International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 03 | Mar 2019 www.irjet.net p-ISSN: 2395-0072

A REVIEW ON PERVIOUS CONCRETE

VR. BHARANIDHARAN[1], K. ASHOK KUMAR[2], M. SAMUEL THANARAJ[3]

[1]PG Student Construction Engineering & Management, Nehru Institute of Technology
[2,3]Assistant Professor, Civil Department, Nehru Institute of Technology, Coimbatore, Tamilnadu, India

---

Abstract – *Pervious concrete is a zero-slump, open graded material consisting of hydraulic cement, coarse aggregate, admixtures and water. Because pervious concrete contains little or no fine aggregates such as sand, it is sometimes referred to as "no-fines" concrete. It is a special type of concrete having a high void content of about 30%, is becoming popular nowadays due to its potential to reduce the runoff to the drainage systems. Pervious Concrete is used to allow water to intentionally pass through the surface of a pavement and allow storm water to eventually absorb back into the surrounding soils. In this paper a comparative study is conducted between the density, infiltration and strength of pervious concrete with different mixes including conventional concrete and concrete with varying fine aggregate proportions.*

Key Words: — zero-slump, no-fines, drainage, storm water, pavement

1. INTRODUCTION

Pervious concrete (also called porous concrete, permeable concrete, no fines concrete and porous pavement) is a special type of and other sources to pass directly through, thereby reducing the runoff from a site concrete with a high porosity used for concrete flatwork applications that allows water from precipitation and allowing groundwater recharge.

Pervious concrete is made using large aggregates with little to no fine aggregates. The concrete paste then coats the aggregates and allows water to pass through the concrete slab. Pervious concrete is traditionally used in parking areas, areas with light traffic, residential streets, pedestrian walkways, and greenhouses. It is an important application for sustainable construction and is one of many low impact development techniques used by builders to protect water quality.

The proper utilization of pervious concrete is a recognized Best Management Practice by the U.S. Environmental Protection Agency (EPA) for providing first flush pollution control and stormwater management. As regulations further limit stormwater runoff, it is becoming more expensive for property owners to develop real estate, due to the size and expense of the necessary drainage systems. Pervious concrete lowers the sites SCS Curve Number by retaining stormwater on site. This allows the planner/designer to achieve pre-development stormwater goals for pavement intense projects. Pervious concrete reduces the runoff from paved areas, which reduces the need for separate stormwater retention ponds and allows the use of smaller capacity storm sewers. This allows property owners to develop a larger area of available property at a lower cost. Pervious concrete also naturally filters storm water and can reduce pollutant load entering into streams, ponds and rivers.

Pervious concrete functions like a storm water infiltration basin and allows the storm water to infiltrate the soil over a large area, thus facilitating recharge of preciousgroundwater supplies locally. All of these benefits lead to more effective land use. Pervious concrete can also reduce the impact of development on trees. A pervious concrete pavement allows the transfer of both water and air to root systems allowing trees to flourish even in highly developed areas.

2. LITERATURE REVIEW

M. Aamer Rafique Bhutta a, K. Tsuruta b, J. Mirza was studied on topic of Evaluation of high- performance porous concrete properties. The aim of this laboratory study was to evaluate the properties of high performance porous concrete. Tests carried out on this concrete were: slump, slump-flow, void ratio, and coefficient of permeability, compressive and flexural strengths, and strength development rate. Furthermore, a test was proposed to determine the effects of high water-reducing and thickening (cohesive) agents on self-compaction of high performance porous concrete. It was meant to evaluate its hardened properties from the viewpoint of practical application. Use of combination of SP and cohesive agent could produce acceptable HPPC with good workability and strength properties. The addition of cohesive agent to HPPC mixture could decrease the total void ratio and permeability and significantly increase the compressive and flexural strengths. Regardless of types of porous concrete and aggregate size, results showed an almost linear relationship between the compressive strength and total void ratio, and between coefficient of permeability and total void ratio for all porous concretes in the range of 15–30% total void ratio. Apparent density, compaction, total void ratio, coefficient of permeability and compressive strength of HPPC are significantly influenced by developing new freely dropping method. The evaluation of workability of HPPC by this method is successfully determined. The apparent density, taken at different positions, is almost the same and showed compaction index more than 80%. The permeability of HPPC by freely dropping method is acceptable. However, HPPC when made with different aggregate sizes, exhibited different permeability values.

