International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 6 June 2023, pp: 506-511 www.ijaem.net ISSN: 2395-5252

Improvement of Ground Water Table Recharge Using Pervious Concrete as a Rigid Pavement

Ms. Femitha T.K[1] , Ms. Shahina K.M[2] , Mr. Muhammed Fasal M.B[3] , Mr. Muhammed Mukhthar K.S[4] , Ms. Sumayyath M.M[5]

[1234]Pursuing B. Tech in Civil Engineering fromAPJ Abdul Kalam Technological University, Kerala, India
[5]Assistant Professor, Department of Civil Engineering,Ilahia College of Engineering and Technology, Kerala , India

----
Date of Submission: 10-06-2023 Date of Acceptance: 20-06-2023

ABSTRACT: Rapidly increasing and uncontrolled changes in the natural landscape caused by human intervention have created a serious problem of rainwater harvesting in many Indian cities. Rainwater is seen wasting on the roads due to inadequate drainage system design. Very less water is infiltrated into the ground and leads to water scarcity in the summer season. Pervious Concrete Pavement (PCP) construction is one of the best methods to solve this problem. Pervious concrete is a mixture of cement, coarse aggregate and water. Pervious concrete lacks fine aggregate. Pervious concrete is a special type of high-porosity concrete used for concrete pavement applications that allows water from rainfall and other sources to pass through directly, reducing site runoff and allowing for groundwater recharge. The biggest challenge limiting its widespread use is its low strength. In this study, glass fiber is used as a partial replacement for cement to increase the strength of pervious concrete. Cement is partially replaced by glass fiber in volumes of 0%, 0.5%, 1%, 1.5% and 2%.

KEYWORDS: Pervious Concrete, Glass fibre, Drainage System, Porosity, Ground Water Recharge.

I. INTRODUCTION

Rapidly growing and uncontrolled changes in the natural landscape caused by human intervention have created a serious problem of stormwater runoff in many Indian cities. As natural disasters such as floods increase every year, there is a need to establish specific water disposal systems in urban and semi-urban areas. This problem is increasing day by day due to lack of modern sewage infrastructure in most Indian cities. During the monsoon, most of the rainwater collects on the road. Due to the inadequate design of the drainage system, rainwater accumulates onthe road. This is mainly because the sewage systems are already clogged in most cities. Thisresults in traffic jams and also poses a serious health risk to local residents. This problem is serious in large cities and industrial areas where roads are built without designing a sewage system. During rains, water remains standing on the road for hours, causing road erosion and reducing the life of the road. This problem can be solved with a proper and rainwater management system. When designing a rainwater management system, it is primarily about capturing rainwater from roads and creating artificial connections for hygienic subsurface water.

Pervious concrete is one of the best solutions to this problem. Pervious concrete is a mixture of cement, coarse aggregate and water. Fine aggregate is not used in the mixture (dosing) of pervious concrete. The coarse aggregate is held together by a paste made of cement and water leaving voids that allow water to infiltrate. Unlike ordinary concrete, pervious concrete has high permeability, lower compressive strength and lower unit weight. The percentage of voids in pervious concrete can range from 15% to 40%, while the percentage of voids in regular concrete ranges from 3 to 4%. Pervious concrete has thus proven to be an effective means of solving important environmental problems and sustainable growth. In this study, glass fiber, a waste product obtained from broken glass, is used to increase the compressive strength of pervious concrete. Fiberglass was chosen as a replacement material because it exhibits similar properties to cement. Glass fiber is used as a partial replacement for cement to increase the strength of pervious concrete. Cement is partially replaced by glass fiber in volumes of 0%, 0.5%, 1%, 1.5% and 2%.

1.1 Objectives

- To develop a suitable concrete mix without fine aggregate.
- To compare the performance characteristics of perviousconcrete with 0%, 0.5%,1%,1.5%and 2% of glass fibre.
- To measure the infiltration rate of specimens with different percentage of glass fibre.

