Journal of Ceramics and Concrete Technology
Volume 9 Issue 3
ISSN No: 2457-0826 (Online)

Pervious Concrete Pavements

Ms. K. Chaitra
Assistant Professor
Department of Civil Engineering
St. Martin's Engineering College
Corresponding Author's Email: *kchaitrace@smec.ac.in*

Gundamaina Harisai
Student
Department of Civil Engineering
St. Martin's Engineering College
Corresponding Author's Email: *harisai092@gmail.com*

Abstract

Pervious concrete pavements have emerged as a sustainable solution to address challenges posed by urbanization and storm water runoff in built environments. Unlike traditional impermeable pavements, pervious concrete is designed with interconnected voids that allow water to infiltrate through the surface, promoting groundwater recharge and reducing the burden on conventional drainage systems. This abstract explores the fundamental characteristics, benefits, applications, and challenges associated with pervious concrete pavements. It begins by elucidating the composition of pervious concrete, which typically includes coarse aggregates, cementations' materials, and water, formulated to achieve high porosity and permeability. The resulting open-cell structure enables rapid drainage of rainfall and minimizes surface runoff, thereby mitigating flooding risks and controlling erosion. The environmental benefits of pervious concrete extend beyond storm water management. By filtering pollutants and contaminants as water percolates through the pavement, it improves water quality in adjacent ecosystems and reduces the discharge of harmful substances into water bodies. Additionally, pervious concrete contributes to urban heat island mitigation by enhancing evaporative cooling and supporting vegetation *growth within urban landscapes. Applications of pervious concrete pavements encompass various settings, including parking lots, sidewalks, driveways, and low-traffic roadways, where its ability to handle pedestrian and vehicular traffic while managing storm water effectively is advantageous. Case studies of successful installations highlight its versatility and performance under diverse environmental conditions. However, challenges such as potential clogging of voids due to sediment accumulation necessitate careful consideration of maintenance practices, including regular vacuuming and cleaning to sustain optimal permeability over time. Furthermore, proper installation techniques, such as adequate compaction and curing procedures, are critical to achieving desired durability and performance outcomes.*

Keywords: *pervious concrete, storm water management, urban sustainability, permeability, pavement design.*