Y. Aoki*, R. Sri Ravindrarajah and H. Khabbaz carried out study on Properties of pervious concrete containing fly ash. In this paper, the findings of an experimental investigation on properties of pervious concrete are reported and discussed. The amount of general purpose Portland cement has been reduced by introducing fly ash as a cementitious agent in pervious concrete samples. The properties of various pervious concrete samples including density, porosity, compressive strength, water permeability and drying shrinkage have been carefully measured. In addition, the relationships among these properties are explored. Properties include density, porosity, 7-day and 28-day compressive strengths and permeability of samples at three different water heads. The density of pervious concrete is approximately 1800 kg/m3. No significant difference in the density is induced by changing aggregate grading or amount of cement replacement with fly ash. The results indicate an acceptable trend as the porosity of pervious concrete decreased with an increase in density. With the density of pervious concrete between 1700 kg/m3 and slightly higher than 1900 kg/m3, the range of porosity is from 0.20 to 0.40. The compressive strength of pervious concrete increased with an increase of density. The compressive strength improved from 8 MPa to 12 MPa, when the density increased by 100 kg/m3. The effect of density on the water permeability coefficient of pervious concrete. When the density increased, the water permeability decreased significantly. The water permeability dropped from 20mm/s with a density of around 1750 kg/m3 to 10mm/s with a density of over 1900 kg/m3. Due to using low calcium fly ash, the long-term effect should be investigated as well as the methodology of curing.

Anush K. Chandrappa, Krishna Prapoorna Biligiri did research on pervious concrete as a sustainable pavement material – Research findings and future prospects. This paper reviews the developments and state-of-the-art pertinent to pervious concrete research and practices. The investigations on mechanical-hydrological-durability properties ofpervious concrete performed in various studies have been reviewed. The use of pervious concrete in low-volume road applications has been attracting urban developers and contractors due to its various benefits. A review has been made on rehabilitation techniques to increase the hydraulic efficiency of pervious concrete pavements. This paper reviewed the current state-of-the-art corresponding to key mechanical and hydrological properties of pervious concrete pavement material. The main objective of this paper was to introduce the reader with the importance of pervious concrete and its benefits in the context of urbanization. The paper has discussed various properties of pervious concrete such as mechanical, hydrological, durability, field performance, environmental and cost-benefits aspects. Based on the previous studies, it was found that there exist several research gaps in the subject area, as indicatedin the future scope of research. These gaps if considered and studied can help in the overall improvement of the understanding of the material and lead to the development and implementation of design standards for pervious concrete pavements. Overall, the past studies indicated that pervious concrete mix is a very promising candidate to be used as a pavement material in low-volume roads such as local streets, pedestrian walkways and driveways, and possibly inarterials and highways in future if mechanistic-based design procedures are developed.

Qiao Dong; Hao Wu,; Baoshan Huang, Xiang Shu,; and Kejin Wang, done an Investigation into Laboratory Abrasion Test Methods for Pervious Concrete. In this study, three laboratory abrasion test methods were investigated for their potential capability of evaluating the abrasion and raveling resistance of PCPC. The three tests are the Cantabro test, the loaded wheel abrasion test, and the surface abrasion test. To evaluate the three test methods, eight PCPC mixtures containing different sizes of coarse aggregates and additives were tested. The comparison of the three abrasion tests indicates that all three tests were fairly effective in differentiating between the PCPC mixtures. However, the results from the Cantabro test may not reflect the abrasion resistance of the mixtures because the failure of the specimens was caused by impact rather than abrasion. With studded wheels and increased wheel load, the loaded wheel abrasion test exhibited best sensitivity and sufficient repeatability. The surface abrasion test successfully differentiated the control mix from other mixtures, but failed to differentiate between the mixtures containing latex and/or fiber, which may be attributed to the unfavorably low weight loss values from this test. The Cantabro, loaded wheel, and surface abrasion tests were evaluated and compared. Eight PCPC mixtures containing different sizes of coarse aggregate and different additives (latex and fiber) were tested for the evaluation. From the results of this study, the following can be concluded:

1. The loaded wheel abrasion test had the best sensitivity and sufficient repeatability among the three tests. The studded steel wheels and high wheel load were effective in improving the level of abrasion for this test.

