

A Review on the Mechanical Properties of Pervious Concrete Pavements

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ABSTRACT- Pervious concrete is a material consisting of coarse aggregate, hydraulic cement, and water, which allows rainwater to percolate through the surface into the bottom before it runs off. This approach reduces storm water runoff volumes and minimizes the introduction of pollutants into storm water from surface areas and also helps in recharging ground water levels. The important properties of pervious concrete are its strength and water absorption. The pervious concrete can be utilized during the construction of parking areas, sidewalks and pathways, residential roads, alleys, driveways, shoulders, medians, under overpasses, bridges, swimming bath decks, slope stabilization and footpaths. By using selected aggregates, fine mineral, admixtures, organic intensifiers and by adjusting the proportion of the concrete mix, the strength and abrasion resistance of the pervious concrete can improve greatly. In this experiment, an impermeable membrane of recycled plastic is used to assist in the catchment area and helps in diversion of the water into a special catchment basin. The pervious concrete pavement (PCP) possesses many advantages that help improve the quality of our environment as follows: I. The rainwater can quickly filter into ground, thereby helping groundwater resources renew and recharge. II. As the pavement is permeable to air and water, the soil underneath these is often kept wet. III. The PCP can absorb the noise from vehicles, creating a quieter environment by reducing noise pollution. IV. The PCP can prevent splashing of water on the surface during the rains, and also doesn't glisten in the dark, thereby improving the comfort and safety of driving.

KEYWORDS: Pervious concrete pavements, compressive strength, permeability, mix design

I. INTRODUCTION

Pervious concrete (PC) is a material consisting of coarse aggregate, hydraulic cement, and water, which allows rainwater to percolate through the surface into the bottom before it runs off. Using PC reduces storm water runoff volumes and minimizes the introduction of pollutants into storm water from surface areas and also helps in recharging ground water levels. The important properties of PC are its strength and water absorption. While pervious concrete are often used for a surprising number of applications, its primary use is in pavement system. Use of PC in pavements may be a unique and an effective means to satisfy growing environmental demands. By capturing rainwater and allowing it to seep into rock bottom, this PC is instrumental in recharging groundwater, reducing storm water runoff, while also meeting the Indian storm water regulations. In fact, the use of PC is one among the basic management practices (BMP) recommended by the EPA and by other agencies including geotechnical engineers across the country for the management of storm water runoff on a regional and native basis. The pervious concrete pavement (PCP) technology creates more efficient land use by eliminating the necessity for retention ponds, swales, and other storm water management devices. In doing so, use of PC has the power to lower overall project costs on a first-cost basis.

Carefully controlled amounts of water and cementitious materials while manufacturing PC are used to create a paste that forms a thick coating around aggregate particles. A PC mixture contains little or no sand, creating a considerable void content. Using sufficient paste to coat and bind the mixture particles together creates a system of highly permeable, interconnected voids that drains quickly. Typically, between 15% and 25% voids are achieved within the hardened concrete, and flow rates for water through pervious concrete are approximately around 200L/m²/min, although they may be much higher.

PC in literature has been also mentioned as porous concrete, permeable concrete, no-fines concrete, gap-graded concrete, and enhanced-porosity concrete and has its application in constructions of pavements. When used during the construction of an environment friendly pavement it is effective in the divergence of storm water. The PC helps in retention of water and also facilitates the easy disposal / transport of water by the use of two systems namely, full infiltration and full attenuation.

Pervious concrete system has advantages over impervious concrete in that it is effective in managing run-off from paved surfaces thereby reduce flooding risk, prevent contamination in run-off water, recharge aquifer, repel salt water intrusion, control pollution in water seepage to ground water, absorb less heat than regular concrete and asphalt, reduce the need for air conditioning, prevent glare and skidding during rainy / winter season by allowing water to infiltrate freely through its pores and also reduce vehicular noise pollution.