INTRODUCTION

Pervious concrete pavement is a unique and effective means to meet growing environmental demands. By capturing rainwater and allowing it to seep into the ground, pervious concrete is instrumental in recharging groundwater, reducing storm water runoff, and meeting U.S. Environmental Protection Agency (EPA) storm water regulations. In fact, the use of pervious concrete is among the Best Management Practices (BMP) recommended by the EPA—and by other agencies and geotechnical engineers across the country—for the management of storm water runoff on a regional and local basis. This pavement technology creates more efficient land use by eliminating the need for retention ponds, swales, and other storm water management devices. In doing so, pervious concrete has the ability to lower overall project costs on a first-cost basis. In previous concrete, carefully controlled amounts of water and cementations' materials are used to create a paste that forms a thick coating around aggregate particles. A pervious concrete mixture contains little or no sand, creating a sub-spatial void content. Using sufficient paste to coat and bind the aggregate particles together creates a system of highly permeable, interconnected voids that drains quickly. Typically, between 15% and 25% voids are achieved in the hardened concrete, and flow rates for water through pervious concrete typically are around 480 in./hr (0.34 cm/s, which is5gal/ft2/ min or 200 L/m2/min), although they can be much higher. Both the low mortar content and high porosity also reduce strength compared to conventional concrete mixtures, but sufficient strength for many applications is readily achieved. While pervious concrete can be used for a surprising number of applications, its primary use is in pavement. This report will focus on the pavement applications of the material, which also has been referred to as porous concrete, permeable concrete, no-fines concrete, gap-graded concrete and enhanced-porosity concrete. Concrete pavements have a rich history that spans over a century, with early applications dating back to the late 19th century. The first concrete pavements were constructed in the 1880s, with the first patent for a concrete pavement granted in 1891. However, these early pavements were plagued by cracking and durability issues, leading to a search for improvements. The early 20th century saw the introduction of reinforced concrete pavements, which marked a significant turning point in the development of concrete pavements. This was followed by the development of prestressed concrete pavements in the mid-20th century, which further enhanced durability and resistance to cracking. This historical overview will explore the evolution of concrete pavements, highlighting key milestones, innovations, and advancements that have shaped the modern concrete pavements used today Pervious concrete pavements represent a sustainable solution in urban and suburban infrastructure, designed to manage storm water runoff effectively while providing a durable surface for pedestrian and vehicular traffic. Unlike traditional concrete pavements, which are impermeable, pervious concrete is engineered with high porosity to allow water to pass through, promoting groundwater recharge and reducing the burden on storm water management systems. This introduction explores the fundamental characteristics, benefits, applications, and challenges associated with pervious concrete pavements. It begins by defining pervious concrete and discussing its composition, which typically includes coarse aggregates, cementations materials, and water. The unique mixture design creates interconnected voids that facilitate water infiltration into the underlying soil or aggregate base. The benefits of pervious concrete extend beyond storm water management. By reducing runoff, it helps mitigate flooding and erosion, enhances water quality by filtering pollutants, and contributes to urban heat island mitigation. Its open-cell structure also promotes vegetation growth and supports sustainable landscaping practices. Applications of pervious concrete pavements span a range of environments, including parking lots, sidewalks, driveways, and low-traffic roadways. Its use in residential, commercial, and municipal projects continues to grow as awareness of sustainable construction practices increases. However, pervious concrete pavements present challenges such as careful maintenance requirements to prevent clogging of voids by debris or sediment accumulation. Proper installation techniques and periodic vacuuming or pressure washing are essential to maintain performance over time. In conclusion, the introduction emphasizes the growing importance of pervious concrete pavements in sustainable urban development and infrastructure planning. Understanding its composition, benefits, applications, and maintenance considerations is crucial for stakeholders seeking effective solutions to storm water management and environmental stewardship.

Pervious concrete pavements represent a innovative approach to sustainable urban development and storm water management. Unlike traditional concrete, which is impermeable, pervious concrete is designed with an interconnected network of voids that allow water to pass through the surface and into the ground below. This unique characteristic helps to mitigate the adverse effects of storm water runoff in urban areas by reducing flooding, minimizing erosion, and improving water quality.

The composition of pervious concrete typically includes coarse aggregates, cementations' materials (such as Portland cement), and water. The absence of fine aggregates in the mix creates voids that range from 15% to 35% of the concrete volume, facilitating water infiltration. The mixture is carefully proportioned to ensure adequate strength and durability while maintaining high porosity.

One of the primary benefits of pervious concrete pavements is their ability to promote groundwater recharge. By allowing rainwater to percolate through the pavement and into the soil below, pervious concrete helps replenish aquifers and maintain natural hydrological cycles. This feature is particularly valuable in urban areas where traditional impervious surfaces contribute to surface runoff and strain on drainage systems.

Moreover, pervious concrete contributes to environmental sustainability by reducing the urban heat island effect. Its open-cell structure enhances evaporative cooling and supports the growth of vegetation, thereby creating a more comfortable and ecologically balanced urban environment.

Applications of pervious concrete pavements range from sidewalks and driveways to parking lots and low-traffic roadways. These applications demonstrate its versatility in various urban and suburban settings, where it effectively balances the dual objectives of supporting vehicular and pedestrian traffic while managing storm water runoff.

However, the effectiveness of pervious concrete pavements relies on proper installation techniques and ongoing maintenance. Careful attention to compaction during placement, adequate curing procedures, and routine cleaning to prevent clogging of voids are essential for ensuring long-term performance and durability.