2. The surface abrasion test was effective in differentiating the control mix from other mixtures. However, modification of the test or test samples is needed to produce more abrasion that would provide higher possibility of differentiating between mixtures containing fibre and/or latex. It is suggested that a longer test period and/or larger abraded area be used in this test to increase its test severity and enhance its effectiveness.

3. The Cantabro test had fairly good sensitivity and repeatability. However, it also gave high values of weight loss and was not so effective in evaluating of the abrasion resistance of PCPC. This is because the specimen damage was caused by impact instead of abrasion in this test. It is recommended that fewer revolutions be used for this test as a potential way to improve its capability.

R. Sriravindrarajah, H.M. Do & L. D. Nguyen & Y.Aoki discussed the Effect of Clogging on the Water Permeability of Pervious Concrete. This paper discusses the results of an experimental investigation into the effect of pore structure clogging and compaction on the water permeability of pervious concrete. The water permeability of pervious concrete was studied under falling head. The results showed that the clayey materials presence in the percolating water had seriously reduced the water permeability of pervious concrete. The effects of compaction and clogging on the water permeability of pervious concrete were investigated. The clogging of pores was achieved by using varying quantities of clayey materials in percolating water though pervious concrete under falling head method. The following conclusions are made from this study:

1. Compaction must not be carried out when placing of pervious concrete pavements, since it seriously damage the water permeability of pervious concrete.

2. Un-compacted pervious concrete, with 50% cement replacement with fly ash, was produced with 7-day compressive strength of 6.9MPa and the water permeability of 12.5 mm/s. The pores clogging has been proved a serious problem in maintaining its water permeability in service.

3. High pressure water cleaning is found to be a reasonable maintenance approach to restore the water permeability of pervious concrete. There is no period after the "et" in the Latin abbreviation "et al..

John T. Kevern, Vernon R. Schaefer, and Kejin Wang studied on Temperature Behaviour of Pervious Concrete Systems. To quantify the temperature behaviour of a pervious concrete system, a fully monitored parking lot— composed of half traditional concrete and half PCPC—was constructed at Iowa State University as part of the Iowa Pervious Concrete Stormwater Project. Sensors were installed through the profile of both pavements and into the underlying soil. The results show that insulation from the aggregate base underneath the pervious concrete substantially delays the formation of a frost layer and permeability is restored when melt water is present. It was also observed that in direct sunlight, the pervious pavement became hotter than traditional concrete, whereas the daily low temperature of the two was similar, indicating less heat storage capacity in the pervious concrete.

1. Air in the aggregate base underneath the pervious concrete acts as an insulating layer that, coupled with the higher latent heat associated with the higher soil moisture content, delays or eliminates the formation of a frost layer under the pervious concrete while maintaining permeability.

2. Even when the air temperature is well below freezing, the temperature at midheight in the pervious concrete is much warmer. This finding suggests that the surface was even warmer yet and may have been above freezing when the air temperature was too low for traditional deicers to function.

3. Thawing of the pervious concrete system is much faster than that of the corresponding traditional system. Thaw under the traditional PCC pavement occurred over a month after that for the PCPC system. The maximum temperature differential between the pervious pavement and the air temperature occurs in the warmest conditions.

4. The maximum temperature differential between the pervious and traditional pavements occurred during moderate conditions. The pervious concrete experienced a more rapid rate of heating and cooling than did the traditional concrete. Daily low temperatures of the pervious concrete were always equal to or cooler than those of the traditional concrete.

