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EXPERIMENTAL STUDY ON MECHANICAL PROPERTIES OF MODIFIED PERVIOUS CONCRETE AS A RIGID PAVEMENT FOR LOW VOLUME TRAFFIC

Chowdary Lokesh[1]
Assistant professor
Department of Civil Engineering
Sri Sivani College of Engineering
Srikakulam, Andhra Pradesh, India
Email.id. lokeshchowdary114@gmail.com.

Dr. P. Revantha Kumar[2]
Assistant professor
Department of Civil Engineering
Sri Sivani College of Engineering
Srikakulam, Andhra Pradesh, India
Email.id: revanthponnana@gmail.com

N. Sai krishna[3]
Assistant professor
Department of Civil Engineering
Sri Sivani College of Engineering
Srikakulam, Andhra Pradesh, India
Email.id. krishnacivil137@gmail.com

B.Visweswara Reddy[4]
Associate Professor
Department of Civil Engineering
Aditya Institute of Technology and Management
Tekkali, Srikakulam, Andhra Pradesh India.
Email Id: bvreddy7@gmail.com

Abstract: ***Pervious concrete also as No-fines concrete that contains cement, water and a particular sized coarse aggregate to form a porous concrete material. Application of pervious concrete in pavements mainly focuses on storm water control mostly in urban areas where scarcity of land is high. Permeable pavement allows water from precipitation and other sources to pass through it and therefore reduces the runoff from a site, which results in the recharge of ground water and increases the level. . In this view it is necessary to study the behaviour of pervious concrete by enhancing its mechanical properties by maintaining required permeability. The main objective of this investigation is to develop a strong pervious concrete mix using with waste tyre rubber powder. In addition, it is also aimed to compare the mechanical properties of these modified mixes with pervious concrete. The properties such as compressive strength, indirect tensile strength, flexural strength and permeability tests are performed to determine the suitability. From the study it is concluded that using of fine aggregate and waste tyre rubber powder as partial replacement material in coarse aggregate shows significant improvement in the mechanical properties (i.e. compressive strength, indirect tensile strength and flexural strength) with maintaining required permeability. Among all the considered modified mixes, MPC-4 (i.e. 10% waste tyre rubber powder as partial replacement material in coarse aggregate) performs better.***

Keywords*: *Modified pervious concrete (MPC), Permeability, Pervious Concrete (PC), Waste tyre rubber powder.

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 is a no fine concrete which has more voids in their structure than normal cement concrete, these voids helps to easy flow of water through it. And it is a special type of concrete with a high porosity used for concrete flatwork applications , by reducing the runoff from a site and allowing groundwater recharge. Pervious concrete is made using large aggregates with a little to no fine aggregates. Pervious concrete has been used in the united state for over 30 years. Pervious concrete also used as pavement surfacing and load bearing walls. Cost efficiency was the main motive due to a decreased amount of sand. 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 rainwater into subsoil and unplanned water withdrawal for agriculture and industry by pumping. Pervious concrete if adopted for construction of pavements, platform/walkways, parking lots designed for lighter load.

LITERATURE REVIEW

Jain and Chouhan [1] (2011) conducted an experimental work on shape of aggregate used in manufacturing of pervious concrete have remarkable bearing on compressive strength and permeability of pervious concrete.

Uma Maguesvaria and Narasimhan [8] (2013) studied about the influence of fine aggregate and coarse aggregate quantities on the properties of pervious concrete. This study illustrates angularity number, which influence properties and behaviour of pervious concrete with fine aggregate and coarse aggregates. It is observed that the increase in fine aggregate results in reduction of volume of voids which in turn increase of various strengths.

Rui Liu [11] (2013) studied about the reuse potential of tire chips as coarse aggregates in pavement concrete was examined in this research by investigating the effects of tire chips on fresh and hardened concrete. The testing results indicate tire chips can be used to replace coarse aggregate in concrete pavement mixture. With 10% of coarse aggregate replaced by tire chips had the best performance.

MATERIALS USED

The materials used in experimental work are:

1. Cement
2. Coarse aggregate
3. Water
4. Waste tyre rubber

Cement

The most common cement used in construction is ordinary Portland cement conforming to IS: 12269-1987.This type of cement is typically used in construction and is readily available from a variety of sources. The cement is fresh and uniform colour. The cement is free from lumps and foreign matter.The fineness is used to quantify the surface area of cement. The surface area provides a direct of the cement fineness. The typical fineness of cement ranges from 350 to 500 kg. The type of grade 53 construction where there is no of cement used all throughout the experiment was Ordinary Portland Cement 53 (OPC-53).This is the most common type of cement used in general concrete exposure to sulphates in the soil or in the ground water.

Coarse Aggregate

The aggregate of size 10-12mm is desirable for structures having congested reinforcement Wherever possible, aggregates of size higher than 20mm could also be used Well-graded cubical or rounded aggregates are desirable Aggregates should be of uniform quality with respect to shape and grading The crushed coarse aggregate of maxim um size 16 mm , 60 % of t passing through 16 mm IS sieve and retaining on 12.5 mm IS sieve and 40 % of this passing through 12.5 mm Is sieve and retaining on 4.15 mm IS sieve size obtained from the local crushing plant.

Water

This is the least expensive but most important ingredient of concrete. The water, which is used for making concrete, should be clean and free from harmful impurities such as oil, alkali. acid etc, In general, the water, which is fit for drinking, should be used for making concrete.

Waste tyre rubber

Waste tyre rubber and scrap rubber disposal has become a major environmental issue in all parts of the world and very serious threat to the ecology. One of the alternative to decrease the amount of tyre waste is to use of scrap tyre rubber into concrete, to replace some of the natural aggregate. According to the different surveys that estimate 1000 million tyres reach the end of their useful lives per year and it is increased to 5000 millions by the year 2030.

Rubber aggregate from waste tyres using different method to reuse it. The first method generates chipped rubber to replace coarse aggregates. As for the second method it usually produce crumb rubber to replace fine aggregates.