1.2 Scope of the study

- To minimize storm water runoff.
- Eliminates the need for holding tanks and other costly stormwater management practices.
- Replenishes aquifers and groundwater levels.

II. LITERATURE REVIEW

[1].Ashiya M Harshad, Salma Saif, Abinav (2022) conducted an experimental study on strength enhancement of pervious concrete. They investigated the use of polypropylene fibers and manganese powder in pervious concrete and found its compressive strength, flexural strength and permeability. The use of polypropylene fibers and manganese powder in pervious concrete improves the bond between coarse aggregate and cement paste.

[2].M.Suleiman, J.Kevern (2019) conducted a study on the effect of compaction energy on pervious concrete. This paper summarizes a study conducted to investigate the effects of compaction energy on the porosity, compressive strength and tensile strength of pervious concrete. Laboratory results show that compaction energy affects pervious concrete's compressive strength, tensile tear strength, unit weight, and freeze-thaw durability.

[3].Bethany Eisenberg, Kelly Collins Lindow, David R Smith (2015) conducted a study on permeable pavement. This review article summarizes the diffusion literature on permeability. pavement Materials used for the arrangement of pavements, conditions necessary for pavement construction, selection of pavement location. Cost analysis is also mentioned.

[4].Yang J. and Jiang G (2002) conducted an experimental study on pavement material properties. In this study, the introduction of smaller aggregate, superplasticizer and silica fume can increase the strength of pervious concrete. It is concluded that the material can achieve a maximum compressive strength of 50 MPa and a bending strength of 6 MPa.

III. MATERIALS AND METHOD

3.1 Materials

3.1.1 Cement

We used ordinary portland cement grade 53. The colour of OPC is gray and by removing the iron oxide during cementproduction we also getwhite cement. The cement thus obtained was tested for physical requirements in accordance with IS: 169-1989.

3.1.2 Aggregate

The aggregate grit used in pervious concrete is typically either single-size coarse aggregate or a grit between 20 mm and 12.5 mm. Round and crushed aggregates, both normal and lightweight, are used to produce pervious concrete.

3.1.3 Glass fibre

It is a material made of extremely fine glass fibers. Fiberglass is a light, extremely strong and robust material. Glass fibers are useful because of their high surface area to weight ratio. Moisture is easily absorbed and can aggravate microscopic cracks and surface defects and reduce toughness. The specification of the glass fiber used here is 12 mm long and 2.7 g/cm3 specific gravity of irregular pieces. It does not absorb water and comes from industry.

3.1.4 Water

Water quality for pervious concrete is governed by the same requirements as for conventional concrete. The higher the water content of the concrete, the higher the workability of the concrete, because water dilutes the concrete. Pervious concrete should contain a relatively low ratio of water to cementitious material (w/cm) (typically 0.26 to 0.40).

3.2 Methods

3.2.1Mix design as per IRC:44 2017

a. Stipulations for proportioning

- Grade designation - M20
- Type of cement - OPC 53 grade
- Minimum Percolation Rate - 350 mm/min

b. Test data for materials

- Specific gravity of cement = 3.15
- Specific gravity of coarse aggregate = 2.7

International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 6 June 2023, pp: 506-511 www.ijaem.net ISSN: 2395-5252

c.Design compressive strength for mix proportioning

$f'ck = fck$ +1.65S { [5] , S= 4 N/$mm2$ }

= 20 + 1.65×4 = 26.6 MPa

d.selecting of water- cement ratio

water – cement ratio as = 0.38 { 0.26 to 0.45}

e. Void content

void content = 25% for percolation rate of 350mm/min

Void content ; Target strength = 26.6 MPa, 9.5mm aggregate.

Extrapolating for 26.6MPa we get 11% by volume.

