

Study of Mechanical Properties of Modified Pervious Concrete

^[1]T.V.Anvesh, ^[2]K.S.B.Prasad, ^[3]M.Pavan Kumar

^[1]Student, GMRIT, ^[2]Assistant Professor, GMRIT, ^[3]Assistant Professor, Sankethika Vidya Parishad

Abstract—Pervious Concrete also known as No-fines Concrete is a type of concrete from which fine aggregates are omitted and coarse aggregates are used, along with cement as a binder to hold aggregates together. Application of pervious concrete in pavements increases the demand in storm water control mostly in urban areas where scarcity of land is high. Implementation of Pervious Concrete Pavements (PCP) differs with Plain Cement Concrete (PCC) in mix proportion, strength parameters, and design considerations. The main objective of this study is to compare the properties of hardened pervious concrete with plain cement concrete and develop a strength and durable pervious concrete. Cement Aggregate ratio of 1:4 is used and properties such as Compressive Strength, Indirect tensile strength and Flexural strength tests were conducted by improving the mix by using Master Cast 1163 and Master Glenium Ace 8630. The principal advantages, major dis-advantages, principal applications in Indian conditions such as parking lots, driveways, sidewalks, road platforms, sub urban streets etc. are discussed.

Keywords—Pervious concrete, chemical admixtures, cost analysis.

I. INTRODUCTION

Pervious Concrete Pavements in India are unrecognized best management practices for storm water control which doesn't require land and can recharge ground water in the purest form and could reduce run-off. In pervious concrete mixture the aggregates are thickly surrounded with binder (preferably cement) which makes the aggregates wrap together forming a permeable structure with interconnected voids allowing the water to drain off quickly. The key feature of using pervious concrete as pavement is lower density, lower drying shrinkage and no segregation. There are no prerequisite standards for mixing and designing of no-fines concrete in Indian context. Hence trial and error approach is followed in this research and optimum mix is determined.

In the United States, pervious pavements are mainly used in sidewalks, parking lots, and low traffic density areas. Unlike other pavement systems, the pervious layer not only needs to possess the required strength and freeze-thaw durability to support the applied loads and resist environmental conditions, but must also have adequate permeability for the design storm of a specific region. Pervious concretes in the United States have been reported to have adequate void ratios but strengths lower than those required for structural concrete used in parking lots and pavement applications¹. Few design variables that differ between pervious and conventional concrete pavements, such as maximum strength, use of dowel bars, traffic distributions, and the types of subgrades/subcases/reservoir layers that are available. Along with the structural design

hydrological design also plays a key role in design of Pervious Pavements.

Master cast 1163 being a high range water reducing admixture improves the early strength of pervious concrete. Master Gallium Sky 8650 excelling the durability of concrete based on Modified Poly Carboxylic Ether. The above additives improve the characteristics of Pervious concrete and their optimum contents are determined in this study based on trial mixes which are discussed further.

II. MATERIALS AND MIX PROPORTIONS

The test procedure indulges with the initial steps of deciding on the tests to be conducted and choosing aggregate proportions and mix ratio in conventional pervious concrete.

CEMENT:

In this present work Nagarjuna Cement of 53 grades OPC (Ordinary Portland Cement) is used. Appearance of cement is grey and free from lumps.

Table 1: Physical Properties of Cement

S.No	Property	Experimental Values
1	Fineness of cement	6.50%
2	Specific gravity	3.10
3	Normal Consistency	29%
4	Initial Setting Time	50 min

5	Final Setting Time	320 min
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SKY 8650	ml/kg	ml/kg	ml/kg
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COURSE AGGREGATE

Coarse aggregates being the main strength constituent in pervious concrete has to attain highest bulk density. Based on the experimental study of bulk density and void ratio values based on IS 2386 Part-3 code specifications shown in Table 2, 55% aggregates passing through 16 mm sieve retained on 12.5 mm sieve and 45% of aggregates passing 12.5 mm retained on 10 mm sieve are found to be optimum.

