IJFEAT
INTERNATIONAL JOURNAL FOR ENGINEERING APPLICATIONS AND TECHNOLOGY

Pervious concrete

***Author**:*

Anjali Jadhav

***Co-Author**:*

Durita chaudhari

Third Year

Civil Department

S.H. Jondhale Polytechnic Dombivli [West]

Under Guidance
Ms.Darshana khare

KEYWORDS
Pervious concrete, void ratio, aggregate testing, pavement design

ABSTRACT

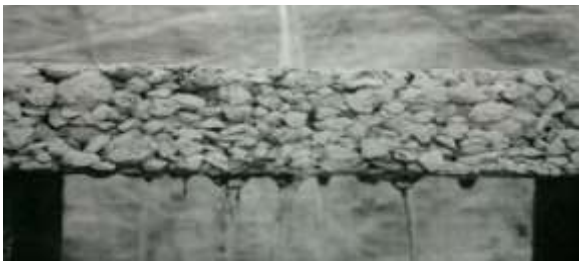
Due to tremendous development in infrastructure, major cities in India are getting covered with impermeable pavements. Concreting everywhere leads to environmental issues such as reduction in recharge of rainwater into the ground hence constant fall of water table which leads to water crisis during summer. One of the solutions is by installing Pervious Concrete pavement instead of impervious concrete for low traffic volume, low speed applications. Pervious Concrete is a low impact, environmentally friendly and sustainable paving option. Pervious Concrete is a special type of concrete obtained by the mixture of cements, water and open graded coarse aggregate. Typically it has little to no fines aggregate particle while maintaining the interconnectivity of the voids. The void content in this type of concrete is in the range of 15%to 22% compared to conventional concrete pavements. Currently, there is no accepted thickness design method for Pervious Concrete pavements in India.

In this project the compressive strength, void content and infiltration rate using various mix designs of Pervious Concrete were determined and analyzed. Considering rainfall data, traffic volume data, soil and geotechnical investigation data of a residential colony which was taken as a part of case study, the suitability of Pervious Concrete as pavement material was checked.

INTRODUCTION

As urbanization increases in India and many parts of the world the problem of water logging and requirement of drainage is also increase. This is partly due to impervious nature of the bituminous and concrete pavements. Pervious concrete which has an open cell helps significantly to provide high permeability due to its interconnected pores. Pervious concrete (also called porous concrete, permeable concrete and no fines concrete) 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 is made using large aggregates with little to no fine aggregates. Pervious concrete has been used in the united state for over 30 years. Pervious concrete was first used in the 1800s in Europe as pavement surfacing and load bearing walls. Cost efficiency was the main motive due to a decreased amount of sand. It becomes popular again in the 1920s for two story homes in Scotland and England. It became

increasingly viable in Europe after the Second World War due to the scarcity of cement. India is facing a typical problem of ground water table falling at a fast rate due to reduce recharge of rain water into subsoil and unplanned water withdrawal for agriculture and industry by pumping. NFC if adopted for construction of pavements, platform/ walkways, parking lots designed for lighter load. It can become a component of rainwater harvesting schemes being prepared by Government of India on a Priority basis. It also reduces the runoff from the pavement areas hence reduce load on drainage systems.



1.2 Properties of Pervious Concrete

1.2.1 Density and porosity

The density of pervious concrete depends on the properties and proportions of the materials used, and on the compaction proportion used in placement. In place density on the order of 1600kg/m^3 to 200 kg/m^3 are common, which is in the upper range of lightweight concretes. The porosity of pervious concrete largely depends on aggregate size.

1.2.2 Permeability

The flow rate through pervious concrete depends on the materials and placing operations Typical flow rates for water through pervious concrete are 288 in. / hr, 120L/m^2/min, or 0.2cm/s to 770 in. hr, 320L/m^2/min, or 0.54cm/s, with rates up to 1650in. /hr, 700/m^2/min,1.2cm/s and higher in having been measured in the laboratory.

1.2.3 Compressive strength

Pervious concrete mixtures can develop compressive strength in the range 3.5 MP to 28 MPa, which is suitable for a wide range of applications. Typical values are about 17MPa. As with any concrete, the properties and combinations of specific materials, as well as placement techniques and environmental conditions, will dictate the actual in-place strength.

1.2.4 Flexural strength

Flexural strength in pervious concretes generally ranges between about 1 MPa and 3.8 MPa Many factors influence the flexural strength, particularly degree of compaction, porosity, and the aggregate: cement (A/C) ratio. However, the typical application constructed with pervious concrete does not require the measurement of flexural strength for design.

