Performance of Pervious Concrete in pavement Layer: A Review

Utkarsh Upadhyay[1], Shivam Yadav[2], Praveen Yadav[3]
[1, 2] Dept of Civil Engineering
[3]Assistant Professor, Dept of Civil Engineering
[1, 2, 3] Bansal Institute of Engineering and Technology Lucknow. India

Abstract- *At many projects water logging at highway and parking is a major issue during monsoon as pavement and floor are normally impermeable. A relatively recent idea in urban road building is pervious concrete, which allows water from sources such as precipitation to pass through directly, minimising runoff from a location. Its capacity to decrease storm water runoff while storing rainwater. This essay provided a thorough explanation of the usage of pervious concrete as a paving medium. This review paper's goal was to analyse in depth the different sustainability advantages that pervious concrete (PC) offers while also presenting the state of the art in terms of its mechanical and hydrological properties. The methods currently used for mix design as well as the effects of additives and recycled materials on PC behaviour have been covered. A remark was made on existing rehabilitation strategies for recovering the infiltration rate of blocked PC surface courses after the impact of pore shape on permeability was evaluated. Pervious concrete pavements (PCP) design, construction, and performance monitoring field investigations were highlighted. Additionally, a summary of PCP's contribution to lessening the environmental effects of developed infrastructure was provided.PCP is a potential material for the building of environmentally friendly PC highways because to its many advantages, including runoff mitigation, heat relief, energy conservation, and emissions reduction.*

However, there is still a significant opportunity to improve the material's properties in order to create sustainable paving systems for metropolitan built environments. Utilizing pervious concrete has various benefits, and it differs from typical conventional concrete in a few ways.

Keywords- Pervious concrete, water harvesting, porosity.

I. INTRODUCTION

A high percentage of impermeable surfaces, such as concrete buildings in metropolitan areas, resulting in less water penetration into the ground as a result of the rapid growth in population and massive urbanisation. The effect on the groundwater table is significant.

The use of permeable concrete can significantly reduce this problem (is also called porous concrete, Permeable concrete and no-fine concrete). High-porosity concrete is a unique kind of concrete used in flat work applications that allows water from precipitation and other sources to pass through directly, minimising runoff from a site and replenishing ground water tables. The Sponge City Construction Technology Guide is made available by the People's Republic of China's Ministry of Housing and Urban-Rural Construction starting in October 2014. In Britain in 1824, pervious concrete was first developed. Midway through the 1970s saw its initial introduction into the United States, and it has since developed quickly. In pervious concrete, a paste made of carefully measured amounts of water and cement components forms a thick shell surrounding aggregate. Because there is little to no sand in pervious concrete, there is a significant amount of vacuum space. It is made up of water, cement aggregate, and a portion of the aggregate. Pervious concrete has many interconnected voids with a high degree of porosity and permeability for rapid drainage. The permeable concrete pavement made of hardened concrete often achieves void spaces of 15% to 30%. Pervious concrete is a relatively recent idea for rural road pavement because it allows water to flow through it. Pervious concrete is an eco-friendly building material that is used in parking lots, low-traffic areas, residential streets, pedestrian walkways, and green homes. The Environmental Protection Agency (EPA) has designated it as a Best Management Practice (BMP) for storm water management.