II. LITERTATURE REVIEW

The Portland cement pervious concrete (PCPC) has a great potential to reduce roadway noise, improve splash and spray, and improve friction as a surface wearing course. A pervious concrete mix design for a surface wearing course must meet the standards of adequate strength and sturdiness under site-specific loading and environmental conditions. To date, two key issues that have impeded the utilization of pervious concrete are that strengths of pervious concrete are less than necessary for required applications and therefore the freeze-thaw durability of pervious concrete has been suspect. A search project on the freeze-thaw durability of pervious concrete mix designs at Iowa State University (ISU) has recently been completed. The results of this study have shown that a robust, durable pervious concrete mix design which will withstand wet, hard- freeze environments is feasible. The strength is achieved through the utilization of a little amount of fine aggregate (i.e., concrete sand) and/or latex admixture to reinforce the particle-to-particle bond within the mix. They have studied the environmentally friendly pervious concrete for sustainable construction. They report an experimental investigation into the, physical and engineering properties of pervious concrete having varying amount of low calcium ash because the cement replacement material. Various properties of pervious concrete were studied like porosity, unit weight, and compressive strength, weight loss on drying, free drying shrinkage and water permeability under constant head [1].

The experiment on optimizing strength and permeability and evaluating the performance of various pervious concrete mixture is an attempt to realize an optimized mix with adequate lastingness and porosity. Besides this a relationship was investigated between permeability and porosity of various mixtures [2].

The compressive strength, split tensile and flexural strength were included to study the hardened properties of pervious concrete. Concrete cubes of size 150 mm x 150 mm x 150 mm were prepared to assess the compressive strength and for flexural strength, beams of size 500 mm x 100 mm x 100 mm are prepared. The investigation was administered at an interval of seven , fourteen & twenty eight days [3].

No-fines concrete may be a sort of concrete from which the fine aggregate is completely omitted and single-sized coarse aggregates are held together by a binder consisting of a paste of Portland cement and water. The methodology and results associated with strength, mix design and water absorption and located that strength and water absorption of the pervious concrete blocks are inversely proportional to every other [4].

The study conducted to evaluate the structural performance of the PC addressed that the permeability and strength depend upon the different coarse aggregate sizes and proportions of the constituent materials. For the various aggregate / cement ratio utilized in this study, coarse aggregate size 9.375 mm had higher compressive strength values compared to those made up of 18.75 mm aggregate size, while 18.75 mm aggregate size had higher permeability values compared to that of 9.38 mm. The relative density of the aggregates sizes was 2.7. The aggregate / cement ratio of 6:1, 8:1 and 10:1 respectively were prepared to produce three different batches of fresh concrete using 18.75 mm aggregate size and same ratios were used for 9.75 mm coarse aggregate size to supply another three different batches. In each case, aggregate / cement ratio of 6:1 gave the very best compressive strength compared to other aggregate / cement ratio of 8:1 and 10:1. The very best compressive strength obtained was 8.2 N/mm^2 and 10.8 N/mm^2 respectively for 18.75mm and 9.375mm coarse aggregate sizes. It was found that the aggregate/cement ratio of 10:1 produced pervious concrete of higher co-efficient of permeability of $3.12 \times 10^{-3} \text{ cm / sec}$ and $3.89 \times 10^{-3} \text{ cm / sec}$ for aggregate size 9.375mm and 18.75mm respectively [5].

The use of pervious concrete pavements continues to grow as builders and communities move toward sustainable development. One among the environmental benefits of pervious pavements is its use in storm water management. However, without proper maintenance, pervious pavement may become clogged and that may affect its its permeability. This research addresses the following main issues that are of interest to both the staff in water management districts and therefore the concrete industry for widespread acceptance of pervious pavements, namely, the planning cross-section to make sure adequate infiltration, credit for replacement of impervious areas, and operational and maintenance issues.

The engineering properties reported in a study indicated a high void ratio, low strength, and limited freeze-thaw test results. It's believed that these reasons have hindered the utilization of PC within the hard wet freeze regions. The

standard mix design of pervious concrete used consisted of cement using single-sized coarse aggregate (25 mm - 100 mm), and water to cement ratio from 0.27 to 0.43. The 28-day compressive strength of PC ranged from 5 to 20 MPa, with a void ratio ranging from 14% to 31% and the permeability ranging from 0.025 to 0.6 cm/sec.