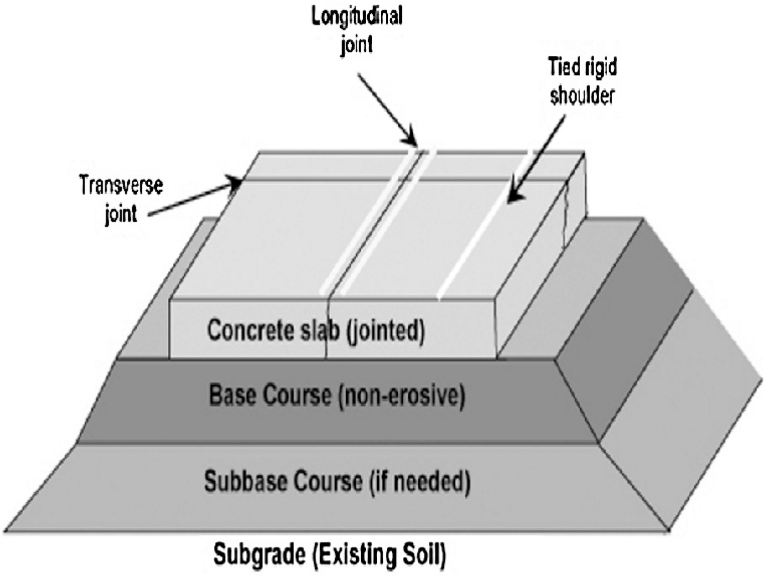

Figure: 1 Layers of the concrete pavement

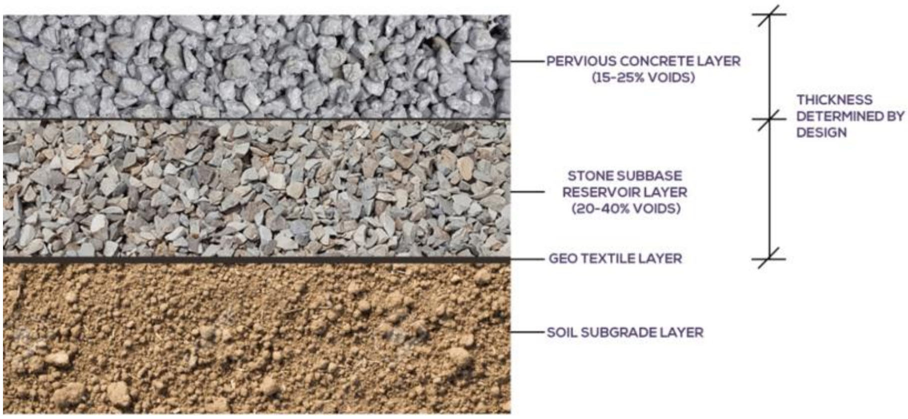

Figure: 2 Pervious concrete pavement

LITERATURE REVIEW

- **M.Uma Maguesvaria and V.L. Narasimha** has conducted research on Studies on Characterization of Pervious Concrete for Pavement Applications. This study illustrates angularity number, which influence properties and behaviour of pervious concrete with fine aggregate and coarse aggregates. It is observed that the increase in fine aggregate results in reduction of volume of voids which in turn increase of compressive strength, flexural strength and split tensile strength. Angularity number is more for higher size aggregate and which is reduced when size of aggregate reduces. The range of compressive strength varies between 10 N/mm2 to 26 N/mm2 when the angularity number varied from 8 to 4. Increasing the aggregate size increases angularity number. Coefficient of permeability increases from 0.4 cm/sec to 1.26 cm/sec when the angularity number is in the range of 4 to 8. The optimum mixes in each coarse aggregate size are identified based on the compressive strength, Void present in aggregate (based on angularity number) and permeability are M1F30, M2F30, M3F20 and M4F20. However, the influence of angularity number on the abrasion value of the pervious concrete could not be established.
- **Darshan Shah Jayesh Kumar Pitt roda (March 2014)** Has conducted an experimental study on durability and water absorption properties of pervious concrete Findings of this study are the main result is found out, such as water absorption and durability are inversely proportional to each other. Means that, concrete made by 1:6 mix proportions has more durability and less water absorption. And concrete made by 1:10 mix proportion has more water.
- **Hilal Elhassana peiman Kianmehr (November 2016)** Has conducted a study on feasibility study of embedded piezoelectric system on a highway for streetlight and found that concrete with 10 mm aggregates and 20% porosity [A – 10- 20] required the least amount of cement and CGBS. The use of CGBS as 50% cement replacement increased the albedo value to 0.52, compared to 0.40 and 0.10 for OPC concrete and asphalt, respectively.
- **Kiran Bapanappa Thombre (September 2016)** Has conducted investigation of strength and workability in No fines concrete and found that no – finds concrete with uniformly graded coarse aggregate size from 10.00 MM to 20MM give the maximum strength and moderate workability at 10% void ratio.