Muhannad T. Suleiman,; Lusu Ni, and Anne Raich, has done a Development of Pervious Concrete Pile Ground-Improvement Alternative and Behavior under Vertical Loading. This research effort aims to develop a new ground-improvement method using pervious concrete piles. Pervious concrete piles provide higher stiffness and strength that are independent of surrounding soil confinement while offering permeability comparable to granular columns. This proposed ground-improvement method can improve the performance of different structures supported on poor soils. To achieve the goal of the research project, four verticalload tests were performed on one granular column and three pervious concrete piles. In this paper, the material properties of pervious concrete, the developed installation method, and the vertical load response of pervious concrete and aggregate piles are presented, and the variation of soil stresses and displacement during pile installation are briefly discussed. A new ground-improvement method has been developed using pervious concrete piles. This paper summarizes the material properties of the pervious concrete and the response of four different vertical load tests performed using the SSI facility. Initially, Test Unit 1 (granular column) and Test Unit 2 (pervious concrete pile) were installed to investigate the effectiveness of the designed laboratory installation method and to compare the vertical load displacement response of the granular column to that of the pervious concrete pile. Then, two instrumented vertical load tests were performed on a precast pervious concrete pile (Test Unit 3) and an installed previous concrete pile (Test Unit 4) to evaluate the effects of the installation method on the soil-pile interaction. Although the testing program focuses on piles installed in loose sand, pervious concrete piles can be used in different soil types, including very soft clays, and peat and organic soils. Based on the experimental results obtained from the four vertical load tests and the discussion of the results presented in this paper, the following conclusions were made:

1. Pervious concrete piles have a compressive strength that is more than 10 times that of granular columns, while providing similar permeability to granular columns.

2. The pervious concrete pile (Test Unit 2), which had the same dimensions, aggregate type, and installation method as the granular column (Test Unit 1), had an ultimate load that was 4.4 times greater than the ultimate load of the granular column. Furthermore, the pervious concrete pile failed by vertically punching into the soil at the pile tip, whereas the granular column failed by bulging outward into the surrounding soil.

3. The installation method had significant effects on the response of the pervious concrete piles. When comparing the response of the two pervious concrete piles installed using different methods [precast pile (Test Unit 3) and installed pile (Test Unit4)], the ultimate load of the installed pile was 2.6 times greater than the ultimate load of the precast pile.

4. Installation of the pervious concrete pile resulted in an increase of the maximum frictional stress transferred at the soil-pile interface. The ratio of the maximum frictional stress calculated using the strain gauges for the installed pile compared with the precast pile ranged from 2.5–5.3.

5. The lateral soil displacements measured at a distance of 1D from the pile center during installation were not uniform along the length of the pile. The installation of the pile also resulted in significant increases of the soil vertical stress and a smaller increase of the soil horizontal stress. The measured change of the vertical and horizontal soil stresses showed trends similar to those reported in the literature.

Hao Wu, Zhuo Liu, Beibei Sun, Jian Yin carried a research on Experimental investigation on freeze–thaw durability of Portland cement pervious concrete (PCPC). Laboratory tests were conducted to evaluate the performance of Portland cement pervious concrete (PCPC) with a particular focus on freeze–thaw durability. The admixtures and modifiers such as airentraining agent (AEA), ethylene- vinyl acetate (EVA) latex, and polypropylene (PP) fibers were considered in various mixtures to explore their influences on the performances of PCPC. In order to address the different behaviors of PCPC produced in field and laboratory, field specimens cored from experimental pavement sections were compared to the specimens molded in the laboratory, and appropriate quantification indicators were proposed in the study for the comparison. The test results showed that even with high porosities, a proper content of AEA added in the PCPC mixture could still improve its strength and increase its freeze–thaw durability to some extent. The mixture with latex modified could achieve much higher strength and better freeze–thaw durability due to the enhancement of interfacial bonding on the cementitious matrix. Apparent improvements on tensile strength and freeze–thaw durability were also observed for the mixture reinforced by PP fibers with various nominal lengths. In addition, the analysis of the relationship between field and laboratory produced PCPC showed that the pervious pavement paved in the actual field usually presented inferior overall mechanical performances than the PCPC produced in the laboratory, especially on the freeze–thaw durability. Therefore, a reduction coefficient should be considered when design a PCPC pavement and predict its performance with the standard laboratory methods that commonly used for ordinary concrete. Mechanical and freeze–thaw tests were carried out on both field and laboratory produced PCPC to investigate their fundamental properties and freeze–thaw durability. Based on the testing results, the following conclusions can be derived:

1) Fast freeze–thaw test was valid to evaluate the durability of PCPC under cold climate. The testing results showed that even with high porosity the PCPC could still subject to severe freeze–thaw damages under special conditions.