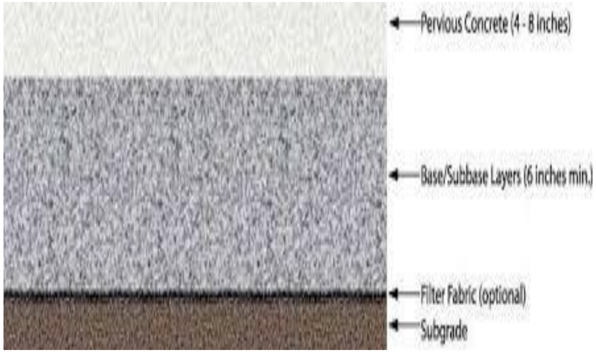

Figure1. Typical pervious concrete pavement section adopted from EPA2015

Figure.2 Source-Google

Air and water are unable to reach the roots of green plants and vegetation because of impermeable pavement, walkways, and landscaping, which hinders their growth. In order to determine if permeable concrete may be used to build road pavement, it must first be determined whether it is suitable for such usage. Permeable concrete is an efficient way to address critical environmental issues and encourage green and sustainable growth. The slump test and compacting factor tests were used to measure the qualities of new concrete. Hardened concrete was also tested for compressive strength and indirect tensile strength. Following that, comparisons between the two types of concrete are made. In Europe, permeable concrete pavement has been used for more than 15 years, while it has been used in Florida and other south-eastern states for more than 25 years. In addition to helping to reduce the urban heat island effect, pervious concrete pavement is a sustainable building material that will last for more than 30 years with little maintenance at a low life cycle cost. Pervious pavement has four benefits.

1. Less need for curved storm and sewage systems.
2. Water treatment by pollution removal.
3. It is ideal for enabling automobiles to maintain appropriate grip without dozing off.
4. Pervious concrete's permeability increases road safety for motorists
5. Lessens the chance of floods and topsoil erosion.
6. Pervious concrete is appropriate for flat locations because drainage gradients may be created with less grading.

Figure1 illustrates the benefits of pervious concrete over traditional cement-based concrete. Pervious concrete has various benefits, including the ability to recharge nearby aquifers and reduce the need for curbs and storm sewers. The relatively open-pore structure of pervious concrete stores less heat and makes it lighter, which is another significant advantage in India as compared to western countries due to the significantly lower cost of labour. Light-coloured concrete pavement also absorbs less heat from solar radiation than darker pavement. Much of the pervious concrete constructions is manual and can be done without heavy equipment and therefore pervious concrete can be placed at lower cost even in rural areas. A warning is that air burn dust is more common in India, which might cause pervious concrete to get clogged. Although some amount of clogging and maintenance-free operation of pervious concrete are both possible, routine preventative maintenance is nevertheless advised. This research compares the contractile characteristics of various pore-free sand permeable concrete and regular concrete, focusing on the relationship and correlation between the mechanical properties of eco-permeable concrete. In order to improve the ecological performance of pervious concrete, the single-factors test is adopted to determine the mechanical properties Such as compressive strength, flexural strength, strength splitting of the eco-permeable concrete specimens in different porosity. Through extensive testing and analysis, preliminary conclusions where drown, which provide a reference for improving the performance of high-performance eco-permeable concrete

Figure. 3 Source-Google

II. LITERATURE REVIEW

2.1Research significances

Studies on pervious concrete (PC) have mostly concentrated on how to improve its drainage performance and porosity, which has led to the usage of single-sized particles. The mix design process involves modifying the paste volume until the desired permeability is attained for a particular aggregate gradation. Several trails could be necessary before reaching the desired property. To make designing a PC with specific qualities easier, a method based on packing density of aggregate is used.

M.UmaMaguesvari and V.L. Narasimha, (2013) When we looked into this, we discovered that they had research on how the mix fraction of concrete affected the characteristics of pervious concrete. The angularity number is the sole basis for this experiment. Total voids compressive strength, flexural strength, split tensile strength, porosity, and abrasion resistance are the properties that are examined in this test.With increasing angularity and decreasing angularity, the total number of voids in pervious concrete both increase and decrease. As the amount of fine aggregate increases, voids become less prevalent.According to the curing times, characteristics including compressive strength, flexural strength, and split tensile strength are supplied. As the amount of fine aggregate increases, the compressive strength of pervious concrete decreases as the amount of coarse aggregate increases. This is brought on by an increase in contact surface area, which decreases as aggregate size increases. The average rise in compressive strength from a curing period of 7 to 28 days was found to be 27%. Similarly, when the curing duration is between 28 and 56 days, the compressive strength would improve by 24%. All of this led us to the conclusion that the pervious concrete's compressive strength falls.The size of the aggregate affects the permeability of pervious concrete. The permeability of the concrete decreases as aggregate size decreases, hence it will also decrease as the amount of fine aggregate utilised in the concrete increases. Evidently, it has been discovered that permeability is extremely consistent with angularity number and that permeability decreases as angularity number increases. Abrasion is a crucial component of the tile abrasion test result for pavement abrasion resistance. The results demonstrate that the percentage increases as the angularity number decreases and reveal that there is no meaningful relationship between the angularity number and abrasion resistance.