Table2: Physical Properties of Coarse Aggregates

S.No	PROPERTY	VALUE
1	Specific gravity	2.65
2	Bulk density	16.43kN/m ³ 16.71kN/m ³
	Loose Compacted	
3	Water absorption	0.5%
4	Fineness modulus	7.00%

Table3: Bulk Density and Void Ratio of Aggregates

PROPORTION	LOOSE BULK DENSITY OF AGGREGATES kg/lit	VOID RATIO
55% x + 45% y	1.643	0.380
60% x + 40% y	1.615	0.391
64% x + 36% y	1.588	0.401
67% x + 33% y	1.558	0.412
70% x + 30% y	1.523	0.425
x = weight of aggregates passing 16 mm IS sieve retained on 12.5 mm sieve y = weight of aggregates passing 12.5 mm IS sieve retained on 10 mm sieve Specific Gravity G = 2.65		

Three trial mixes were done for confining the optimum content of Master cast 1163, Master Gallium Sky 8650 for additive in pervious concrete and comparative study of strength properties is done. The mix proportions are shown in table:4 below

Table4: Mix Percentages

MASTER CAST 1163	3 ml/kg	5.5 ml/kg	8 ml/kg
MASTER GLENIUM	3	7.5	12

III. MIX DESIGN

For plain cement concrete pavement M15 grade with maximum size of the aggregate is used

Table5: Mix Design

Mix	Cement	Fine Aggregates	Coarse Aggregates	Water
Ratio	1	2	4	0.6
Quantity	325 kg/m ³	650 kg/m ³	1300 kg/m ³	195 lit/m ³

Table 6: Pervious concrete Mix design

Mix	Cement	Coarse Aggregates	Water
Ratio	1	4	0.3
Quantity	350 kg/m ³	1400 kg/m ³	135 lit/m ³

Table7: Pervious concrete with additives

Mix	Cement	CA	Water	Master Cast 1163 (Ml/Kg)			Master Glenium Sky 8650 (ml/kg)		
Ratio	1	4	0.3						
Quantity	350 kg/ m ³	1400 kg/m ³	135 lit/m ³	3	5.5	8	3	7.5	12

IV. PREPARATION OF SAMPLE AND TESTING

Mechanical properties on hardened concrete to be found out are Compressive strength of concrete, Flexural Strength, Indirect Tensile strength, Porosity.

For calculation of compressive strength cubes of dimensions 150 × 150 × 150 mm are used. The sample is mixed and poured in the cube in three layers with a tamping of 25 blows each layer and left for curing for a period of 7,14 and 28 days. The compressive strength is determined by placing the cured cube in Compression Testing Machine (ACTM) with 4 KN/sec rate of loading.

For Determining the Flexural Strength of the specimen, mix is prepared and poured into the prisms of dimensions 100 × 100 × 500 mm and cured respectively. After proper curing, a three point load is applied on the specimen using UTM (Universal Testing Machine).

Indirect tensile strength also known as cylindrical strength is calculated by testing cylindrical specimens of dimensions 150 mm diameter and 300 mm height. The hardened specimen is placed in the Compressive Testing Machine ACTM along the longitudinal axis; load is applied with a rate of 2.3 KN/sec.

V. RESULTS

Table8: Plain Cement Concrete Results

Plain Cement Concrete	Compressive Strength (N/Mm ²)	Flexural Strength (N/Mm ²)	Indirect Tensile Strength (N/Mm ²)
7 Days	7.58	0.64	2.43
14 Days	12.31	1.05	3.64
28 Days	18.46	1.92	5.28

Table9: Conventional Pervious Concrete

Pervious Concrete	Compressive Strength (N/Mm ²)	Flexural Strength (N/Mm ²)	Indirect Tensile Strength (N/Mm ²)
7 Days	7.78	0.80	1.71
14 Days	11.22	1.05	2.32
28 Days	17.1	1.35	2.85

A comparison between strengths of Pervious Conventional Concrete with the Plain cement concrete are shown in figure1, figure2, figure3 below