2) On account of improving the bonding strength of cementitious matrix, the latex-modified PCPC mixtures could achieve overall better mechanical performances than the mixtures without latex modified. The polypropylene fibers with various lengths (from 3 mm to 12 mm) showed observable reinforcement effects on the tensile strength and freeze–thaw durability of the PCPC mixture. A proper incorporating content of AEA could increase the compactability and uniformity of the PCPC mixture, and thus enhancing its freeze–thaw durability to some extent.

3) There were strong relationships existed between strength and freeze–thaw durability of PCPC, which indicates that the PCPC mixture with relatively higher strength usually exhibits better durability. In addition, the tensile strength was found had more significant and direct influences on the freeze– thaw durability of PCPC than that of compressive strength.

It was confirmed that, under similar curing conditions, PCPC specimens molded in the laboratory usually presented better uniformity, higher strength and superior freeze–thaw durability than the specimens cored from the actual pavement. Therefore discrepancies should be considered when design or evaluate a PCPC pavement using laboratory methods.

Jing Yang*, Guoliang Jiang done an Experimental study on properties of pervious concrete pavement materials. In this paper, a pervious concrete pavement material used for roadway is introduced. Using the common material and method, the strength of the pervious concrete is low. Using smaller sized aggregate, silica fume

(SF), and superplasticizer (SP) in the pervious concrete can enhance the strength of pervious concrete greatly. The pervious pavement materials that composed of a surface layer and a base layer were made. The compressive strength of the composite can reach 50 MPa and the flexural strength 6 MPa. The water penetration, abrasion resistance, and freezing and thawing durability of the materials are also very good. It can be applied to both the footpath and the vehicle road. It is an environment-friendly pavement material

1. Due to voids in pervious concrete, it is difficult to obtain high-strength materials by using the common material and proportion of mixture.

2. Using smaller sized aggregate can enhance the strength of the pervious concrete. However, the cement quantity must be adjusted accordingly.

3. Using SF and SP in the pervious concrete can enhance the strength of pervious concrete greatly. Controlling the pressing force to keep the unit weight of 1900–2100 kg/m3 can ensure good water penetration. The organic polymer also can enhance the strength of the pervious concrete greatly. However, it is difficult to ensure water penetration due to the polymer-filling property. Its cost is also high due to its high dosage.

4. The pervious pavement materials are composed of a surface layer and a base layer. The compressive strength of the composite can reach 50 MPa and the flexural strength 6 MPa. The water penetration, abrasion resistance, and freezing and thawing durability of the materials are also very good. It can be applied to both the footpath and the vehicle road. It is an environment-friendly pavement material.

K. C. Mahboub, Jonathan Canler, Robert Rathbone, Thomas Robl, and Blake Davis has study Pervious Concrete: Compaction and Aggregate Gradation. Pervious concrete is very different from traditional portlandcement concrete (PCC). Therefore, there are open questions regarding the suitability of the current standard concrete testing protocols as they may be applied to pervious concrete. There are unique features associated with pervious concrete that may require special testing considerations. This paper examines the compaction and consolidation of pervious concrete. This study presents cylindrical specimen preparation techniques that will produce laboratory specimens that are similar to the field pervious concrete slab. Additionally, a simple correlation is provided that allows concrete designers to estimate the porosity of pervious concrete based on its aggregate bulk density when crushed limestone is used. This practical tool saves time when designing pervious concrete mixtures. Accurately measuring the air content of pervious concrete is a challenge due to its highly porous nature. Current literature suggests that air porosity of pervious concrete should be within 18 to 35% to ensure a desirable permeability;1 however, there are no suitable AASHTO or ASTM International test methods for determination of air porosity for such a concrete. Tennessee Technological University researchers investigated this issue and conducted research for a new test method to determine pervious concrete air porosity. These researchers have investigated flexural, split-tensile, and compressive strengths of pervious concrete for pavement design inputs.