- **Nalini Thakre, Hirendra Rajput, Jaya Saxena Harish Mitangale** Studied comparative study on strength and permeability of pervious concrete by using nylon and polypropylene fibre and found that when the nylon fibre and polypropylene fibre used in pervious concrete in various proportions like 0.1 percent, 3.15%, 0.2%, 0.25% 3% of volume of concrete, concrete, the result obtained by the compressive strength of nylon fibre and polypro line fibre up to 0.2% of used result get increased.

METHODOLOGY

Methods

A myriad of studies have been devoted to the development and evaluation of various types of PCP in recent years, yet few review articles have summarized the recent progress and future trends of this technology from a holistic view of the environmental benefits, preparation process, properties, and maintenance activities. In addition, the environmental sustainability and durability aspects of PCP are rarely reviewed in a comprehensive fashion.

Environmental benefits

PCPs are credited with a variety of environmental benefits, including runoff reduction and infiltration improvement of storm water, skid resistance enhancement of pavement surface, improvement of underground water quality, and reduction of hydroplaning, heat-island effect and traffic noise. These benefits can improve resilience, environmental stewardship, and traffic safety of local transportation systems or communities. Governmental agencies in many countries are promoting green infrastructure.

Design, fabrication, maintenance and durability

The durability and long-term performance of PCP depend on its proper design, fabrication (placement), and maintenance activities. If properly designed and constructed, the PCPs can be used for collector streets and most residential streets for 20–30 years while exhibiting structural performance similar to traditional pavements (Goede and Haselbach, 2012). If the PCP is used on low-volume roads, in which garbage, construction, utility, and emergency vehicles contribute most of the load cycles,

Modeling and simulation of PCP

Studies have been conducted to model the mechanical properties and performance of permeable concrete. Deo et al. (2010) used a statistical model to build a relationship between the compressive strength and the relevant pore structure features. A Monte-Carlo simulation was employed in this model to evaluate the sensitivity of the predicted compressive strength. Lian et al. (2011a, 2011b) presented a discrete element method which uses particle flow code to evaluate the structural properties.

Environmental benefits

Numerous studies have demonstrated the multiple environmental benefits of PCPs (if implemented appropriately), including: storm water runoff management, groundwater and air quality improvements, heat-island effect mitigation, traffic noise reduction, and skid resistance improvement. Nonetheless, knowledge gaps still remain in many of these aspects of PCPs and the development of new technologies is expected to further enhance its environmental benefits. Some of the research needs are briefly.

Figure: 3 Pervious pavements

Figure: 4 Construction of pervious concrete pavements

CONCLUSION

Recent years have seen increasing interest in PCPs and this work provides a high-level overview regarding the environmental benefits and the design, fabrication, maintenance, and durability of PCPs, followed by an examination of recent studies on modeling and advanced characterization. As a green infrastructure solution, PCPs can be used to supplement or replace conventional grey infrastructure and greatly contribute to sustainable and low impact development.

From the performed theoretical study, it is perspicuous that the pervious concrete pavements have been emerging in the trend of sustainable pavement technology with new alterations in the aspect of design and materials. After a long appraisal of various considerations, PCP has ratified several advantages over conventional pavements in terms of better infiltration rate, reasonably economical in both construction and maintenance, environmentally sound with non-polluting and energy efficient aspects. In addition to the excellence of PCP, it has been authenticated to be a quintessential alternative to counteract the Urban Island Effect. With the increasing demand for land sustainability, the pervious concrete pavement has given a good source of replacement thereby utilizing the infiltration rate for recuperating the dwindling groundwater table and also been a source to take the edge off for stormwater management.

