IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

# "Making Green Porous Concrete for Rain water harvesting and urban pavement"

[1] Deokar A.H, [2] Dhaktode S.Y, [3] Patil S.S,
[4] Gadhave S.M, [5] Chavan A.N, [6]Masal P.N

**Abstract:**

In numerous developed nations, the adoption of permeable concrete for constructing pavements, parking lots, and driveways is gaining popularity. To establish material specifications for permeable concrete, testing to assess the performance of this innovative high-quality concrete is essential. Moreover, the substantial carbon dioxide emissions from Portland cement production significantly contribute to global warming, leading to adverse climate change effects. Hence, minimizing the use of Portland cement in permeable concrete mixes by partially substituting it with industrial by-products like fly ash and slag, which have proven successful as supplementary cementitious materials in structural concrete mixes, is imperative. Permeable concrete is manufactured using conventional cementitious materials, aggregates, and water. This concrete undergoes testing for properties such as density, porosity, compressive strength, water permeability, and drying shrinkage. The crucial property of permeable concrete is its water permeability, yet there is currently no standardized experimental procedure to determine this property. Consequently, a method was devised to ascertain water permeability. Fly ash is utilized as a supplementary cementitious material to replace Portland cement partially in permeable concrete mixes, up to 50% by weight. Enhancing the surface texture is essential to improve the acceptance of permeable concrete.

## I. Introduction

**General**:

Conventional normal weight Portland cement concrete is generally used for pavement construction. The impervious nature of the concrete pavements contributes to the increased water runoff into the drainage system, over -burdening the infrastructure and causing excessive flooding in built-up areas. Porous concrete has become significantly popular during recent decades, because of its potential contribution in solving environmental issues. Porous concrete is a type of concrete with significantly high water permeability compared to normal weight concrete. It has been mainly developed for draining water from the ground surface, so that stormwater runoff is reduced and the groundwater is recharged. Figure 1.1 shows the typical porous concrete used

Figure .1 Porous Concrete Road

for the pavement. Porous concrete is a special kind of concrete that has high porosity. The only difference between porous concrete and normal concrete is that a porous concrete mix does not consist of sand or other small particles. The lack of sand and small particles creates voids in the concrete. The voids that area created are the reason why water is able to pass through a porous concrete mix. Porous concrete is used for low traffic areas such as parking lots and pavements. The main purpose of porous concrete is to reduce or even eliminate storm water runoff which has a number of benefits.

## 1.1 WHAT IS POROUS CONCTRETE

Pervious concrete (also called porous concrete, permeable concrete, no fines concrete and porous pavement) is a special type of concrete with a high porosity used for concrete flatwork applications that allows water from precipitation and other sources to pass directly through, thereby reducing the runoff from a site and allowing groundwater recharge
Pervious concrete pavement is a unique and effective means to address important environmental issues and support green, sustainable growth. By capturing storm water and allowing it to seep into the ground, porous concrete is instrumental in recharging groundwater, reducing storm water runoff, and meeting U.S. Environmental Protection Agency (EPA) storm water regulations. Up to 75 percent of urban surface area is covered by impermeable pavement, which inhibits groundwater recharge, contributes to erosion and flooding, conveys pollution to local waters, and increases the complexity and expense of storm water treatment.

## 1.3 OBJECTIVES

1. To evaluate the aggregate suitability for preparing a porous pavement block. To evolve optimum size of coarse aggregate for maximum effective porosity and permeability. To determine the strength characteristics such as compressive strength and abrasion resistance to evaluate the suitability of porous concrete for pavement blocks.

To determine the porosity and permeability of the standard 15cm X 15cm X 7.5cm porous concrete in order to understand its effectiveness in groundwater infiltration and rain water harvesting . To study the effect of grass turf laid porous concrete pavement blocks in its permeability characteristics.