Take an average value of 18% to satisfy the requirement of percolation rate and compressive strength

Table 1. Mix proportioning of pervious concrete

MIX	M1	M2	M3	M4	M5
Glass Fibre (%)	0	0.5	1	1.5	2
Glass Fibre (kg)	0	10.13	20.56	30.69	41.12
Cement (kg/m^3)	333.81	321.8	312.9	304	292.67
Coarse Aggregate (kg/m^3)	1587.6	1587.6	1587.6	1587.6	1587.6
Water (kg/m^3)	126.8	126.8	126.8	126.8	126.8

f. Paste volume (Vp) , cement content (c) and water content (w)

Paste volume = by interpolating we get 23.2% paste volume for 18% void content

Vp = cement volume + water Volume

c = 0.232/(0.315 +0.38) × 1000

= 333.81 kg/ m^3

w/c ratio = 0.38

w = 0.38×333.81= 126.84 kg/ m^3

g. Volume of coarse aggregate [5]

Volume of concrete = 1m^3

Void content = 0.18

Paste volume= 0.232

Volume of coarse aggregate = 1-(0.232+0.18)

= 0.558 m^3

Mass of coarse aggregate = volume of C.A × specific gravity of C.A× 1000

= 0.558×2.7×1000 = 1587.6 kg/m^3

Ratio of M20 mix = C:FA:CA = 1: 0: 4.75

Fig 1. Mixture of cement and glass fibre

3.2.2 Mix Proportioning

[5].Permeable concrete mix design (M20) was done based on IRC: 44, 2017. Water to cement ratio was kept constant at 0.38 for all concrete mixes. The resulting mixture ratio is 1:0:4.75.

Five concrete mixes (M1, M2, M3, M4 AND M5) were prepared by replacing cement with glass fibers at different percentages (0%, 0.5%, 1%, 1.5% and 2%) to increase the compressive strength. The details of the mix for 1m3 are given in Table -1.

3.2.2 Casting of Specimens

Cube of dimensions 150×150×150 mm and cylinder of dimensions 100×200 mm of different

International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 6 June 2023, pp: 506-511 www.ijaem.net ISSN: 2395-5252

mixtures were cast for compression tests and permeability tests.

IV. RESULT AND DISCUSSIONS

4.1 Compressive Strength

Compressive strength test, a mechanical test measuring the maximum pressure load that a material can withstand before tearing.After 28 days of curing, the test specimen was removed from the water and the wet surfaces were wiped dried and tested. Record the maximum load and calculate the compressive strength of the concrete blocks using the following equation.

Compressive Strength = Load in N /Area in mm^2

The compression test was done after 28 days and the compression test result is shown in Table-2.

4.2 Permeability Test

The ability of a given concrete to pass liquids or gases is called concrete permeability. This is a test method for measuring the water permeability of pervious concrete. Permeability test was done as per IRC 44 2017. Cylinder samples of size 100x200mm shall be cast for permeability test. Testing should be done after a 7-day or 28-day water cure as specified. The principle of measuring the permeability of pervious concrete is that the test specimens are pre-moistened before the first test. A given amount of water is poured into the sample and the time it takes for the water to infiltrate is measured. The permeability test result is shown in Table-3.

Fig 2. Permeability Testing Setup

Table2. Compressive Strength Results

Mix	% of glass fibre	Average Compressive Strength after 28 days (MPa)
Mix 1	0	19.20
Mix 2	0.5	20.10
Mix 3	1	21.16
Mix 4	1.5	23.5
Mix 5	2	21.9

International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 6 June 2023, pp: 506-511 www.ijaem.net ISSN: 2395-5252

