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Study on Porous Concrete as an Alternative Drainage System

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ABSTRACT: In this study, porous concrete is examined as an alternate drainage solution for urban areas. Traditional concrete sidewalks and pavements can contribute to increased runoff and flash flooding, both of which can harm the environment and infrastructure. Concrete with pores, commonly referred to as permeable concrete, allows water to pass through it, minimising runoff and enhancing water quality. The study examines the characteristics of porous concrete, as well as its advantages and drawbacks. A case study of a pilot project in a residential area of a US coastal city is also included in the paper. Porous concrete was used in the pilot project to replace conventional concrete in a parking lot and sidewalk. The results showed The outcomes demonstrated the efficiency of porous concrete in lowering runoff and enhancing water quality. According to the study's findings, porous concrete can be a practical alternative to traditional drainage systems in urban settings, offering a long-term approach to stormwater management.

KEYWORDS: alternative drainage method, urban areas, porous concrete, permeable concrete, stormwater management

I. INTRODUCTION

Urban areas with regular concrete sidewalks and pavements may experience increased runoff and flash flooding, which may harm the environment and infrastructures. In recent years, the use of porous concrete as an alternative drainage system has grown in favour. Concrete that has holes in it, or porous concrete, allows water to pass through, minimising runoff and enhancing water quality. Stormwater management in urban areas may be made sustainable by using porous concrete.
Porous concrete is a concrete with continuous voids which are intentionally incorporated into the concrete. It belongs to acompletely different category from conventional concrete and hence its physical characteristics differ greatly from those ofnormal concrete. This porous concrete mixture has little to no sand which creates an open-cell structure that allows rain water to filter right through to the underlying soil. Porous concrete is one of the leading materials used bythe concrete industry as GREEN industry practices for providing pollution control, storm water management and sustainable design. Porous concrete can be used in numerous civil engineering and architectural application. It has been called as the green construction material for pavement because it has been recognized by the LEED (Leader shipping Energy and Environmental Design).

The increased interest in porous concrete is due to those benefits in storm water management sustainable development.Impervious nature of bituminous and concrete used for the construction of pavements, walkways, open car parkscontribute to the increased water runoff to the drainage system, over-burdening the infrastructure and causing excessive flooding in built-up areas. With the changing climatic conditions and increasing urbanisation had resulted in flooding in major cities around the world. Porous concrete is an engineered concrete to have very high permeability to allow the rain water to drain rapidly.

Case Study-1
A trial investigation was carried out in a residential area of a coastal city in the United States to assess the efficacy of porous concrete as an alternative drainage system. Porous concrete was used in the pilot project to replace conventional concrete in a parking lot and sidewalk. The 18% porosity of the porous concrete was intended to filter impurities out of the water as it went through the concrete.

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The trial project's findings demonstrated that porous concrete was efficient at lowering runoff and enhancing water quality. The quality of the water leaving the site greatly improved while runoff from the site was decreased by 50%. Additionally, the urban heat island effect in the area was lessened because to the use of porous concrete.

II. BACKGROUND HISTORY OF POROUS CONCRETE

Porous concrete was first used in 1800 s in Europe as pavement surfacing and load bearing wall. The initial use of porous concrete was in the United Kingdom in 1852 with the construction of two residential houses and a sea groyne. Cost efficiency seems to have been the primary reason for its earliest usage due to the limited amount of cement used. It was not until 1923 when porous concrete re surfaced as a viable construction material. This time it was limited to the construction of 2-story homes in areas such as Scotland, Liverpool, London and Manchester.

Use of porous concrete in Europe increased steadily, especially inthe World War II era. Since porous concrete use less cement thanconventional concrete and cement was scare at that time. It seemedthat porous concrete was the best material for that period. Porousconcrete continued to gain popularity and its use spread to areassuch as Venezuela, West Africa, Australia, Russia and the MiddleEast. After World War II, porous concretebecame wide spread for applications such as cast-in-place load- bearing walls of single and multi-storey houses and, in someinstances in high-rise buildings, prefabricated panels, and stem cured blocks. Also, applications include wallsfor two story houses, load-bearing walls for high-rise buildings (upto 10 stories) and infill panels for high-rise buildings.India is facing a typical problem of ground water Table falling at afaster rate due to reduced recharge of rain water into subsoil andunplanned water withdrawal for agriculture and industry. It wouldbe beneficial for India to exploit the potentialof porous concrete.

III. NEED OF POROUS CONCRETE

In rural areas larger amount of rainwater ends up falling onimpervious surfaces such as Parking lots, driveways, sidewalks,and streets rather than soaking into the soil. This creates animbalance in the natural ecosystem and leads to a host of problemsincluding erosion, floods, ground water level depletion andpollution of rivers, as rainwater rushing across pavement surfacespicks up everything from oil and grease spills to de-icing salts andchemical fertilizers.

A simple solution to avoid these problems is to stop constructingimpervious surfaces that Block natural water infiltration into thesoil. Rather than building them with conventional concrete, weshould be switching to Porous Concrete or Porous Pavement, amaterial that offers the inherent durability and low life-cycle costsof a typical concrete pavement while retaining storm water runoffand replenishing local watershed systems. Instead of preventinginfiltration of water into the soil, porous pavement assists theprocess by capturing rainwater in a network of voids and allowingit to percolate into the underlying soil.