Use different percentage of fine aggregate and check maximum strength and porosity.
Stormwater Management: Green porous concrete is designed to facilitate natural stormwater management by allowing rainwater to infiltrate into the ground, reducing stormwater runoff and alleviating pressure on drainage systems. This helps to mitigate urban flooding and minimize erosion of natural waterways.
Groundwater Recharge: By enabling rainwater to percolate into the ground, green porous concrete promotes groundwater recharge, replenishing aquifers and sustaining water resources. This is especially important in areas facing water scarcity or where groundwater levels are declining.
Water Quality Improvement: Green porous concrete acts as a natural filtration system, removing pollutants and contaminants from stormwater as it passes through the pavement layers. This helps to improve water quality in surrounding water bodies and protects ecosystems from harmful runoff.
Reduction of Heat Island Effect: Green porous concrete surfaces absorb less heat than traditional impervious surfaces like asphalt or concrete. By reducing the urban heat island effect, which contributes to higher temperatures in urban areas, it helps to create more comfortable and sustainable urban environments.

## 1.4 ADVANTAGES

Creating green porous concrete offers several advantages, aligning with sustainability goals and environmental stewardship. Here are some key benefits:
Green porous concrete, like other porous concretes, effectively manages stormwater by allowing rainwater to infiltrate into the ground. This helps reduce runoff, alleviates pressure on stormwater infrastructure, and recharges groundwater sources
By filtering out pollutants and contaminants as water percolates through the pavement, green porous concrete contributes to better water quality in local water bodies and aquifers. This is especially important in urban areas where runoff can carry pollutants from roads and other surfaces
Incorporating green elements such as vegetation or recycled materials into porous concrete not only provides structural integrity but also enhances aesthetics and biodiversity in urban environments. It can contribute to the creation of green spaces, which offer numerous benefits like improved air quality and urban cooling.
Green porous concrete, particularly when combined with vegetation, helps mitigate the urban heat island effect by reducing surface temperatures. Vegetation provides shade and evaporative cooling, while the permeable surface allows water to evaporate, further cooling the surroundings.
Some formulations of green porous concrete incorporate recycled materials or alternative binders that have lower carbon footprints compared to traditional concrete. By using eco-friendly materials and reducing reliance on cement, green porous concrete can contribute to overall carbon emissions reduction in construction projects.
Building with green porous concrete can help developers and municipalities meet regulatory requirements related to stormwater management and sustainable development. Additionally, projects using sustainable materials may qualify for green building certifications such as LEED (Leadership in Energy and Environmental Design), further enhancing their environmental credentials.

Green porous concrete projects can serve as educational tools and community engagement opportunities. They showcase innovative sustainable technologies and practices, fostering awareness and appreciation for environmentally friendly design and construction methods.

Overall, green porous concrete offers a multifaceted approach to sustainable urban development, addressing issues related to water management, climate resilience, biodiversity, and resource efficiency.

## 1.5 DISADVANTAGES

Limited Load-Bearing Capacity: Green porous concrete typically has lower structural strength compared to traditional concrete. This limits its use in applications where heavy loads or vehicular traffic are expected. Using it in high-traffic areas without proper support can lead to premature wear and damage.

Clogging: Over time, the pores in porous concrete can become clogged with debris, sediment, and organic matter, reducing its permeability and effectiveness in managing stormwater. Regular maintenance, such as vacuuming or pressure washing, is necessary to prevent clogging and maintain its performance.

Cost: Green porous concrete may have a higher initial cost compared to traditional concrete due to the specialized materials and installation techniques required. However, it's important to consider the long-term benefits and savings associated with reduced stormwater management costs and improved environmental sustainability.

Freeze-Thaw Durability: In regions with cold climates and frequent freeze-thaw cycles, the durability of porous concrete may be compromised. Water that infiltrates into the pores can freeze and expand, leading to cracking and deterioration over time. Proper design and maintenance practices, such as adequate drainage and sealing, are essential to mitigate this risk.

## 1.6 Methodology

Different types of coarse aggregates viz: river side pebbles and crushed granite stones were analyzed for their size gradation, angularity, surface roughness, impact factor etc., to understand the best suitable material for coarse aggregate. Different mix designs have been carried out and optimum water: cement: aggregate ratio identified. Different grade size of OPC and PPC available in the market have been tested for understanding the strength characteristics in standard pavement blocks. Media for culturing grass seeds has been prepared and tested its effectiveness in various conditions. A) Preparation of Cube Specimens1. Take mix proportion of water, aggregate and cement while concreting.2. Fill concrete in three layers.3. Compact each layer[ 35 nos']4. Finish top surface by using trowel.