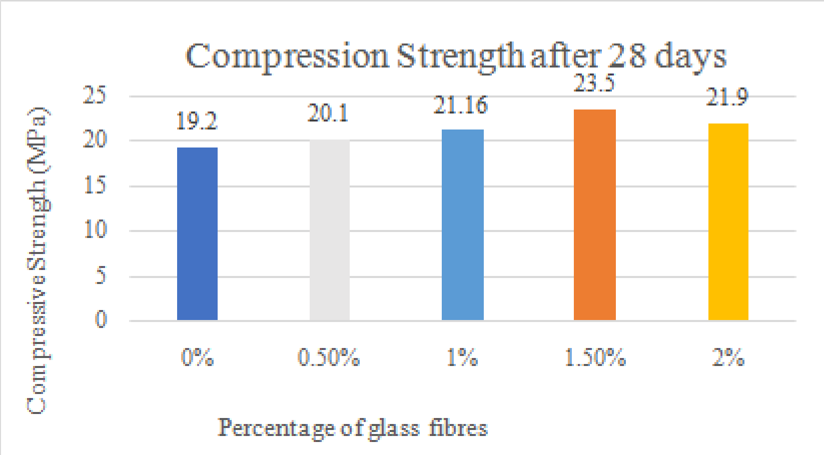

Chart 1. Compressive Strength Results

Table 3. Permeability Test Results

Mix	% of glass fibre	Permeability (mm/sec)
Mix 1	0%	10.42
Mix 2	0.5%	10.31
Mix 3	1%	10.15
Mix 4	1.5%	9.88
Mix 5	2%	9.76

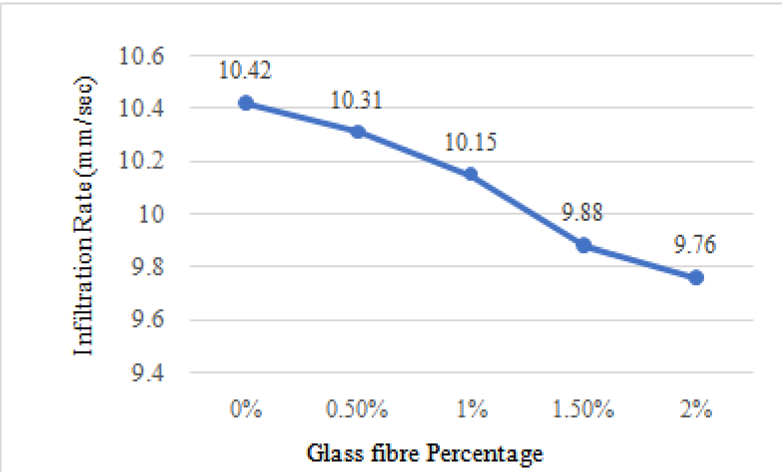

Chart 2. Permeability Test Results

International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 6 June 2023, pp: 506-511 www.ijaem.net ISSN: 2395-5252

V. CONCLUSION

It is clear from the above study that the content of glass fibres has a significant effect on the strength and permeability of pervious concrete. It is obvious that by adding glass fibres to pervious concrete, the compressive strength will increase to a limit and the permeability will decrease. This means that the compressive strength is inversely proportional to the infiltration rate. When choosing the optimal mix, we should consider both strength and permeability. Based on a study of a mixture with 0.5% to 1.5% glass fibre, the compressive strength increases with the optimum infiltration rate.So we can substitute any number between 0.5% to 1.5%. The optimal dosage of glass fibres is therefore between 0.5-1.5%, which have both considerable compressive strength and permeability.This pervious concrete can be used for paving applications in theform of tiles where sufficient water drainage is required and to monitor water runoff problems especially in urban areas. It can also be used as a sustainable drainage system for pedestrian walkways and as a surface layer for parks, bike paths, tennis courts, etc.

REFERENCES

[1]. Ashiya M Harshad, Salma Saif, Abinav, “Experimental Study on Increasing the Strength of Pervious Concrete”, International Journal Of Engineering Research And Technology, Volume 1 , Pp 1-16, 2022.

[2]. M.Suleiman, J.Kevern “Effect of Compaction Energy on Pervious Concrete” , Case Studies in Construction , Pp 97-113, 2019.

[3]. Bethany Eisenberg , Kelly Collins Lindow , David R Smith “Permeable Pavement”, Case studies in construction, 2015.

[4]. Yang J. and Jiang G “Influence of Water Cement Ratio and the Size of Aggregate on the Properties of Pervious Concrete”, Case studies in construction, Pp 340-357, 2002.

[5]. IRC:44-2017,“Guidelines for Concrete Mix Design for Pavements”.