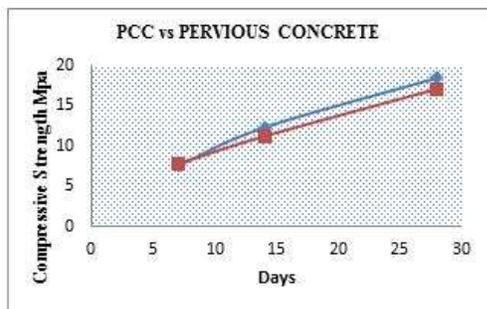


Fig1: Compressive strength comparison

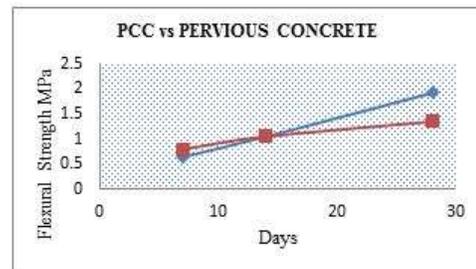


Fig2: Flexural strength comparison

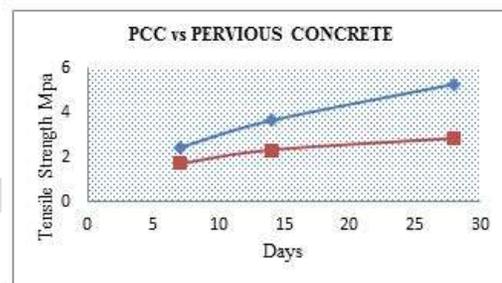


Fig2: Tensile strength comparison

After Trial Mixes being calculated addition of 3ml/kg of master cast 1163, 3ml/kg cement of master genium sky 8650 were found to be optimum and further properties were enhanced.

Table9: Compressive strength of cubes for different mixes

Curing Period (Days)	Pervious Concrete (PC)	PC + 3ml/kg Master cast 1163	PC + 3 ml/kg Master Genium sky 8650
7	7.78	8.26	8.36
14	11.22	12.64	12.72
28	17.1	18.27	18.44

Table 10: Flexural Strength of Cubes for Different Mixes

Curing Period (Days)	Pervious Concrete (PC)	PC + 3ml/kg Master cast 1163	PC + 3 ml/kg Master gallium sky 8650
7	0.80	0.91	0.96
14	1.05	1.17	1.09
28	1.35	1.42	1.53

Table 11: Tensile Strength of Cubes for Different Mixes

Curing Period (Days)	Pervious Concrete (PC)	PC + 3ml/kg Master cast 1163	PC + 3 ml/kg Master glenium sky 8650
7	1.71	1.79	1.74
14	2.32	2.37	2.31
28	2.85	3.02	3.14

VI. COST ANALYSIS

Table12: Cost Comparison of plain and pervious concrete

Type	plain concrete(per m ³ of concrete)	pervious concrete (per m ³ of concrete)	pc+ 1163 (per m ³ of concrete)	PC + 8650 (per m ³ of concrete)
Cement	1,950	2,100	2,100	2,100
Coarse Aggregates	1,040	1,120	1,120	1,120
Fine Aggregates	292.5	-	-	-
1163	-	-	115.5	-
8650	-	-	-	126
Total	3282.5	3,220	3335.5	3346