B) Mixing

1.Mix concrete by using trowel by manually or using concrete mixer) Sampling1) Clean the mounds by using brush and apply grease

2) Fill the mixture of concrete in the mounds in 3 equal layers 3) Compact every layer of concrete by using temping rod at least 30 to 40 times. 4) The mound will fulfill with concrete by using trowel. Curing the concrete mound and place its room temperature for 1day for better results.

C) Curing The concrete mound are place in room temperature for 1 day for better result .after that release the mound and concrete block sock in water for carrying out test.

Fig no :1 Concrete Cylinder

D) Procedure:1. The unit weight and void ratio are the important factors to be considered in mix design. According to mix design the quantity of cement for one cubic meter of porous concrete The other consideration is aggregate to cement A/C ratio and W/C ratio.

The mix design procedure gave the value of cement to aggregate ratio C/A for size of aggregate crossing on minimum 20 mm is sieve. The W/C Ratio for porous concrete should be range of 0.25 to 0.36. .a) For the proper working select the W/ C ratio as0.3.b)Calculate the void ratio of porous concrete and unit weight range.

## 1.7 LITERATURE REVIVE

Darshna shah, Prof. Jayesh Kumar Pitroda and Prof. J. J. Bhavsar published a research paper Pervious Concrete: New Era for Rural Road Pavement" in 2013.Object of the study was to gauge the cost effectiveness of the pervious concrete compared to normal concrete. During the study, Normal concrete was used as per IS design of M20 grade, which was constituted by 59.25 kg of cement (300rs/50kg), 88.88 kg of Fine aggregate (600rs/1 ton) and 177.8 kg of course aggregate (1000rs/1ton). Pervious concrete was used as per

NRMCA guideline, which was constituted by 46.5 kg of cement (300rs/50kg) and course concrete (1000rs/1ton). They conclude that the pervious concrete reduces the storm water runoff to improve the ground water level to eliminate the costly storm water management practices. And there is considerable saving in amount about 29rs/m3 or 18rs/ft2.Husain N Ham Dulay, Roshni J John and D R Soroche published an experiment in 2015 named „Effect of Aggregate Grading and Cementitious by Product on Performance of

Pervious Concrete". Object of the study was to exchange the cement with industrial by-product like fly ash, GGBFS which are used successfully as supplementary Cementous material. In this study, cement of 53 grade (specific gravity 3.15), coarse aggregate (passed through 20 mm and retained on 10 mm sieve), GGBFS (specific gravity 2.88), fly ash and water are used. Now maintaining the W/C ration constant, following mix proportions are used. FA are utilized in 85:15 and 65:35 proportions and GGBFS are utilized in 75:25 and 50:50 proportion. They concluded that the compressive strength of concrete was increased by using GGBFS as supplementary material and grading of aggregate is equally important to provide strength and permeability, grater size have law compressive strength and high permeability vice versa.Sukamal Kanta Ghosh, Ananya Chaudhury, Rohan data and D.K.Bera published a review paper named „A Review of Performance of Pervious Concrete Using Waste Material" from KIT University from Odisha. This review paper illustrates the performance of pervious concrete with solid waste like fly ash, furnace slag, and rice husk ash, silica fume, and solid waste (glass powder, ceramic waste, bottom ash) and Its effect on compressive strength and permeability.

## 1.8 FUTURE SCOPE

The future of green porous concrete holds promises for addressing environmental challenges and enhancing sustainability in construction and urban development. Here are some potential directions for its future scope:

Advanced Materials: Continued research into innovative materials and additives can enhance the properties of green porous concrete. This may involve incorporating recycled aggregates, industrial by-products, or novel admixtures to improve strength, durability, and environmental performance.

Carbon Capture: Integration of carbon capture technologies into the production process could make porous concrete a carbon-negative material. Techniques such as carbonation curing or utilizing CO2 as a curing agent may help sequester carbon dioxide within the concrete matrix.