MIX DESIGN

Pervious concrete uses the same material as in the case of conventional concrete, except that there is usually no or little fine aggregate. The size of the coarse aggregate used to keep fairly uniform in size to minimize surface roughness and for a better aesthetic water to cement ratio Should be within 0.3 to 0.45.ordinary Portland cement and blended cement can be used in pervious concrete. Admixtures can be used in pervious concrete.

Generally, NC ratios are in the range of 4.0 to 45 by mass. These A/C ratios lead to aggregate contents of between about 1300 kg/m^3 to 1800 kg/m^3, Higher A/C ratios (greater than 4:5:1) have been used in laboratory studies, but significant reductions in strength result, However mix design implemented based on literature study and trial mixes is given in Table.

Proportions of materials used in pervious concrete

Type	Proportions kg/m^3
Cementious materials	450
Aggregate	1800
Water :cement ratio (by mass)	0.4,0.35 and 0.3
Aggregate :cement ratio (by mass)	4:1
Fine :coarse aggregate ratio (by mass)	0

RESULT AND DISCUSSION

Each of the compressive strength, indirect tensile strength, flexural strength and permeability test data plotted in figures or given tables corresponds to the mean value of the three test concrete cylinders in series for compressive, flexural, tensile strengths and three test concrete cubes for permeability test.

Mechanical properties of Control Pervious Concrete mix (CPC):

Compressive strength:

Table 1 shows the compressive strength results of control pervious concrete of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4 at 7 days and 28 days curing period. Refer fig. 1 for compressive strength Vs curing period with different W/C ratios.

Table 1 Compressive strength of control pervious concrete mix

Curing period (days)	Water/cement ratios	Compressive strength (N/mm^2)
7	0.3	7.2
	0.35	7.47
	0.4	7.6
28	0.3	14.12
	0.35	14.5
	0.4	14.87

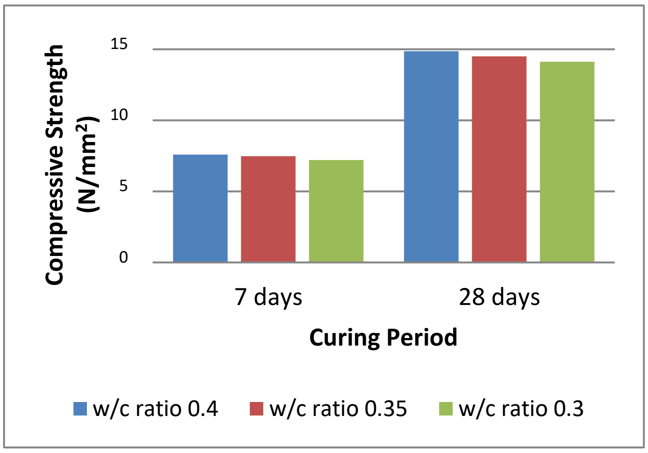

Fig. 1 Compressive strength of control pervious concrete mix

From figure 1, it is observed that there is an increase in compressive strength of CPC (w/c-0.4) by 5.5% and 1.75% when compared with CPC (w/c- 0.3) and CPC (w/c- 0.35) respectively at 7 days curing period. For 28 days curing period, compressive strength of CPC (w/c-0.4) increased by 5.31% and 2.55% when compared with CPC (w/c- 0.3) and CPC (w/c- 0.35) respectively.

Indirect tensile strength:

Table 2 shows the indirect tensile strength results of control pervious concrete of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4 at 7 days and 28 days curing period. Refer fig. 2 for Indirect tensile strength Vs curing period with different W/C ratios.

Table 2 Indirect Tensile strength of control pervious concrete mix

Curing period (days)	Water/cement ratios	Indirect Tensile strength (N/mm^2)
7	0.3	2.1
	0.35	2.28
	0.4	2.3
28	0.3	3.2
	0.35	3.48
	0.4	3.5

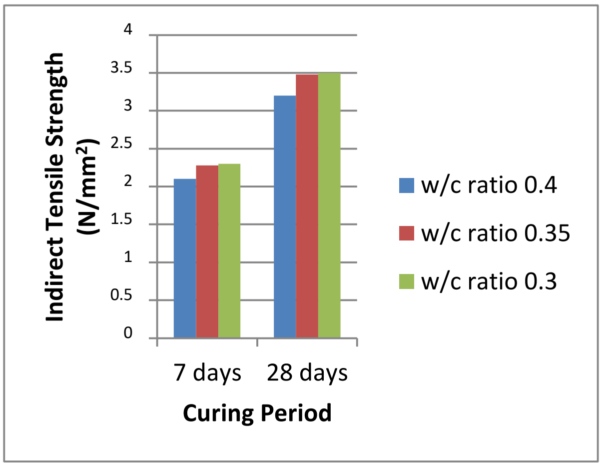

Fig. 2 Indirect tensile strength of control pervious mix

From figure 2, it is observed that there is an increase in indirect tensile strength of CPC (w/c-0.4) by 9.5% and 1% when compared with CPC (w/c- 0.3) and CPC (w/c- 0.35) respectively at 7 days curing period. For 28 days curing period, indirect tensile strength of CPC (w/c-0.4) increased by 9.3% and 1% when compared with CPC (w/c- 0.3) and CPC (w/c- 0.35) respectively.

Flexural strength:

Table 3 shows the Flexural strength results of control pervious concrete of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4 at 7 days and 28 days curing period. Refer fig. 3 for Flexural strength Vs curing period with different W/C ratios.