3. CONCLUSION

Pervious concrete is a cost-effective and environmental friendly solution to support sustainable construction. Its ability to capture storm water and recharge ground water while reducing storm water runoff enables pervious concrete play a significant role. Due to its potential to reduce the runoff, it is commonly used as pavement material. The smaller the size of coarse aggregate should be able to produce a higher compressive strength and at the same time produce a higher permeability rate. The mixtures with higher aggregate/cement ratio 8:1 and 10:1 are considered to be useful for a pavement that requires low compressive strength and high permeability rate. The ideal pervious concrete mix is expected to provide the maximum compressive strength, and the optimal infiltration rate. Pervious concrete is one of the leading materials used by the concrete industry as GREEN industry practices for providing pollution control, storm water management and sustainable design.

REFERENCES

[1] Y. AOKI , R. SRI RAVINDRARAJAH & H. KHABBAZ (2012) PROPERTIES OF PERVIOUS CONCRETE CONTAINING FLY ASH, ROAD MATERIALS AND PAVEMENT DESIGN, 13:1, 1-11, DOI:10.1080/14680629.2011.651834

[2] M. AAMER RAFIQUE BHUTTA A, K. TSURUTA B, J. MIRZA C, "EVALUATION OF HIGH-PERFORMANCE POROUS CONCRETE PROPERTIES" CONSTRUCTION AND BUILDING MATERIALS 31 (2012) 67–73

[3] ANUSH K. CHANDRAPPA, KRISHNA PRAPOORNA BILIGIRI "PERVIOUS CONCRETE AS A SUSTAINABLE PAVEMENT MATERIAL – RESEARCH FINDINGS AND FUTURE PROSPECTS: A STATE-OF-THE-ART REVIEW" CONSTRUCTION AND BUILDING MATERIALS 111 (2016) 262–274

[4] QIAO DONG, PH.D., A.M.ASCE1; HAO WU, PH.D.2; BAOSHAN HUANG, PH.D., P.E., M.ASCE3; XIANG SHU, PH.D., A.M.ASCE4; AND KEJIN WANG, PH.D., P.E., M.ASCE5 "INVESTIGATION INTO LABORATORY ABRASION TEST METHODS FOR PERVIOUS CONCRETE" DOI: 10.1061/(ASCE)MT.1943- 5533.0000683.

[5] R. SRIRAVINDRARAJAH, H.M. DO & L. D. NGUYEN & Y. AOKI " EFFECT OF CLOGGING ON THE WATER

PERMEABILITY OF PERVIOUS CONCRETE" HTTPS://WWW.RESEARCHGATE.NET/PUBLICATION/280864953

[6] JOHN T. KEVERN, VERNON R. SCHAEFER, AND KEJIN WANG "**TEMPERATURE BEHAVIOR OF PERVIOUS CONCRETE SYSTEMS"** TRANSPORTATION RESEARCH BOARD OF THE NATIONAL ACADEMIES, WASHINGTON,D.C., 2009, PP. 94–101. DOI: 10.3141/2098-10

[7] MUHANNAD T. SULEIMAN, A.M.ASCE1; LUSU NI, S.M.ASCE2; AND ANNE RAICH, M.ASCE3 "DEVELOPMENT OF PERVIOUS CONCRETE PILE GROUND-IMPROVEMENT ALTERNATIVE AND BEHAVIOR UNDER VERTICAL LOADING" DOI: 10.1061/(ASCE)GT.1943-5606.0001135.

[8] HAO WUA,B,⇑, ZHUO LIU A, BEIBEI SUN A, JIAN YIN C "EXPERIMENTAL INVESTIGATION ON FREEZE–THAW DURABILITY OF PORTLAND CEMENT PERVIOUS CONCRETE (PCPC)" CONSTRUCTION AND BUILDING MATERIALS 117 (2016) 63–71

[9] JING YANG*, GUOLIANG JIANG "EXPERIMENTAL STUDY ON PROPERTIES OF PERVIOUS CONCRETE PAVEMENT MATERIALS" CEMENT AND CONCRETE RESEARCH 33 (2003) 381–386

[10] K. C. MAHBOUB, JONATHAN CANLER, ROBERT RATHBONE, THOMAS ROBL, AND BLAKE DAVIS "**PERVIOUS CONCRETE: COMPACTION AND AGGREGATE GRADATION"** TITLE NO. 106-M58