Experimental Comparison of Conventional Concrete against Permeable Concrete

Pratiksha Shinde[1] Kiran Sapkal[2] Sachin Hapat[3] Prof. Bilal Haji[4] Prof. V.R. Upadhye[5]
[1,2,3]U.G. Student [4,5]Assistant Professor
[1,2,3,4,5]Department of Civil Engineering
[1,2,3,4,5]Marathwada Institute of Technology, Aurangabad, Maharashtra, India

Abstract— Permeable concrete is used to improve the drainage system and erosion of soil due to runoff. In the present study, an attempt has been made how permeable concrete is beneficial over conventional concrete for the land where runoff is more. Material used in permeable concrete lime stone of size (4.75mm, 9.5mm, 12.5mm), OPC (53Grade), sand (7%of total aggregate volume), super plasticize er (430), it is found that the compressive strength of conventional concrete is 16.59 KN/mm^2, 21.74 KN/mm^2, 32.84 KN/mm^2 and for permeable concrete it is 9.967 KN/mm^2, 14.41 KN/mm^2, 15.57 KN/mm^2 for 7, 14, and 28 days respectively. From results compressive strength of conventional concrete is more as compare to permeable concrete but still can use at residential road, drive way, side walk, tennis court, parking area where the strength of concrete need not be more.

Key words: Lime Stone, OPC, Sand, Super Plasticizer

I. INTRODUCTION

A. *General:*

Pervious concrete pavement is a unique and effective means to address important environmental issues and support green, sustainable growth. Pervious concrete is known by several names: porous, permeable, gap-graded, no-fines and drain-crete. It is a discontinuous mixture of coarse aggregate, hydraulic cement (and sometimes other cementitious materials), water, admixtures, and, in some applications, fibers.

Presently natural resources are increasingly consumed due to rapid urbanization and thereafter human construction activities. So that various strategies are being investigated by engineers to protect and restore natural ecosystem in the world. Permeable pavement is termed as comprising materials that facilities storm water infiltrate and transfer to the underlying subsoil with substructure which stores water underground temporarily it is called permeable pavement system .instead of installing rainfall detention ponds or soak ways, this new system is more cost effective compared to the traditional impervious pavement. Mean while, it has been acknowledged by many researchers that permeable pavement system is capable of reducing the sediments and contaminants for lessening the pollutant loads on storm water, thus it is considered as economic and environmental friendly construction as a part of city drainage system.

Pervious concrete has been used successfully in many types of construction on applications such as parking lots, streets, plazas, nature trails, and walkways. Pervious concrete is a performance-engineered concrete made with controlled amounts of aggregates, water and cementitious materials to create a mass of aggregate particles cover with a thin coating of paste. A pervious concrete mixture contains little or no sand, creating a substantial void content. Using sufficient paste to coat and bind the aggregate particles together creates a system of highly permeable, interconnected voids that drains quickly. Typically, between 15% and 25% voids are achieved in the hardened concrete, and flow rates for water through pervious concrete are typically around 480 in./hr (0.34 cm/s), although they can be much higher. Both the low mortar content and high porosity also reduce strength compared to conventional concrete mixtures, but sufficient strength for many applications is readily achieved.

1) *Conventional Concrete:*

Concrete is very common construction material widely used for various types of structures due to its strength. With increasing demand for concrete as a construction material on the one hand and continuous reduction of the resources on the other hand, necessitates the optimum utilization of the available construction material further the concrete produced should also meet all the requirements for which it is designed. Hence the present day art of producing concrete requires most economical concrete mix using admixtures, industrial or agro based waste materials which improve the strength and performance of the concrete.

Every year the production of Portland cement is increasing with increasing demand of construction industries. The worldwide annual increase of production of Portland cement is 3 to 5%. It can be seen from the chemical reaction

$$5CaCO_3 + 2SiO_2 \text{ --- } 3CaO.SiO_2 + 2CaO.SiO_2 + 5CO_2$$

In the production of Portland cement production huge amount of carbon dioxide gas released to the atmosphere. In manufacturing of cement due to de-carbonation of limestone in the kiln carbon dioxide is produced. Therefore the rate of release of carbon dioxide to the atmosphere during the production of Portland cement is also increasing. For rice growing countries, rice husks have attracted more attention due to environmental pollution and an increasing interest in conservation of energy and resources. There are several reasons that draw the attention of concrete researchers.

There are many environmental benefits in reducing the use of Portland cement in concrete and using a byproduct material such as fly ash, silica fume, ground granulated blast furnace slag and rice husk ash as a substitute. With silica as the main constituent, rice husk ash has great potential as a cement replacing material in concrete. The importance of the use of rice husk ash and silica fume as cement replacing material is beyond doubt. It works as ingredients of Portland Pozzolana Cement (P.P.C), partial replacement of cement and strength improving admixture in concrete.