Table 3 Flexural strength of control pervious concrete mix

Curing period (days)	Water/cement ratios	Flexural strength (N/mm^2)
7	0.3	3.18
	0.35	3.4
	0.4	3.6
28	0.3	5.8
	0.35	6.1
	0.4	6.4

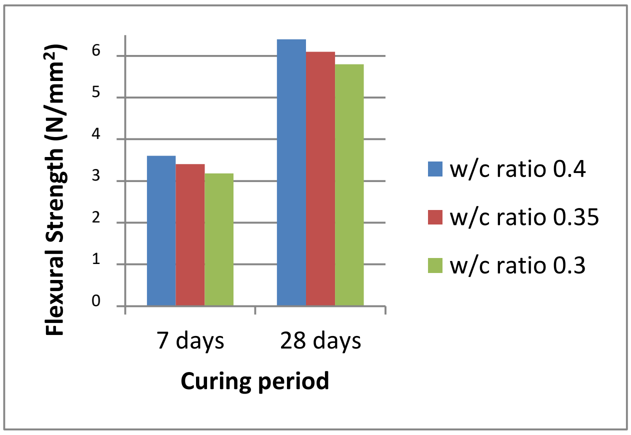

Fig 3 Flexural strength of control pervious concrete mix

From figure 3, it is observed that there is an increase in flexural strength of CPC (w/c-0.4) by 13.2% and 5.9% when compared with CPC (w/c- 0.3) and CPC (w/c- 0.35) respectively at 7 days curing period. For 28 days curing period, flexural strength of CPC (w/c-0.4) increased by 10.3% and 5% when compared with CPC (w/c- 0.3) and CPC (w/c- 0.35) respectively.

Permeability test:

Table 4 shows the permeability test results of control pervious concrete of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4. Refer fig. 4 for permeability Vs different W/C ratios.

Table 4 Permeability test for control pervious concrete mix

Water cement ratio	Permeability mm/hr
0.3	2032
0.35	1939
0.4	1880

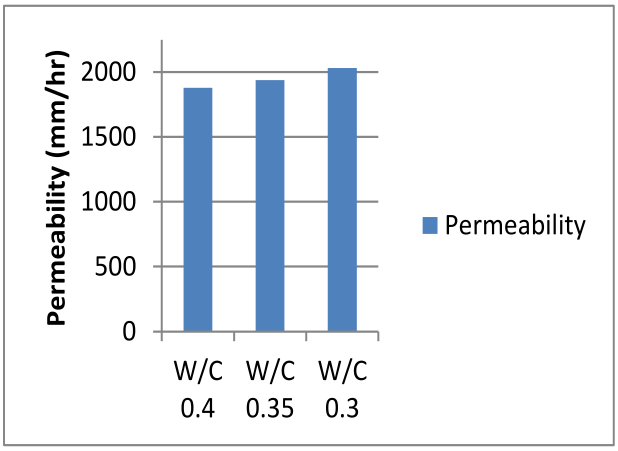

Fig. 4 Permeability test of control pervious concrete mix

From figure 4, it is observed that there is slight increase in permeability of CPC (w/c- 0.3) by 4.7% and 8.8% when compared with CPC (w/c- 0.35) and CPC (w/c-0.4) respectively.

Mechanical properties of Modified Pervious Concrete mix with replacement of 5% fine aggregate to the coarse aggregate (MPC-1):

Compressive strength:

Table 5 shows the compressive strength results of modified pervious concrete with replacement of 5% fine aggregate to coarse aggregate of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4 at 7 days and 28 days curing period. Refer fig. 5 for compressive strength Vs curing period with different W/C ratios.

Table 5 Compressive strength of modified pervious concrete mix (MPC-1)

Curing period (days)	Water/cement ratios	Compressive strength (N/mm^2)
7	0.3	7.3
	0.35	7.76
	0.4	7.82
28	0.3	14.8
	0.35	15.2
	0.4	15.87

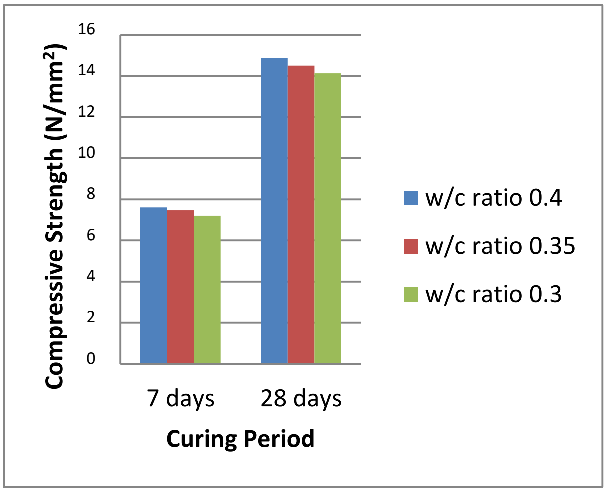

Fig. 5 Compressive strength of modified pervious concrete mix (MPC-1)

From figure 5, it is observed that there is an increase in compressive strength of MPC-1 (w/c-0.4) by 7.1% and 1% when compared with MPC-1 (w/c- 0.3) and MPC-1 (w/c-0.35) respectively at 7 days curing period. For 28 days curing period, compressive strength of MPC-1 (w/c-0.4) increased by 7.2% and 4.45% when compared with MPC-1 (w/c- 0.3) and MPC-1 (w/c- 0.35) respectively.

Indirect tensile strength:

Table 6 shows the indirect tensile strength results of modified pervious concrete with replacement of 5% fine aggregate to coarse aggregate of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4 at 7 days and 28 days curing period. Refer fig. 6 for indirect tensile strength Vs curing period with different W/C ratios.