The benefits of pervious concrete include improving skid resistance by removing water that makes splash and spray during precipitation events, reducing noise, minimizing heat islands in large cities, preserving native ecosystems, and minimizing cost in some cases. Surface coarse pervious concrete pavement systems are reported to be extensively used in Canada, Europe and Japan. Few studies have shown that pervious concrete generally produces a quieter concrete with noise levels starting from 3% to 10% lesser than those of the normal concrete. The research conducted at ISU included studies of the materials utilized in the pervious concrete, the combination proportions and specimen preparation, the resulting strength and permeability, and the effects of freeze-thaw cycling.

A spread of aggregate sizes was tested and both limestone aggregates and river run gravels were used. The key parameters investigated were strength, permeability, and freeze-thaw resistance. It is observed that as the void ratio increases, the strength decreases while the permeability increases. Subsequent freeze-thaw tests showed that a durable mix developed by addition of a little amount of sand (5% to 7%), increased the bonding of the paste to the aggregates may be critical to obtain a mixture of PC which can provide sufficient strength, adequate permeability, and good freeze-thaw resistance.

III. CONCLUSION

By the following literature review done, it is inferred that

- Compressive strength of the pervious concrete is increased with addition of little amount of fine aggregate to increase the inter particle bond in the mix.
- Compressive strength & permeability of pervious concrete are inversely proportional to each other.
- Replacement of about 1/3rd of cement with fly ash has increased the compressive strength of the concrete.
- The permeability and strength of pervious concrete depend upon the particle sizes and proportions of the constituent materials of which the concrete is made up of.
- The various aggregate/cement ratio utilized, coarse aggregate size 9.375 mm has higher compressive strength values compared to those made up of 18.75 mm aggregate size while 18.75 mm aggregate size had higher permeability value compared thereto of 9.38 mm.
- Lower water / cement ratio is considered compared to conventional concrete due to absence of fine aggregates.
- Pervious concrete has highest efficiency of use in low load density areas.
- Pervious concrete is a unique and effective means to address important environmental issues and sustainable growth.

REFERENCES

- [1] Tennis, P., Leming, M.L., and Akers, D.J., "Pervious Concrete Pavements," EB 302, Portland Cement Association (PCA), Skokie, Illinois, pp. 25
- [2] A.L.Alaica, M.H. Dolatabadi, A. Sucic, M. Shehata, "Optimizing the strength and permeability of pervious concrete", Annual Conference of the Transportation Association of Canada, 2010
- [3] Darshan S. Shah, Jayeshkumar Pitroda, J. J. Bhavsar, "Pervious Concrete: New Era For Rural Road Pavement" International Journal of Engineering Trends and Technology , vol. 4, pp. 3495-3499, July 2013
- [4] Ghafoori, N., and Dutta, S., "Building and Non pavement Applications of No-Fines Concrete," Journal of Materials in Civil Engineering, vol. 7, pp.286-289, November 1995.
- [5] O. Ajamu, A.A. Jimoh , J.R. Oluremi, "Evaluation of structural Performance of Previous Concrete in Construction", International Journal of Engineering and Technology. Vol. 2 No. 5, May,2012



- [6] J.T. Kerven, V.R. Schaefer, Mixture proportioning considerations for improved freeze-thaw durability of pervious concrete, *J Mater Civil Eng*, 25, pp., 886–892, 2013
- [7] Leming, M.L., Rooney, M.H., and Tennis, P.D., “Hydrologic Design of Pervious Concrete,” PCA R&D Serial No. 2829 (in press), Skokie, Illinois, 2007
- [8] National Ready Mixed Concrete Association (NRMCA), Freeze Thaw Resistance of Pervious Concrete, Silver Spring, MD, May 2004.
- [9] Sri Ravindra Rajah R and Aoki Y. (2008), “Environmentally friendly porous concrete”, Proceedings of the Second International Conference on Advances in Concrete and Construction, Hyderabad, India, Feb 2008.
- [10] Dev Mani Tripathi, “An Experimental Study on Pervious Concrete (Mix-Ratio, Strength and Porous Properties)”. *International Journal of Engineering Research & Technology (IJERT)* Vol. 6 Issue 12, December – 2017