B. *Necessity:*

Many developed areas across the world are now entering a state of 'water stress' – not because there’s less water available, but because we're mismanaging this essential resource.

As we continue to develop over green land, we are fundamentally altering the way rainwater maintains our landscapes. Increased levels of impermeable hard standing areas (such as roads, roofs and paved surfaces) intercept and redirect surface water run-off before it has a chance to infiltrate naturally into the ground. This creates a number of problems, which are likely to get worse as global development continues.

1) Permeable Paving:

A permeable paving combines hard standing with sustainable urban drainage systems and works in a very different way to a traditional pavement. It is designed to allow rainfall to percolate immediately through the surface near to where the raindrop lands – so surface ponding is completely eradicated without the need for an additional channel drainage system. The water flows into a specially prepared sub-base, where the voids between the stones which make up the structure act as a temporary reservoir. During rainstorm, the water is collected in the sub-base before it is released slowly either by natural infiltration into the ground beneath the pavement, into the main sewer at a controlled rate via a flow restrictor, or a combination of both.

Most importantly, to the untrained eye, there is no discernable difference between a traditional concrete block paved surface and a permeable pavement.

C. Objective of Investigation:

The objective of this project is to study the properties pervious pavements for different size of aggregate in specimen viz. permeability, compressive strength, etc.

1) Scope of Present Work:

- To study properties of specimens by varying aggregate size.
- The properties of specimens such as permeability and compressive strength.
- To determine suitability of permeable paving in comparison with traditional paving.
- To determine the voids ratio by varying aggregate size.

D. Organization Report

For this work we have considered aggregate of same size and mixture of two different aggregate sizes for a particular specimen so that the porosity can be achieved for a specimen. For making pavements we used admixtures to achieve strength and permeability.

II. METHODOLOGY

A. Materials:

1) Cement used in project:

Ordinary Portland cement

2) Sand:

7% of total aggregate. Increases by 7%for each next trial.

3) Water:

Potable water was used for the experimentation.

4) Aggregates:

Aggregate can be rounded like gravel or angular like crushed lime stone and still make for a good mixture. All properties of aggregates are tested as per IS 2386 (Part-I, II, and III)-1963 'Method of Tests for Aggregates for Concrete' and confirming to IS 383 1970.

5) Aggregate used in project:

Rounded and Angular, Natural and Artificial of Size: 4.75mm, 9.5mm, 12.5mm.

B. Mix Design of Concrete for M_{40}:

1) Given Data:

- Grade of designation - 53
- Type of cement - OPC
- Max nominal size of aggregate-4.75, 9.5, 12.5mm
- Min cement content- 350kg /m^3
- Max cement content-380 kg /m^3
- Workability -15mm (slump)
- Specific gravity of cement-3.15
- Specific gravity of coarse aggregate-2.6
- Type of aggregate-limestone aggregate
- w/c ratio- .2 to .3
- cement aggregate ratio-1:3.18

III. TEST RESULTS

A. Tests on Permeable Pavement:

1) Test for Permeability:

ASTM C1701 is a standard method to calculate in infiltration rate. An infiltration ring is temporary sealed to the surface of pervious pavement. After pre wetting the specimen, a given mass of water is introduced into the ring and the time for the water to infiltrate the pavement is recorded. The infiltration rate is calculated using the equation provided in the std. Test performed on the specimen maybe used to detect reduction of infiltration of the pervious concrete, possibly by clogging, thereby identifying the need for remediation. Allow infiltration rate reading on pervious concrete pavement suggest paste sealing during construction due to either in proper mixture proportion or construction practices

2) Test for Voids:

Wt. of Mould = 12.585 kg

$A = 1 - (W_2-W_1/ \rho_w X V_1) * 100$

A = Total void ratio of porous concrete (%)

W_1 = Underwater wt. of block specimen (Kg)

W_2 = Wt. of block which is dried in air (Kg)

ρ_w= Density of Water (Kg/m^3)

V_1 = Specimen volume (m^3)

3) Test for Porosity:

a) Dry Unit Weight (γ_D):

The Unit Weight represents the bulk density of the granular material. This value is determined in a lab as the mass of the material over the compacted volume (including air voids). Most mineral soils have dry unit weights between 1,500 and 2,000 kg/m3.

b) Aggregate Specific Gravity (G_s):

The GS value is the density of the aggregate particles relative to the density of water. The particle density is the mass of the particles without considering the volume of the voids between the particles. These values are a unit less ratio.

c) Unit Weight of Water (γ_W):

The Unit Weight of Water is a constant value that represents the density of water at standard temperature and pressure. This value is 1,000 kg/m3.

d) Porosity (n):

The *n* value is the calculated percentage of the material volume that is comprised as the voids between aggregate particles.