Table 6 Indirect tensile strength of modified pervious concrete mix (MPC-1)

Curing period (days)	Water/cement ratios	Indirect Tensile strength (N/mm^2)
7	0.3	2.22
	0.35	2.28
	0.4	2.32
28	0.3	3.38
	0.35	3.48
	0.4	3.51

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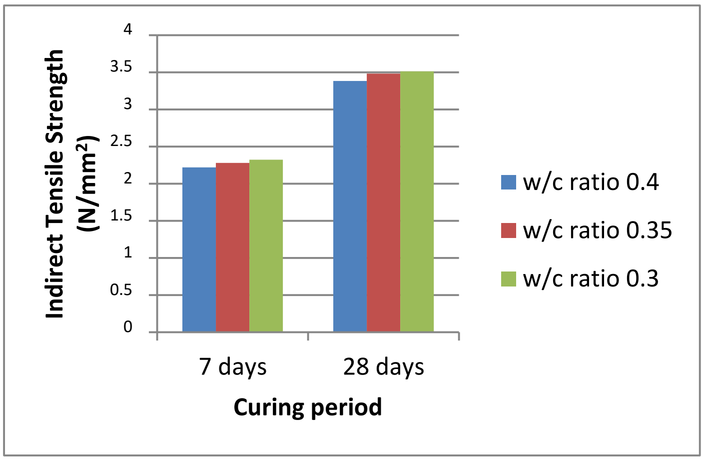

Fig. 6 Indirect tensile strength of modified pervious concrete mix (MPC-1)

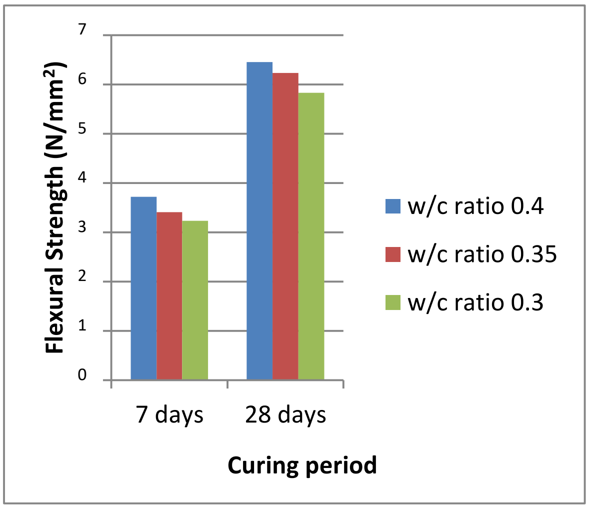

Fig. 7 Flexural strength of modified pervious concrete mix (MPC-1)

From figure 6, it is observed that there is an increase in indirect tensile strength of MPC-1 (w/c-0.4) by 4.5% and 1.75% when compared with MPC-1 (w/c- 0.3) and MPC-1 (w/c- 0.35) respectively at 7 days curing period. For 28 days curing period, indirect tensile strength of MPC-1 (w/c-0.4) increased by 3.8% and 1% when compared with MPC-1 (w/c- 0.3) and MPC-1 (w/c- 0.35) respectively.

Flexural strength:

Table 7 shows the Flexural strength results of modified pervious concrete with replacement of 5% fine aggregate to coarse aggregate of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4 at 7 days and 28 days curing period. Refer fig. 5.7 for Flexural strength Vs curing period with different W/C ratios.

Table 7 Flexural strength of modified pervious concrete mix (MPC-1)

Curing period (days)	Water/cement ratios	Flexural strength (N/mm^2)
7	0.3	3.23
	0.35	3.41
	0.4	3.72
28	0.4	5.83
	0.35	6.23
	0.3	6.45

From figure 7, it is observed that there is an increase in flexural strength of MPC-1 (w/c-0.4) by 15.17% and 9% when compared with MPC-1(w/c- 0.3) and MPC-1 (w/c- 0.35) respectively at 7 days curing period. For 28 days curing period, flexural strength of MPC-1 (w/c-0.4) increased by 10.6% and 3.5% when compared with MPC-1 (w/c- 0.3) and MPC-1 (w/c- 0.35) respectively.

Permeability test:

Table 8 shows the permeability results of modified pervious concrete with replacement of 5% fine aggregate to coarse aggregate of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4. Refer fig. 8 for permeability Vs different W/C ratios.

Table 8 permeability of modified pervious concrete mix (MPC-1)

Water cement ratio	Permeability mm/hr
0.3	1985
0.35	1896
0.4	1792

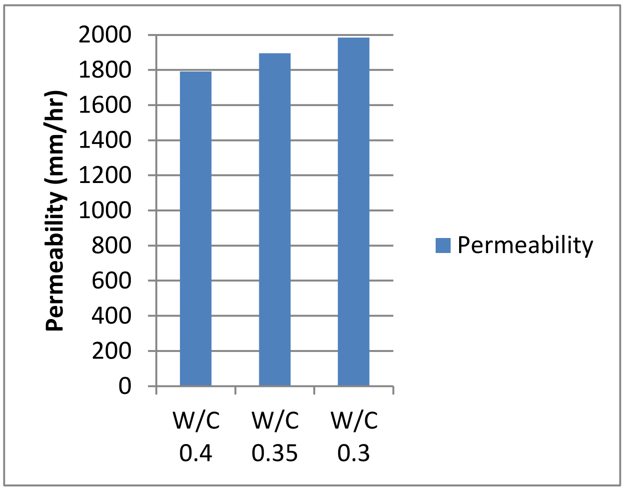

Fig. 8 Permeability of modified pervious concrete mix (MPC-1)

From figure 8, it is observed that there is slight increase in permeability of MPC-1 (w/c- 0.3) by 4.7% and 10.8% when compared with MPC-1 (w/c- 0.35) and MPC-1 (w/c-0.4) respectively.

Mechanical properties of Modified Pervious Concrete mix with replacement of 10% fine aggregate to the coarse aggregate (MPC-2):

Compressive strength:

Table 9 shows the compressive strength results of modified pervious concrete with replacement of 10% fine aggregate to coarse aggregate of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4 at 7 days and 28 days curing period. Refer fig. 9 for compressive strength Vs curing period with different W/C ratios.