K Nagababu(2015) In this study, we examine pervious concrete, a type of high-porosity concrete used in flat work applications that allows water from precipitation and other sources to pass through, reducing runoff from a site. Its void content ranges from 18 to 35%, and its compressive strength ranges from 3 to 28 MPa (28 to 281 kg/cm^2), according to the study. The infiltration rate of pervious concrete will be between 720 litres per minute per square metre. A renewed interest in pervious concrete reflects a focus on environmentally friendly building practises. due to its advantages in preventing pollution and regulating storm water runoff. The comparatively open pore structure of pervious concrete retains less heat, reducing the impact of heat islands in metropolitan areas, while the light colour of concrete pavements absorbs less heat from solar radiation than darker pavement. Cementous materials like Ordinary Portland Cement 53 grade (IS-12269.1989) and PPC (IS1489: Part 1 1991) may be used in pervious concrete, along with other cementations materials including fly ash, pozzolana, GGBS, silica fume, and others. According to IS 383:1970, the most common coarse aggregate consists of fragments with sizes between 12.5 mm and 2.36 mm and 20 mm to 4.75 mm. The specific gravity and crushing value of coarse aggregate are 2.7 and 20,50%, respectively. It should be mentioned that controlling water is crucial in the formulations for pervious concrete. About 0.27 to 0.30 is the water cement ratio. Retarding or hydration stabilising admixture, air interning admixture, and other admixtures are commonly utilised. Unit weight of pervious concrete mixture is approximately 70% of traditional concrete mixture; density is typically between 1600 kg/m^3 and 2000 kg/m^3; these concrete mixtures can develop compressive strength in the range of 3.5 MPa to 28 MPa which is suitable for a wider range of applications; and flexural strength of pervious concrete is approximately 80% of traditional concrete mixture. To calculate porosity, permeability, compressive strength, and failure load, certain formulae are utilised.

Determination of porosity

$$Vr = [[1 - \frac{(W1 - W2)}{\rho w}] \times Volume] \times 100$$

Determination of permeability

$$K = \left(\frac{aL}{At}\right) \log\left(\frac{h2}{h1}\right)$$

Determination of compressive strength

7days $y = 0.021X_2 + 0.011x + 7.643$

28days $y = 0.024X_2 + 0.026x + 11.19$

Failure load

$y = 5.603X^3 + 143x + 1135$

Haojie Liu &Rentai Liu (2018): The first phase in the economy's swift expansion is that organisations have grown quickly and continuously made land disappear. The country's impervious surfaces, like marble cement and asphalt, become harder when the permeability of the soil naturally changes. This leads to environmental issues, drainage runoff, and other issues, like the Songhva River in 2005 due to the hasty formation of traditional urban construction methods. In this US study, the compressive strength of pervious concrete might reach 28 MPa in 1979.

The following steps are used in the author's experiment to prepare pervious concrete: (1) Test materials are ready (2) First aggregate and 70% water are added to mix for 1 minute, and admixture and 50% cementitious materials are added to mix at time 1 minute (3) Remaining cementing material and water are at mix to minute (4) The pervious concrete is mooted.(5)When the compressive strength and flexural strength of pervious concrete within 5% SF is obviously improved compare to the pervious concrete without SF, it can be seen from the standard curing test at 20+1'C temperature at relative humidity 95% and the aggregate diameter of 4.75mm-9.5mm &aggregate-cement ratio. The compressive strength of the pervious concrete reached 32.1MPa and the flexural strength reached 4.5MPa within0.5%Superplasticizer and 5%SilicaFume, indicating that the strength of the pervious concrete may continue to rise when 0.5% SP or more water is added. SF may enhance the microstructure of hardened cement paste by filling the harden hole in the cement paste and reacting with the concrete, however as the proportion of SF increases to10% the strength compares decreases. Compressive strength, flexural strength, and permeability coefficient all rise when the water-to-cement ratio reaches 0.28. They start to decline when the water cement ratio exceeds 0.28. Cementitious material is not used in the region because it results in poor fluidity since the water-cement ratio there is relatively low. Increased aggregate cement content reduces the need for cementitious material, thinned aggregate surfaces have less adhesive force,it is because this pervious concrete has far better corrosion and abrasion resistance than regular pervious concrete, and because the corrosion resistance of the sulphate in this concrete is higher than the corrosion resistance of chloride.