$$n = 1 - (\gamma_D / \gamma_w G_s)$$

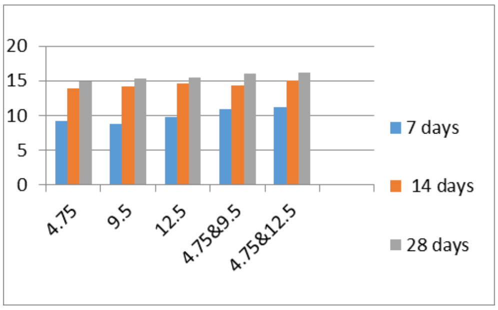

Fig. 1: Compressive strength vs Aggregate size for permeable concrete

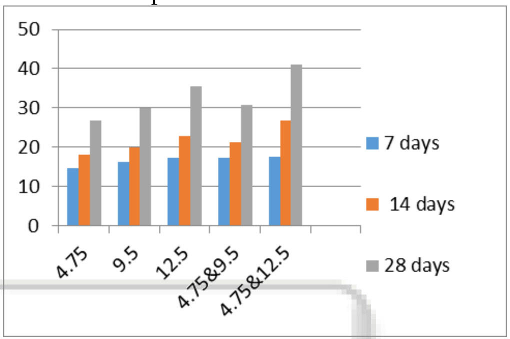

Fig. 2: Compressive strength vs Aggregate size for conventional concrete

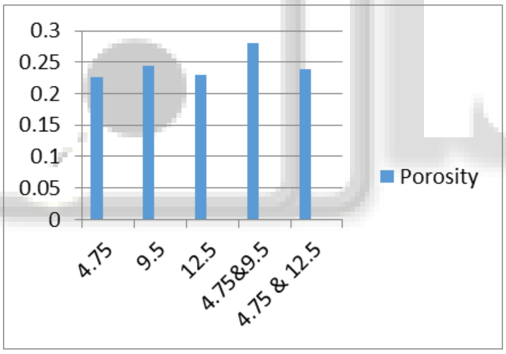

Fig. 3: Porosity vs Aggregate size

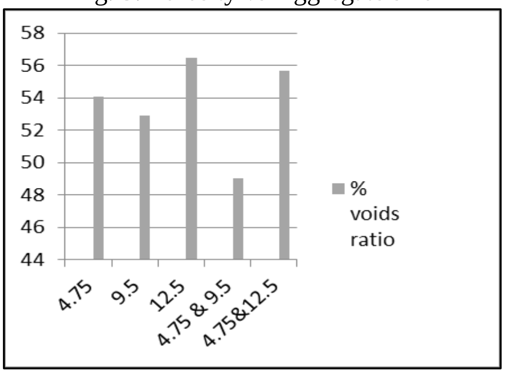

Fig. 4: % Voids Ratio vs. Aggregate size

IV. Conclusion

1) From CTM test results it is clear that conventional concrete has higher compressive strength than permeable concrete. Thus permeable concrete cannot be use in road pavement but can use in sidewalks, parking lots, etc.
2) Permeable concrete increased infiltration into the sub grade soils contributes to the highest removal of pollutants from site runoff, although some pollutants such as soluble nutrients, chlorides or sodium raise concern for groundwater pollution. Reduces heat island effect. On the other hand the conventional concrete does not allow any percolation through it.
3) Imperviousness of conventional concrete allows more runoff but the pervious concrete reduces runoff and provides solid/liquid separation with wastewater.
4) Financial considerations, either the cost of installing permeable pavement systems or the cost savings from reduced storm water management facilities, will play a major role in determining the feasibility of any given project.
5) Cost of manufacturing is comparatively less as there is no use or optimum use of fine aggregate.
6) Also permeable concrete is environmental friendly as we use natural sand in manufacturing of conventional concrete which consumes approximately 45-48% volume of total aggregate required which is reduced to 7% only.

References

[1] Jing Yang, Guoliang Jiang, "Experimental study on properties of pervious concrete pavement materials, Cement and Concrete Research" (2003) pp 381–386.
[2] C. Lian, Y. Zhuge, (2010) "Optimum mix design of enhanced permeable concrete – An experimental investigation, Construction and Building Materials"
[3] Baoshan Huang, Hao Wu, Xiang Shu, Edwin G. "Burdette Laboratory evaluation of permeability and strength of polymer-modified pervious" concrete Dept. of Civil and Environmental Engineering, The University of Tennessee, Knoxville, TN 37996, USA 17 November 2009
[4] Miklas Scholz_, Piotr Grabowiecki "review of permeable pavement system" Institute for Infrastructure and Environment, School of Engineering and Electronics, the University of Edinburgh, William Rankine Building, The King's Buildings, Edinburgh EH9 3JL, Scotland, UK20 November 2006.
[5] IS 2386 (Part-I, II, and III)-1963 'Method of Tests for Aggregates for Concrete'
[6] IS 9103(1999): Specifications for concrete admixtures.
[7] Concrete mix proportioning guidelines IS 10262:2009.
[8] Concrete mix design by M.S. Shetty.
[9] Concrete technology by M.S. Shetty.