Table 9 Compressive strength of modified pervious concrete mix (MPC-2)

Curing period (days)	Water/cement ratios	Compressive strength (N/mm^2)
7	0.3	7.42
	0.35	7.78
	0.4	7.88
28	0.3	14.81
	0.35	15.6
	0.4	16.02

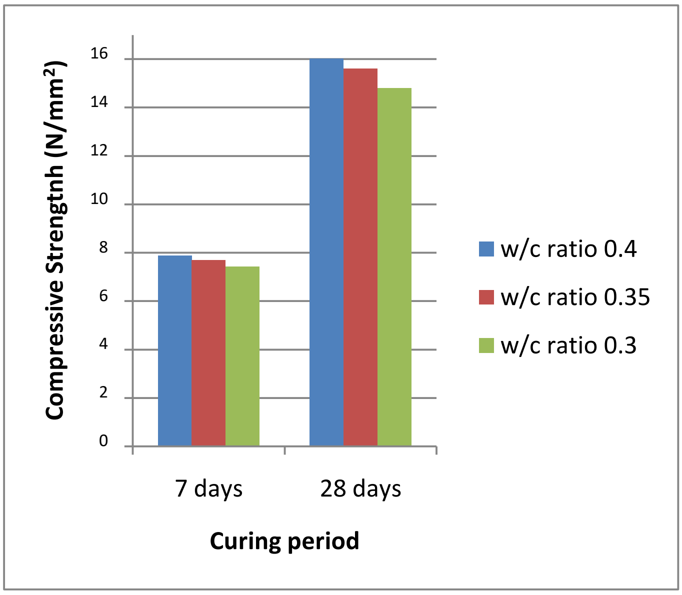

Fig .9 Compressive strength of modified pervious concrete mix (MPC-2)

From figure 9, it is observed that there is an increase in compressive strength of MPC-2 (w/c-0.4) by 6.2% and 1.2% when compared with MPC-2 (w/c- 0.3) and MPC-2 (w/c- 0.35) respectively at 7 days curing period. For 28 days curing period, compressive strength of MPC-2 (w/c-0.4) increased by 8.2% and 2.6% when compared with MPC-2 (w/c- 0.3) and MPC-2 (w/c- 0.35) respectively.

Indirect tensile strength:

Table 10 shows the indirect tensile strength results of modified pervious concrete with replacement of 10% fine aggregate to coarse aggregate of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4 at 7 days and 28 days curing period. Refer fig. 5.10 for indirect tensile strength Vs curing period with different W/C ratios.

Table 10 Indirect tensile strength of modified pervious concrete mix (MPC-2)

Curing period (days)	Water/cement ratios	Indirect Tensile strength (N/mm^2)
7	0.3	2.24
	0.35	2.3
	0.4	2.36
28	0.3	3.41
	0.35	3.5
	0.4	3.57

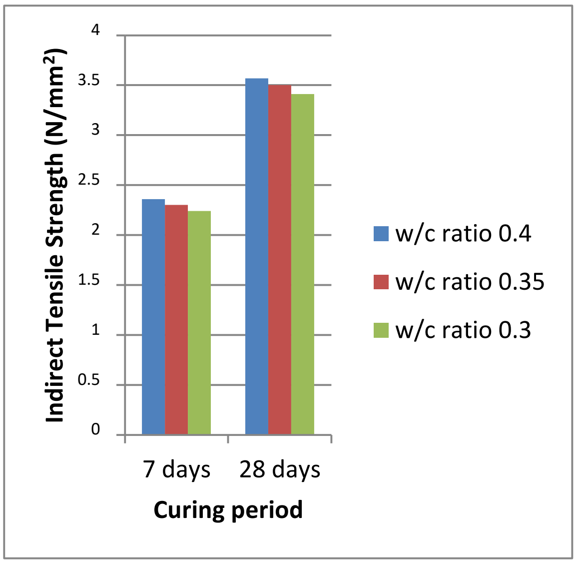

Fig. 10 Indirect tensile strength of modified pervious concrete mix (MPC-2)

From figure 10, it is observed that there is an increase in indirect tensile strength of MPC-2 (w/c-0.4) by 5.3% and 2.6% when compared with MPC-2 (w/c- 0.3) and MPC-2 (w/c- 0.35) respectively at 7 days curing period. For 28 days curing period, indirect tensile strength of MPC-2 (w/c-0.4) increased by 4.7% and 2% when compared with MPC-2 (w/c- 0.3) and MPC-2 (w/c- 0.35) respectively.

Flexural strength:

Table 11 shows the Flexural strength results of modified pervious concrete with replacement of 10% fine aggregate to coarse aggregate of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4 at 7 days and 28 days curing period. Refer fig. 11 for Flexural strength Vs curing period with different W/C ratios.

Table 11 Flexural strength of modified pervious concrete mix (MPC-2)

Curing period (days)	Water/cement ratios	Flexural strength (N/mm^2)

7	0.3	3.28
	0.35	3.45
	0.4	3.75
28	0.3	5.54
	0.35	6.28
	0.4	6.85

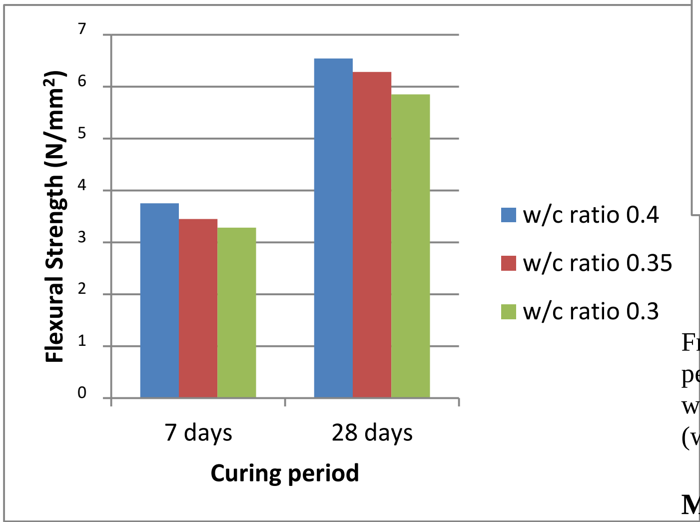

Fig. 11 Flexural strength of modified pervious concrete mix (MPC-2)

From figure 11, it is observed that there is an increase in flexural strength of MPC-2 (w/c-0.4) by 14.32% and 8.7% when compared with MPC-2(w/c- 0.3) and MPC-2 (w/c- 0.35) respectively at 7 days curing period. For 28 days curing period, flexural strength of MPC-2 (w/c-0.4) increased by 23.6% and 9.07% when compared with MPC-2 (w/c- 0.3) and MPC-2 (w/c- 0.35) respectively.