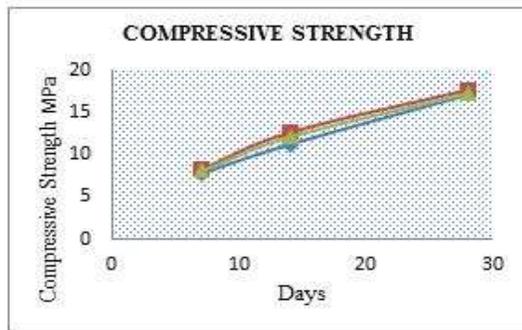


Fig4: Compressive Strength comparison of different mixes

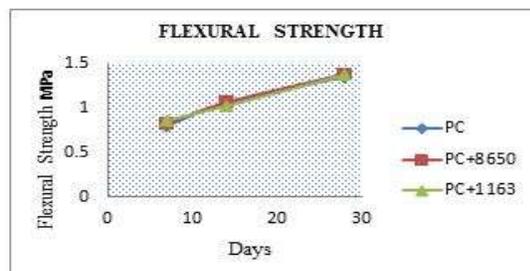


Fig 5: Flexural Strength comparison of different mixes

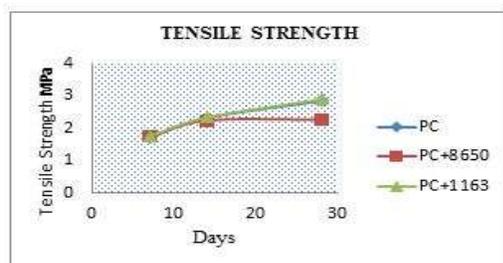


Fig 6: Tensile Strength comparison of different mixes

Along with the benefits of the Pervious concrete, it is also beneficial in economical aspect as per the cost analysis obtained. Hence it satisfies the minimum requirement of Characteristic compressive strength along with economic aspects.

Comparing the Cost of plain cement concrete with the Pervious concrete with the help of additives, there is a difference of 53 rupees for Master cast 1163 and 63.5 rupees for Master Gallium Sky 8650. This increment in cost with respect to plain cement concrete will be satisfactory by increase of durability with master cast 1163 and master gallium sky 8650 in pervious concrete. It also enhances ground water recharge and pervious concrete being the best management practice in Storm water control.

CONCLUSION

- In the comparative study of Pervious Concrete and Plain cement concrete, there is a difference of 7.9% compressive strength.
- Based on comparative results of pervious and plain concrete the minimum compressive strength of M 15 concrete i.e 15 N/mm² has been exceeded hence it is safe for a pervious concrete to be laid.
- In Master cast 1163 and master glenium sky 8650 improvement of compressive strength by 6.84 % and 7.83%, Flexural strength by 5.18% and 13.3% and Split tensile strength by 5.96% and 10.17% respectively.

REFERENCE

[1] "Development of NO-Fines Concrete Pavement Applications" by Nader Ghafouri and Shivaji Dutta, Journal

of Transportation Engineering. Vol. 121. No.3. May/June. 1995. DASCE. ISSN 0733-947X/95/0003-02X3-02XX/

[2] "Experimental Study of Pervious Concrete Pavement" by Min-Gin Lee, Yi-Shou Huang, Tao-Kuang Chang, Chun-Hua Pao, Geotechnical Special Publication No. 218, ASCE 2011.

[3] "An Innovative No-Fines Concrete Pavement Model" Navya Gundu, Markandeya Raju Ponnada, IOSR Journal of Mechanical and Civil Engineering Volume 12, Issue 5 Ver. III (Sep. - Oct. 2015), PP 34-44.

[4] "No-Fine Concrete as a Road Pavement" Govind Ravish, International Journal of Engineering Trends and Technology (IJETT)- Volume 24 Number 4- June 2015.

[5] "Building and Non pavement Applications of No-Fines Concrete", Nader Ghafoori, Shivaji Dutta, Journal of Materials in Civil Engineering, Vol. 7, No.4, November, 1995.

[6] Ammar A.Muttar, Improving the Mechanical properties of Pervious concrete, Journal of Babylon University/Engineering Sciences Volume 21 (2013).

[7] Basim Alam, Mohammad Javed et al, Mechanical properties of No-fines Bloated Slate aggregate concrete for construction application, An Experimental study, International Journal of Civil and Structural Engineering Volume 3(2012).

[8] Darshan S.Shah and Jayeskumar pitroda, An experimental study on Hardened properties of Pervious concrete, Journal of International Academic Research for Multidisciplinary Volume 2 (2014).

[9] Ghafoori and Dutta, Laboratory investigation of Compacted No-fines concrete for paving material, Journal of Material in Civil Engineering (1995).

[10] Tanvir Hossain, Md.Abdus et al, Pervious concrete using Brick chips as Coarse aggregate, an experimental study, Journal for Civil Engineering.

[11] George N.McCain and Mandar M.Dewoolkar, Strength and Permeability characteristics of Porous Concrete Pavements (2009).

[12] Hussam A.A.Rehman, Some properties of Fiber reinforced No-fine concrete, Al-Qadisiya Journal for Engineering Sciences Volume 5 (2012).

[13] Neetu B.yadav, Jayesh A.shah et al, Pervious concrete: Solution for Low cost construction, Journal of Innovative Science and Modern Engineering Volume1, (2013).