1.2.4 Shrinkage

Drying shrinkage of pervious concrete develops sooner, but is much less than conventional concrete. Specific values will depend on the mixtures and materials used, the material's low paste and mortar content is a possible explanation. Roughly 50% to 80% of shrinkage occurs in the first 10 days, compared to 20% to 30% in the same period for conventional concrete. Because of this lower shrinkage and the surface texture, many pervious concretes are made without control joints and allowed to crack randomly.

1.2.5 Durability

1) Freeze-thaw resistance:

Freeze-thaw resistance of pervious concrete in the field appears to depend on the saturation. The typical deterioration of concrete exposed to freeze-thaw conditions is random cracking surface scaling. And joint deterioration due to cracking.

The first two are primarily due to lack of adequately entrained air in the concrete mass or the surface layer, respectively, and the latter phenomenon is primarily related to non-durable aggregate.

2) Sulphate resistance:

Aggressive chemicals in soils or water, such as acids and sulfates, are a concern to conventional concrete and pervious concrete alike, and the mechanisms for attack are similar. However, the open structure of pervious concrete may make it more susceptible to attack over a larger area. Pervious concrete can be used in areas of high-sulfate soils and groundwater if isolated from them. Placing the pervious concrete over a 6-in. (150-mm) layer of l-in (25-mm) maximum top size aggregate provides a pavement base, storm water strong, and isolation for the pervious concrete.

3) Abrasion resistance:

Because of the rougher surface texture and open structure of pervious concrete, abrasion and raveling of aggregate particles can be a problem, particularly where snowplows are used to clear pavements. This is one reason why applications such as highway generally are not suitable for pervious concretes.

Environmental Benefits Checklist

- Allows storm water to infiltrate into the ground to replenish ground water aquifers.
- Retains storm water so that retention ponds are not needed for parking lots.
- Keeps pavement surface dry even in wet situations, such as greenhouses.
- Allows parking lots to be ice-free in freeze/thaw areas since snow melt immediately drains off the surface.
- Allows water and air to get to the roots of trees within a parking area.
- Aerobic bacteria that develop within the pavement and base can break down oil and

remove other pollutants from the water that washes off the surface.

Light reflectivity is higher than with asphalt surfaces, reducing any heat island effects.

- Allows a project to claim LEED points. (Leadership in Energy and Environmental Design is a rating system developed by the U.S. Green Building Council to evaluate the environmental performance of a building.)
- Can collect irrigation and retain water to be used for irrigation.

Research Objectives:

- Review of the pervious concrete mix designs & standards currently being used worldwide.
- Investigate mix design variants resulting in optimum job mix formula of pervious concrete.
- Estimate material characterization (compressive & toughness) laboratory test parameters.
- Conduct permeability tests to investigate porous characteristics.
- Perform acoustical tests to investigate noise damping characteristics.
- Test sections using pervious concrete mix designs.

Scope of work

- To analysis need for use of Pervious Concrete

To study the Properties and application of pervious concrete

Economic Benefits of Pervious Concrete

- A parking lot properly constructed from pervious concrete has a life span ten times as long as an asphalt lot, thereby providing excellent long term benefits. It is true that the initial costs for pervious pavement may be slightly higher due to the preparation of the sub-base, but those who look long term will realize the economic benefits.
- As far as material goes, pervious concrete is installed in a thicker quantity than conventional concrete, usually six-inches (15cm.) vs. four-inch (10cm.) However, one must look beyond the costs per square foot, at the product that overall system. Pervious concrete is a sustainable saves money in the long run for the following reasons
- Lower installation costs due to the elimination of costly curbs, gutters, storm drain outlets and retention basins that cost two to three times more to construct than pervious. Less money will be needed for labor, construction and maintenance of ponds, pumps, drainage pipes and other storm water management systems.
- Allows for the use of existing storm sewer systems for new developments.
- Increase land utilization since there is no need to purchase additional land for large relation ponds and other filtering systems.

Land developers can get a better return on investment with efficient land use that does not have to allow for large detention ponds since the pavement itself acts as a detention area.

- Lower life-cycle costs equal to that of conventional concrete that if properly constructed will last for 20 to 40 years. Pervious requires fewer repairs than asphalt, and can be recycled once it has reached its lifecycle.
- Recent reports from multiple regions around the U.S. indicate that the cost for asphalt binder has recently increased as much as 50% and more, resulting in dramatic cost increases for asphalt pavement.
- Easy maintenance that consists primarily of prevention of clogging through pressure washing and power vacuuming.
- Supports local economies by having its mix design adapt to different regions, making use of available materials for coarse aggregates. Since time is a critical factor after the batching, local companies are used for transportation and materials.