Biodegradable Binders: Exploration of biodegradable binders derived from renewable resources could reduce the environmental impact of concrete production. Biopolymers or bio-based materials as alternatives to conventional cementitious binders may offer greener solutions for porous concrete.

Self-Healing Properties: Development of self-healing mechanisms within porous concrete can enhance its longevity and reduce maintenance requirements. Incorporating bacteria, encapsulated healing agents, or microvascular networks that can repair cracks autonomously could prolong the service life of green porous concrete.

Smart Technologies: Integration of sensors and IoT (Internet of Things) devices into porous concrete structures can enable real-time monitoring of performance parameters such as permeability, moisture content, and structural integrity. This data-driven approach can facilitate proactive maintenance and optimization of green porous concrete infrastructure.

Urban Greening: Incorporating greenery into porous concrete systems through techniques like pervious pavements with vegetation can enhance the aesthetic appeal and ecological functionality of urban spaces. Green roofs, bioswales, and rain gardens integrated with porous concrete surfaces can contribute to biodiversity, mitigate urban heat island effects, and improve stormwater management.

Circular Economy Practices: Embracing principles of the circular economy by promoting reuse, recycling, and repurposing of construction materials can further enhance the sustainability of green porous concrete. Designing for disassembly and implementing closed-loop systems for material recovery and reuse can minimize waste and resource depletion.

By advancing research and innovation in these areas, green porous concrete has the potential to become a cornerstone of sustainable infrastructure development, contributing to a more resilient and environmentally conscious built environment.

## 1.9 CONCLUSION

Each and every mixture can fulfill the requirements for even the worst rainstorm but only some of them have the compressive strength necessary for

particle use. In other words, only some mixtures are able to withstand the compression forces of human traffic and light vehicles.

1.From the findings of this project, it was found that the samples that had Lower strength without fine aggregate.

2. The porous concrete showed significantly medium strength 10% fine aggregate.

3. The porous concrete showed significantly higher strength 20% fine aggregate.

4. From the findings of this project, it was found that the samples that had the highest compression strength were the 20% of fine aggregate in the mixture.

5. Due to this fact, the 20% of fine aggregate in the mixture would be the best design mixture for practical use.

6. The porous concrete showed significantly higher porosity without fine aggregate.

7. The porous concrete showed significantly medium porosity 10% fine aggregate.

8. The porous concrete showed significantly low porosity 20% fine aggregate.

9. In the other hand, without fine aggregate had more porosity but low compressive strength. 20% fine aggregate mixture have high compressive strength but low porosity than without fine aggregate.

## 2 REFERENCE

➢ACI 522.1-13 Specification for Pervious Concrete Pavement

➢American Society for Testing Materials (2000). "Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous
Materials Using a Flexible Wall Permeameter (ASTM D 5084-90),"Annual Book of ASTM Standards, Section Four, Construction, Volume4.08.

➢Runoff in Dhaka https://www.thedailystar.net/news-detail-3883.

➢Ammann, A. A., E. Hoehn, S. Kock. (2003) "Ground water pollution by roof runoff infiltration evidenced with multi-tracer experiments." Water Research 37, 1143- 1153.

➢Barraud, S., A. Gautier, J. P. Bardin, V. Riou. (1999) "The Impact of Intentional Stormwater Infiltration on Soil and Groundwater." Wat. SciTech. 39(2), 185- 192.

➢Ladd, T. (2004) "A Water Quantity Study of a Porous Concrete Infiltration Best Management Practice." Master's Thesis. Villanova University, Villanova, PA.

➢Swisher, D. (2002) "Chemical and Hydraulic Performance of a Porous Pavement Parking Lot with Infiltration to Ground Water" Master's Thesis, The Pennsylvania State University.

➢Traver, R., A. Welker, C. Emerson, M. Kwiatkowski, T. Ladd, L. Kob.(2003) "Lessons Learned – Porous Concrete Demonstration Site. "Stormwater 5(6).

➢ASTMC39, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens, ASTM, Editor. 2005.