Sujeet Kumar shah(2018): Numerous features of pervious concrete were the subject of the thorough investigation. He funded many locations around the US that have pervious concrete paving systems in one research. This study looked at how pervious concrete open structures performed and behaved in the climate of India. This paper's primary goal is to investigate how pervious concrete performs in open structures. It also examines how pervious concrete's effects on fine aggregate, water cement ratio admixture, and conventional concrete's strength qualities. By allowing rain to permeate, porous concrete pavement systems can provide an effective storm water management technique in retention areas. They can also lower ground water levels and improve aquifer recharge. According to ASTM D2434, the compressive strength test, split tensile strength, flexural strength, and permeability test should all be conducted. The results of these tests range from 3.23 N/mm^2 to 29.5 N/mm^2 for compressive strength and from 1.8 N/mm^2 to 3.6 N/mm^2 for flexural strength. Similar results are found for split tensile strength and coefficients of permeability, which range from 0.28 cm/sec to 1.5 cm/sec and 0.62 N/mm^2 to 3.11 N/mm^2, respectively. The effects of sand and fibre addition together with the influence of water cement, superplasticizers, and cement-admixture ratio magnitude relation were assessed, and the observed quantity of fibre in fixes had a significant impact on strength and permeability. For instance, compressive strength increases with an increase in fibre up to 1% of the cement's weight, but when fibre is increased further, its values decline. Based on these findings, it can be said that sample M5, which contains 1% fibre, has better strength and permeability than samples M2,M3,M4,M6,M7, and M8.Similar to this, it was discovered that the addition of sand was directly proportional to the compressive strength of pervious concrete but inversely proportional to permeability, i.e., samples M1 and M2 without sand showed poor strength but gave good permeability after analysing all the results maintained in the graph, it showed that which decrease in w/c ratio, strength of pervious concrete increased, i.e., sample M1to M4 bearing water cement ratio of 0.32. M1 to M4>M5&M6M7&M8, as opposed to M1 to M4>M5&M6M7&M8 for permeability.

III. CONCLUSION

1. Fibres in pervious concrete increases its adaptability.

2. Ratios of cement to water and cement to aggregate effect over the permeability and strength of pervious concrete. Concrete made of pervious materials will be stronger thanks to aggregate. For maximum strength and permeability coefficient, there is a preferred water to cement ratio. Concrete made of pervious materials will be stronger thanks to aggregate.
3. The permeability coefficient is low, the aggregate-cement ratio is low, and the strength of pervious concrete is high. In this study, we discovered that using lightweight aggregate, such as ECAS seashells, is a great way to create pervious concrete with mechanical permeability.

REFERENCES

[1] Malhotra, V.M 1976 “Permeable Concrete – Its properties and Applications”, Journal of American Concrete Institute.Vol73.No11.pp 628-644.
[2] Abadjieva, T&Sephiri,P. “Investigations on some Properties of Permeable Concrete”
[3] M.Uma Maguesvari and V.L. Narasimha “Studies on characterization of pervious concrete for pavement application”
[4] Sujeet Kumar shah 2018 “Experimental Study on behavior of Pervious Concrete in Strength and Permeability by Changing Different Parameters”
[5] Haojie Liu et al 2018 “Experimental study onthe performance of pervious concrete”
[6] http://www.ijettjournal.org