1.5Disadvantages

- Runoff from adjacent areas onto pervious concrete needs to be pavement.
- The parking areas are generally limited to auto parking and occasional trunks.
- If reinforcement is required, epoxy coated bars should be used.
- Concrete is variable in permeability; over vibration signigificantly reduce permeability.
- It is still a new material that requires acceptance from cities and states.

1.6Applications

- Pervious concrete has been used in a wide range of applications, including:
- Pervious pavement for parking lots
- Rigid drainage layers under exterior mall areas.
- Greenhouse floors to keep the floor free of standing water.
- Structural wall applications where lightweight or better thermal insulation characteristics, or both, are required.
- Pavements, walls, and floors where better acoustic absorption characteristics are desired.
- Base course for city streets, country roads, driveways, and airports.
- Surface course for parking lots, tennis courts, zoo areas, and animal barns and stalls.
- Bridge embankments.
- Swimming pool decks& Beach structures and seawall.

Pavement Design

6.1 Basis for Pavement Design

Design thickness of Pervious Concrete Pavement depends on two factors;

Hydraulic factors such as Permeability, volume of voids and

- Mechanical properties such as Strength and stiffness
- Pervious Concrete used in the pavement system must be designed for traffic loads and also takes into consideration storm water management system. Appropriate material and soil properties, appropriate pavement thickness, other characteristics and traffic loads required for the design should be considered as final design thickness of pervious pavement.

6.1.1Hydraulic Factors

Hydraulic factors for design must included amount of rainfall expected, intensity of surface runoff, pavement characteristics and underlying soil properties. The amount of runoff is always less than total rainfall because some portion of rain is Ultratechumulated in small depression on the ground, some portion flows as a surface runoff and only some portion infiltrates into the soil. Excess surface runoff is caused by either excessively low permeability or inadequate storage capacity. Normally for Conventional Concrete runoff coefficient is l i.e. infiltration is almost negligible whereas in case of Pervious Concrete runoff coefficient is 0.6, thus it helps to infiltrate large portion of runoff into the soil and contributes to ground water recharge.

6.1.1.1 Rainfall Expected

An appropriate rainfall event must be used to design Pervious Concrete pavement. Two important considerations are the rainfall amount for a given duration and the distribution of that rainfall over the time period specified. Also the storage capacity typically depends upon specific rainfall events. Total value of rain is important but the infiltration rate must be considered.

6.1.1.2 Underlying Soil Properties

This is an important factor for the design of Pervious Concrete. Ideally Pervious Concrete should be laid on sandy soil but if soil is clayey appropriate sub-base can be provided. It is recommended that highly

organic materials must be excavated and replaced with soil containing high amount of coarser fill material. Also the design may include filter reservoirs of sand, open graded stone and gravel to provide adequate containment and increase the support value.

6.2 Design Criteria and Specifications

The cross-section of Pervious Concrete pavement typically consists of four layers. As shown in figure 12, a description of the layers is presented below:

- Pervious Concrete layer: The Pervious Concrete layer consists of an open-graded concrete mixture usually ranging from depths of 4 to 6 inches depending on the required bearing strength and pavement design requirements (6 inches is the recommended minimum for mostly all parking applications). Void content of Pervious Concrete can be assumed to range from 16% to 20% for design purposes. For example, a 6 inch thick Pervious Concrete layer would hold 1.08 inches of rainfall.
- Aggregate reservoir layer. The aggregate base course consists of a clean and durable crushed aggregate with a void space of 35%-40%. The designer may wish to verify the porosity and condition of the aggregate prior to placement. The aggregate sub-base layer should have a minimum depth of 10 inches. A 12 inch aggregate layer is recommended for parking lot applications. The layer should be designed to drain completely in 48 hours. Aggregate contaminated with soil shall not be used. An observation well for monitoring infiltration performance and water Ultratechumulation in the aggregate base is recommended. The observation well consist of perforated PVC pipe 4 to 6 inches in diameter and placed at the downstream end of the facility and provided with an Ultratechess lid for measurement and inspection purpose.
- Geotextile filter fabric. The bottom and sides of the sub-base aggregate layer are separated from the subgrade soils with a geotextile fabric. The filter fabric provides a separation and filter to prevent migration of fine soil particles (sit/slay fines) into the reservoir layer and reducing storage capacity.

Future Scope

- To obtain and optimum strength and permeability more number of samples should be tested for establishing a proper relationship between strength and permeability.
- Statistical analysis of such data will give us proper variation of strength and permeability.
- No fixed guidelines or IS codes are available for mix design of Pervious Concrete, pavement design of Pervious Concrete in India. Hence there is scope of more research so that there will be wide use of Pervious Concrete.
- Fiber reinforcement, admixtures of other material can be used in mix design to improve strength of Pervious Concrete.
- Proper analysis of Pervious Concrete pavement should be done to arrive at certain empirical formulae which will help in design of pavements.