Further researches are being made in the flow to find solutions to some mechanical problems like stiffness and strength. But a reduced pavement thickness and less content of cement usage have made pervious concrete pavement to stand as one of the best replacements for conventional pavements. In accordance with the traffic flow and bearing capacity, experiments are still in progress. From all the analysis performed various characteristics of PCP, it is absolutely and utterly clear that Pervious Concrete Pavement(PCP) can be termed as a Sustainable Pavement Technology(SPT).

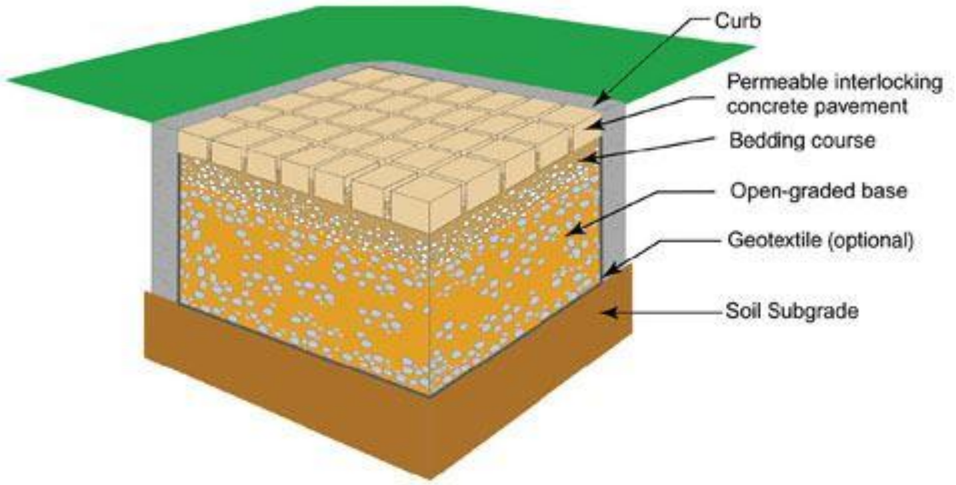

Figure: 5 Permeable interlocking concrete pavements

REFERENCES

1. Prof Satish Chandra, Ph. D Director, CSIR-Central Road Research Institute Delhi, Flexible Pavement versus Rigid Pavement.
2. Report on Pervious Concrete 2010 American Concrete Institute ISBN 9780870313646.
3. S Rajesh Kumar 2015 Characteristic Study on Pervious Concrete International Journal of Civil Engineering and Technology (IJCIET) Volume 6 Issue 6 Pp. 165-176 Article Ids: 20320150606017.
4. John T Kevern, Vernon R. Schaefer & Kejin Wang 2011 Mixture Proportion Development and Performance Evaluation of Pervious Concrete for Overlay Applications Materials Journal American Concrete Institute. 108 (4): 439–448
5. Salunkhepatil S S , Patil O D , Dhemare A M , Jadhav S A, Bhirud SV 2018 A Review On Mix Design For Pervious Concrete 8th National Conference On Emerging Trends In Engineering And Technology, NCETET ISBN: 978-93 87793-03-3
6. M Harshavarthana Balaji , M R Amaranth, R A Kavin, S Jaya Pradeep 2015 Design of Eco Friendly Pervious Concrete International Journal of Civil Engineering and Technology (IJCIET) Volume 6 Issue 2.

7. Dang Hanh Nguyen, Nassim Sebaibi, Mohamed Boutouil , Lydia Leleyter, Fabienne Baraud 2014 A Modified Method For The Design Of Pervious Concrete Mix Construction and Building Materials 73 271–282.
8. Wanielista M, Chopra M, Spence J and Ballock C Hydraulic Performance Assessment of Pervious Concrete Pavements for Storm water Management Credit Storm water Management Academy University of Central Florida 81 pp.