Permeability test:

Table 12 shows the permeability results of modified pervious concrete with replacement of 10% fine aggregate to coarse aggregate of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4. Refer fig. 12 for permeability Vs different W/C ratios.

Table 12 permeability of modified pervious concrete mix (MPC-2)

Water cement ratio	Permeability mm/hr
0.3	1889
0.35	1839
0.4	1689

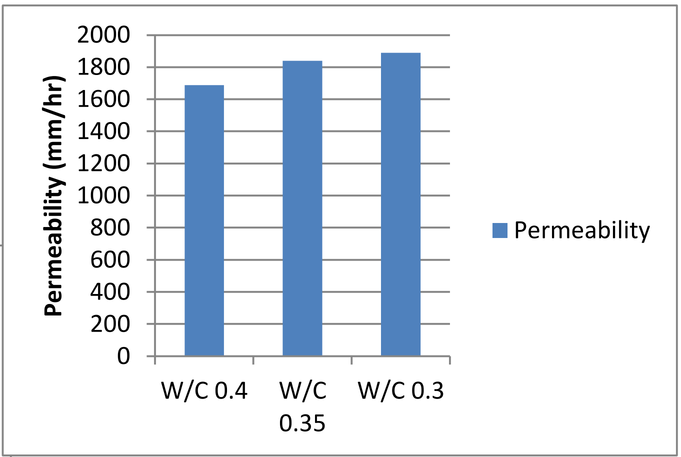

Fig. 12 Permeability of modified pervious concrete mix (MPC-2)

From figure 12, it is observed that there is slight increase in permeability of MPC-2 (w/c- 0.3) by 2.71% and 11.84% when compared with MPC-2 (w/c- 0.35) and MPC-2 (w/c-0.4) respectively.

Mechanical properties of Modified Pervious Concrete mix with replacement of 5% waste tyre rubber powder to the coarse aggregate (MPC-3):

Compressive strength:

Table 13 shows the compressive strength results of modified pervious concrete with replacement of 5% waste tyre rubber powder to coarse aggregate of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4 at 7 days and 28 days curing period. Refer fig. 13 for compressive strength Vs curing period with different W/C ratios.

Table 13 Compressive strength of modified pervious concrete mix (MPC-3)

Curing period (days)	Water/cement ratios	Compressive strength (N/mm^2)
7	0.3	7.5
	0.35	7.8
	0.4	7.93
28	0.3	14.9
	0.35	15.82
	0.4	16.17

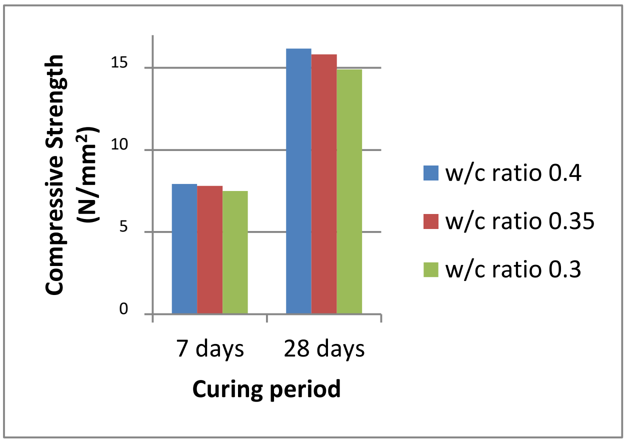

Fig. 13 Compressive strength of modified pervious concrete mix (MPC-3)

From figure 13, it is observed that there is an increase in compressive strength of MPC-3 (w/c-0.4) by 5.73% and 1.7% when compared with MPC-3 (w/c- 0.3) and MPC-3 (w/c- 0.35) respectively at 7 days curing period. For 28 days curing period, compressive strength of MPC-3 (w/c-0.4) increased by 8.5% and 2.21% when compared with MPC-3 (w/c- 0.3) and MPC-3 (w/c- 0.35) respectively.

Indirect tensile strength:

Table 14 shows the indirect tensile strength results of modified pervious concrete with replacement of 5% waste tyre rubber powder to coarse aggregate of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4 at 7 days and 28 days curing period. Refer fig. 14 for indirect tensile strength Vs curing period with different W/C ratios.

Table 14 Indirect tensile strength of modified pervious concrete mix (MPC-3)

Curing period (days)	Water/cement ratios	Indirect Tensile strength (N/mm^2)
7	0.3	2.26
	0.35	2.36
	0.4	2.38
28	0.3	3.45
	0.35	3.55
	0.4	3.61

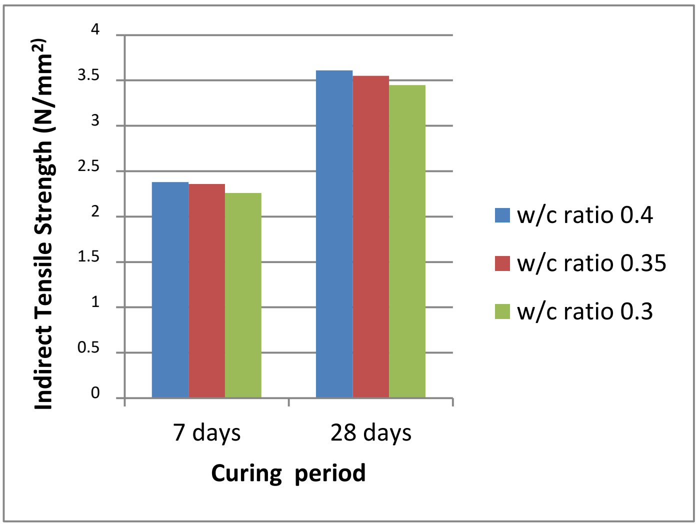

Fig. 4 Indirect tensile strength of modified pervious concrete mix (MPC-3)

From figure 14, it is observed that there is an increase in indirect tensile strength of MPC-3 (w/c-0.4) by 5.3% and 1% when compared with MPC-3 (w/c- 0.3) and MPC-3 (w/c- 0.35) respectively at 7 days curing period. For 28 days curing period, indirect tensile strength of MPC-3 (w/c-0.4) increased by 4.6% and 1.7% when compared with MPC-3 (w/c- 0.3) and MPC-3 (w/c- 0.35) respectively.