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IV. ADVANTAGES

a) Suitable for cold-climate applications, maintains recharge capacity when frozen
b) Extended pavement life due to well drained base and reduced freeze-thaw
c) Less lighting needed due to highly reflective pavement surface
d) No standing water or black ice development during winter weather conditions
e) Reduction in storm water infrastructure (Piping, Catch- Basins, Ponds, Curbing, etc.)
f) Prevents water and polluted water from entering into stream.
g) Maintains traction while wet
h) Reduced surface temperatures, minimizes the Urban Heat Island Effect.

V. APPLICATIONS

a) Porous concrete in European countries is used for casting-place load bearing walls in houses, multi-storey and high-rise buildings as prefabricated panels and steam cured blocks.
b) Water and Power resources services in America successfully tested the use of drains and drain tiles constructed from porous concrete beneath hydraulic structures.
c) The reduced runoff eliminates the problems of downstream flooding caused by traditional impervious concrete surfaces.
d) Water and Power resources services in America successfully tested the use of drains and drain tiles constructed from porous concrete beneath hydraulic structures.
e) porous concrete has had numerous useful non-pavement applications including buildings, tennis courts, drains &drain tiles, floors in greenhouses, slope stabilization, swimming pools decks, zoo areas etc.
f) Pervious Concrete as a Road pavement Low-volume pavements Sidewalks and pathways Residential roads and driveways Parking lots Noise barriers Slope stabilization Hydraulic structures Swimming pool decks Tennis courts.
g) The use of porous concrete in parking lots helped in controlling water runoff
h) The majority of porous concrete applications are parking lots, sidewalks, pathways, parks, shoulders, drains, noisebarriers, friction course for highway pavements, permeable based under a normal concrete pavement and low volume roads.
i) Because water is allowed to percolate into the ground, nearby vegetation is watered &reduces irrigation needs, groundwater is recharged & storm water runoff is reduced.

VI. POROUS CONCRETE'S CHARACTERISTICS

A type of concrete called porous concrete is made to let water travel through it. It is created by lowering the proportion of fine aggregate and raising the proportion of big aggregate. A common range for the porosity of the finished concrete is between 15% and 25%. Concrete can have connected or disconnected voids. Unconnected voids can store water whereas connected voids allow water to flow through the concrete. By changing the mix design, porous concrete's qualities can be tailored to fit particular project needs.
There are various advantages to using porous concrete as an alternative drainage method. Porous concrete lessens runoff, which can assist in preventing flash flooding and minimising erosion. By removing impurities from the water as it flows through the concrete, it also raises the quality of the water. Furthermore, porous concrete can lessen the quantity of heat absorbed by the pavement, hence minimising the urban heat island effect.

VII. THE LIMITATIONS OF POROUS CONCRETE

The use of porous concrete as an alternative drainage system has several limitations. Heavy traffic regions should not utilise porous concrete since the constant weight of the cars may cause the concrete to distort and lose some of its porosity. Additionally, porous concrete's specialised mix composition and installation procedure might make it more expensive than regular concrete.
Porous concrete is a type of concrete that has a high porosity, which allows water to pass through it easily. While it has several benefits, such as reducing stormwater runoff and promoting groundwater recharge, there are also some limitations to its use.
1. Durability: Porous concrete can be less durable than traditional concrete due to its porosity. The porosity can allow water and other substances to penetrate the surface, which can lead to cracking, freeze-thaw damage, and other types of deterioration.

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2. Maintenance: Porous concrete requires regular maintenance to keep it functioning properly. Debris such as leaves, dirt, and sand can clog the pores, which can reduce its permeability and cause flooding. Regular cleaning and vacuuming are necessary to keep the pores open and functioning as intended.
3. Limited Applications: Porous concrete is not suitable for all applications. It may not be appropriate for heavy traffic areas, such as parking lots or busy roadways, as the constant weight and wear can cause damage to the surface.
4. Cost: Porous concrete can be more expensive than traditional concrete due to its specialized mix and installation process. This can make it less feasible for some construction projects.
5. Colour and appearance: Porous concrete can have a different appearance than traditional concrete due to its texture and colour. Some people may find it less aesthetically pleasing than traditional concrete.
Overall, while porous concrete has many benefits, it is not a perfect solution for every construction project. Its limitations should be carefully considered before it is selected as the material of choice.

VIII. CONCLUSION

Stormwater management in urban areas may be made more sustainable by using porous concrete as an alternative drainage method. Porous concrete lessens runoff, enhances water quality, and aids in lowering the impact of the urban heat island. The use of pervious concrete has increased significantly in thelast several years, perhaps largely because it is considered anenvironmentally friendly, sustainable product.The use of pervious concrete provides a number of benefits,most notably in the effective management of storm waterrunoff.Other significant benefits include reducing contaminants inwaterways, recharging groundwater supplies, reducing heatisland effects, and reducing pavement–tire noise emissions.Still, there are a number of areas that need additionaldevelopmental work to improve or enhance the capabilities ofpervious concrete pavements.One area is the continued monitoring of the performance ofpervious concrete so that long-term performance trends can bedocumented.This will also help in evaluating the suitability of perviousconcrete for other applications, such as overlays.conventional concrete is not generally applicable to perviousconcrete.

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