeable Pavements

Imran, Akib and Karim reviewed permeable pavement and stormwater-management systems. Their work discusses the use of permeable pavements as a stormwater-management approach.

Antunes and co-authors investigated the reduction of environmental impacts through the use of permeable pavements for stormwater harvesting. This research connects permeable pavement systems with stormwater management and harvesting applications.

The studies support the consideration of permeable pavement as part of a wider urban stormwater-management strategy. They also provide a basis for evaluating the potential environmental benefits of collecting and managing rainwater through pavement systems. [13], [14]

K. Sustainable Urban Drainage Systems

The review by Xu and co-authors discusses urban rainwater utilisation and different rainwater-management and harvesting approaches. It provides a broader perspective on the management of urban rainwater.

Tota-Maharaj and co-authors reviewed sustainable drainage systems for rainwater harvesting and stormwater management in temporary humanitarian settlements. Their work considers the relationship between sustainable drainage and rainwater management.

These studies provide a broader context for the proposed project. Permeable pavement can be considered as one component of a decentralised stormwater-management arrangement, particularly when combined with suitable collection and storage facilities. [15], [16]

L. DOTCON Construction Method and Technical Evaluation

The uploaded DOTCON technical documents include the *Technical Evaluation Report – DOTCON Construction Method*, prepared by the Association for Rainwater Storage and Infiltration Technology in association with PUMPMAN.

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The technical material describes DOTCON as a construction method associated with rainwater storage and infiltration. The uploaded construction examples, product brochure and application-method document provide additional information about the system's construction and application.

The DOTCON documentation is relevant to the present project because it provides the technical basis for the existing system on which the proposed modification is developed.

The present project proposes an additional rainwater collection, filtration and storage arrangement. This proposed addition should be distinguished from the original DOTCON construction method. The original system's documented features should not be treated as evidence that the proposed modified system has already been tested or validated.

The uploaded research-paper list also identifies DOTCON+ load-bearing performance testing and experimental construction work associated with rainwater storage and infiltration. These documents are relevant to understanding the continuing development of the DOTCON system. [17]-[20]

III. COMPARATIVE REVIEW AND SYNTHESIS

The reviewed literature establishes that permeable pavement performance involves both hydraulic and structural considerations. The studies on pervious concrete focus on pore structure, porosity, mix proportions, aggregate characteristics and mechanical strength. The hydrological studies consider infiltration, storage and the performance of individual pavement layers.

The research on pavement design under traffic highlights the need to consider structural loading and the intended pavement application. The rainwater-harvesting studies extend the function of permeable pavement by considering the collection and possible reuse of stormwater. The water-quality studies indicate that the collected water must be evaluated before it is considered suitable for reuse.

The DOTCON technical documents provide a construction and product reference for the existing pavement concept. The proposed project builds on this concept by introducing an additional collection, filtration and storage arrangement.

The following table summarises the main contributions of the reviewed sources.

Research area	Main contribution	Relevance to the present project
Pervious concrete properties	Discusses porosity, permeability and mechanical properties	Selection and evaluation of pavement material
Mix proportion and aggregate size	Examines the influence of water-cement ratio and aggregate size	Concrete mix development
Hydrological performance	Reviews infiltration and stormwater-management behaviour	Evaluation of water movement
Layer-by-layer hydraulic performance	Examines the contribution of individual pavement layers	Design of pavement cross-section
Structural pavement design	Considers pavement behaviour under traffic loading	Structural evaluation of the modified system
Rainwater harvesting	Discusses collection and use of rainwater	Development of collection and storage arrangement
Water-quality performance	Examines stormwater quality in treatment systems	Evaluation of proposed filtration arrangement
DOTCON technical documentation	Provides information on DOTCON construction and application	Reference for the existing pavement system

IV. RESEARCH GAP

Based on the uploaded literature and technical documents, the following research requirements are identified:

1. **Integration of pavement and harvesting:** The project proposes an additional arrangement for collecting and storing water passing through a DOTCON-based pavement system.

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2. **Filtration arrangement:** The proposed modification requires an appropriate filtration arrangement, and its effect on collected-water quality needs to be evaluated.

3. **Hydraulic performance:** The infiltration and water-collection behaviour of the modified pavement need to be studied together.

4. **Structural performance:** The additional collection and filtration components should not adversely affect the structural performance of the pavement.

5. **Storage performance:** The quantity of water that can be collected and retained needs to be determined through design calculations and testing.

6. **Water quality:** The collected water must be tested before its suitability for non-potable reuse can be established.

7. **Performance evaluation:** The modified system requires evaluation under the selected project conditions. The performance of the proposed modification should not be assumed from the performance of the original DOTCON system.

V. PROPOSED MODIFICATION IN THE PRESENT PROJECT

The present project proposes a modified DOTCON-based permeable pavement system with an additional rainwater collection, filtration and storage arrangement.

The proposed system is intended to allow rainwater to pass through the permeable pavement structure. The water will then move through the designed pavement layers and be directed towards the proposed collection arrangement. A filtration component is proposed before the water enters the storage tank.

The conceptual water-flow sequence is:

Rainfall → Permeable pavement surface → DOTCON-based pavement structure → Aggregate layer → Proposed filtration arrangement → Collection and storage tank → Potential non-potable reuse

The proposed arrangement aims to combine stormwater management with rainwater harvesting. The actual performance of this system will depend on the design of the pavement layers, filtration components, drainage arrangement and storage capacity.

The project should evaluate the following parameters:

- Infiltration rate of the pavement.
- Quantity of water entering the collection arrangement.
- Water-storage capacity.
- Runoff reduction compared with the selected reference condition.
- Structural strength of the pavement.
- Performance of the filtration arrangement.
- Quality of the collected water.

These parameters will help establish the performance of the modified system through experimental evaluation.

VI. CONCLUSION

The literature review indicates that permeable pavement and pervious concrete have potential applications in urban stormwater management. Their hydraulic performance depends on the interconnected pore structure, pavement-layer arrangement, aggregate characteristics and underlying soil conditions. At the same time, sufficient mechanical strength is necessary to support the intended pavement application.

The reviewed studies also demonstrate the importance of considering rainwater harvesting and water quality when collected stormwater is intended for reuse. A suitable collection and filtration arrangement can therefore be considered as an additional component of a permeable pavement system.

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The DOTCON technical documents provide the reference for the existing DOTCON construction concept. The present project proposes to modify this concept by incorporating an additional rainwater collection, filtration and storage arrangement. The proposed system requires experimental evaluation to establish its infiltration, storage, water-quality and structural performance.

The review therefore provides the technical foundation for developing and evaluating a modified DOTCON-based permeable pavement system for urban flood mitigation and rainwater harvesting.

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