Flexural strength:

Table 15 shows the Flexural strength results of modified pervious concrete with replacement of 5% waste tyre rubber powder to coarse aggregate of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4 at 7 days and 28 days curing period. Refer fig. 15 for Flexural strength Vs curing period with different W/C ratios.

Table 15 Flexural strength of modified pervious concrete mix (MPC-3)

Curing period (days)	Water/cement ratios	Flexural strength (N/mm^2)
7	0.3	3.3
	0.35	3.52
	0.4	3.8
28	0.3	5.88
	0.35	6.34
	0.4	6.66

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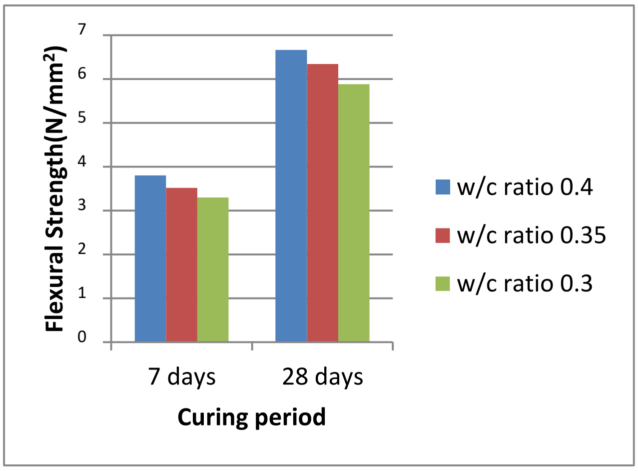

Fig. 15 Flexural strength of modified pervious concrete mix (MPC-3)

From figure 15, it is observed that there is an increase in flexural strength of MPC-3 (w/c-0.4) by 15.15% and 8% when compared with MPC-3(w/c- 0.3) and MPC-3 (w/c-0.35) respectively at 7 days curing period. For 28 days curing period, flexural strength of MPC-3 (w/c-0.4) increased by 13.26% and 5% when compared with MPC-3 (w/c- 0.3) and MPC-3 (w/c- 0.35) respectively.

Permeability test:

Table 16 shows the permeability results of modified pervious concrete with replacement of 5% waste tyre rubber to coarse aggregate of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4. Refer fig. 16 for permeability Vs different W/C ratios.

Table 16 permeability of modified pervious concrete mix (MPC-3)

Water cement ratio	Permeability mm/hr
0.3	1952
0.35	1886
0.4	1732

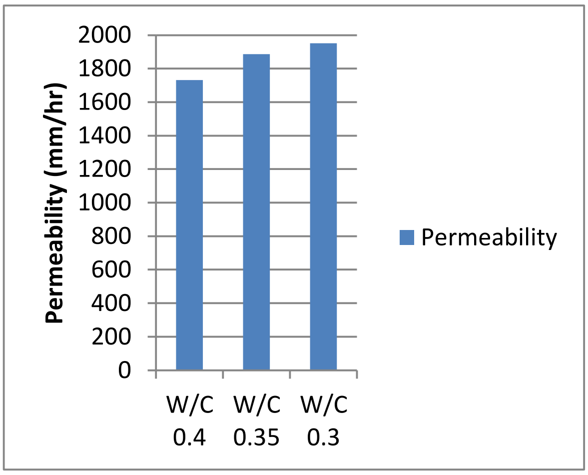

Fig. 16 Permeability of modified pervious concrete mix (MPC-3)

From figure 16, it is observed that there is slight increase in permeability of MPC-3 (w/c- 0.3) by 3.4% and 12.71% when compared with MPC-3 (w/c- 0.35) and MPC-.3 (w/c-0.4) respectively.

Mechanical properties of Modified Pervious Concrete mix with replacement of 10% waste tyre rubber powder to the coarse aggregate (MPC-4):

Compressive strength:

Table 17 shows the compressive strength results of modified pervious concrete with replacement of 10% waste tyre rubber powder to coarse aggregate of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4 at 7 days and 28 days curing period. Refer fig. 17 for compressive strength Vs curing period with different W/C ratios.

Table 17 Compressive strength of modified pervious concrete mix (MPC-4)

Curing period (days)	Water/cement ratios	Compressive strength (N/mm^2)
7	0.3	7.45
	0.35	7.94
	0.4	7.97
28	0.3	14.98
	0.35	15.86
	0.4	16.23

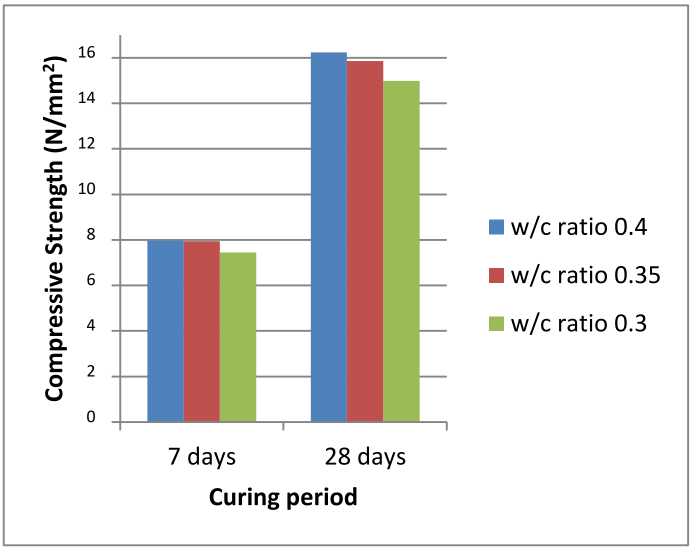

Fig. 17 Compressive strength of modified pervious concrete mix (MPC-4)