1 Conclusion :

The outcome of the research can be concluded as:

- Strength of Pervious Concrete is less than that of conventional concrete of nearly same mix design but pervious concrete has very high degree of permeability as compared to conventional concrete's which is nearly zero.
- Pervious Concrete has good enough strength to be used as a paving material in parking lots, walking pathways etc. And has good enough permeability to allow high intensity of rainfall, runoff to percolate through it.
- Pervious Concrete pavement can be effectively implemented in a residential colony considered as a case study. This will help in ground water recharge reducing surface runoff during rainy season which will help in solving problem of water crisis during summer.

BIBLIOGRAPHY

1. "Portland Cement Association (PCA)," [Online]. Available: http://pervious.info./[Ultratechessed 2014]. "Portland Cement Association (PCA).2014.
2. "National Ready Mixed Concrete Association," [Online]. Available:

http://www.perviouspavement.org/. 2014.

3. Chopra, Marty Wanielista and Manoj. Performance assessment of Portland Cement Pervious concrete.
4. Mix design development for Pervious Concrete in cold climates. Schaefer VR, Wang K, Suleiman MT, Kevern J. lowa State Univ., Ames, lowa: Technical report National Concrete Pavement Technology Center, 2006.
5. Pervious Concrete: Past, Present and Future. Johnston, Kimberly.
6. Use of Porous Concrete as a Green Construction Material for Pavement.
7. PERVIOUS CONCRETE: A concrete step towards greener earth. Barot, Yogesh.
8. Michigan Concrete Association.
9. Lowa Storm water Management Manual 2J-2 Version 3; 1 2j-2 Pervious Concrete Pavement. 2009.
10. Comparison of test specimen preparation Cement Pervious Concrete pavements. Bradley J.Putman, Andrew I. Neptune. USA: s.n.
11. Performance assessment of Portland Cement Pervious Concrete. Chopra, Marty Wanielista, Manoj.2007.
12. Pervious concrete Pavements. Paul D. Tennis, Michael L. Laming, and David J. Akers.
13. The effect of aggregate-to-cement ratio and types of aggregates.
14. Pavement Analysis and Design, p.564. Huang. 2004.
15. Milani S. Sumanasooriya a, Narayanan Neithalath b, Cement &Concrete Composites. A Department of Civil and Environmental Engineering, Clarkson University, Potsdam, NY 13699, United States : s.n., Available online 17jene 2011.

M. Sonebi a, M.T. Bassuoni b. Construction and Building Materials. A school of planning, Architecture and Civil Engineering, Queen's University Belfast, BT7 1NN, Belfast, Northern Ireland, UK: s.n., Available online 210September 2012.

16. Obla, Karthik H. 2014, Pervious Concrete-An Overview.
17. George N. McCain, Graduate Research Assistant. 2014, Strength and Permeability Characteristics of Porous Concrete Pavements.
18. "Porosity, "Pervious Concrete: Investigation Info Structural Performance and Evaluation. GOEDE, WILLIAM GUNTER. 2012, PERVIOUS CONCRETE; INVESTIGATION INFO

STRUCTURAL PERFORMANCE AND EVALUATION OF THE.

19. Laboratory Evaluation of Abrasion Resistance of Portland Cement Pervious Concrete: Wu, Hao, et al. 2011.
20. Omkar Deo a, Narayanan Neithlath a, b, Construction and Building Materials 25(2011) 4181 – 4189.A department of Civil and Environmental Engineering, Clarkson University, Potsdam, NY 13699, USA: s.n., Available online 23may 2011.
21. ACI 522R-10. Pervious Concrete. American Concrete Institute Committee; ASTM C29; ASTM C (1688).Committee, American Concrete Institute and ASTM.
22. Virginia state water control board 1979 handbook. Al, Thalen ET. 1972.
23. LEED POINTS of Pervious Concrete. Erin Ashley Director of Codes and Sustainability, NRMCA. 2008, Using Pervious Concrete to Achieve LEED Points.
24. ACI 522R-10. Pervious Concrete. American Concrete Institute committee; ASTM C29; ASTM C 1688.
25. LEED Credits. 2012, Pervious concrete Handbook.
26. Use of Porous Concrete as a Green Construction Material for Pavement. Ganpule, Sneha. D.Y.Patil College of Engineering, Pune: s.n.
27. No fines Pervious Concrete for paving. Menninger, Richard C.
28. "LEED POINTS of Pervious Concrete, "Using Pervious Concrete to Achieve LEED Points... Ashley, N.Erin.2008.
29. LEED Credits "Pervious Concrete Handbook". 2014.