From figure 17, it is observed that there is an increase in compressive strength of MPC-4 (w/c-0.4) by 7% and 1% when compared with MPC-4 (w/c- 0.3) and MPC-4 (w/c-0.35) respectively at 7 days curing period. For 28 days curing period, compressive strength of MPC-3 (w/c-0.4) increased

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by 8.3% and 2.3% when compared with MPC-4 (w/c- 0.3) and MPC-4 (w/c- 0.35) respectively.

Indirect tensile strength:

Table 18 shows the indirect tensile strength results of modified pervious concrete with replacement of 10% waste tyre rubber powder to coarse aggregate of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4 at 7 days and 28 days curing period. Refer fig. 18 for indirect tensile strength Vs curing period with different W/C ratios.

Table 18 Indirect tensile strength of modified pervious concrete mix (MPC-4)

Curing period (days)	Water/cement ratios	Indirect Tensile strength (N/mm^2)
7	0.3	2.28
	0.35	2.364
	0.4	2.4
28	0.3	3.48
	0.35	3.56
	0.4	3.71

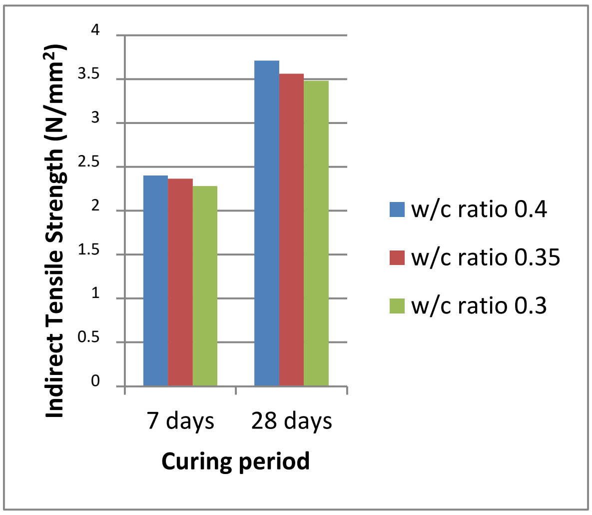

Fig. 18 Indirect tensile strength of modified pervious concrete mix (MPC-4)

From figure 18, it is observed that there is an increase in indirect tensile strength of MPC-4 (w/c-0.4) by 5.26% and 1.5% when compared with MPC-4 (w/c- 0.3) and MPC-4 (w/c- 0.35) respectively at 7 days curing period. For 28 days curing period, indirect tensile strength of MPC-4 (w/c-0.4) increased by 6.6% and 4.21% when compared with MPC-4 (w/c- 0.3) and MPC-4 (w/c- 0.35) respectively.

Flexural strength:

Table 19 shows the Flexural strength results of modified pervious concrete with replacement of 10% waste tyre rubber powder to coarse aggregate of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4 at 7 days and 28 days curing period. Refer fig. 5.19 for Flexural strength Vs curing period with different W/C ratios.

Table 19 Flexural strength of modified pervious concrete mix (MPC-4)

Curing period (days)	Water/cement ratios	Flexural strength (N/mm^2)
7	0.3	3.28
	0.35	3.45
	0.4	3.75
28	0.3	5.85
	0.35	6.28
	0.4	6.54

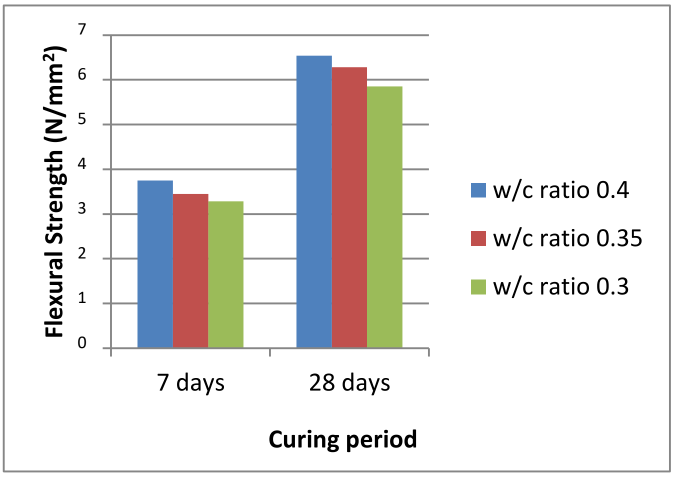

Fig. 19 Flexural strength of modified pervious concrete mix (MPC-4)

From figure 19, it is observed that there is an increase in flexural strength of MPC-4 (w/c-0.4) by 14.32% and 8.7% when compared with MPC-4 (w/c- 0.3) and MPC-4 (w/c- 0.35) respectively at 7 days curing period. For 28 days curing period, flexural strength of MPC-4 (w/c-0.4) increased by 11.8% and 4.1% when compared with MPC-4 (w/c- 0.3) and MPC-4 (w/c- 0.35) respectively.

Permeability test:

Table 20 shows the permeability results of modified pervious concrete with replacement of 10% waste tyre rubber to coarse aggregate of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4. Refer fig. 20 for permeability Vs different W/C ratios.

Table 20 permeability of modified pervious concrete mix (MPC-4)

Water cement ratio	Permeability mm/hr
0.3	1901
0.35	1794
0.4	1686

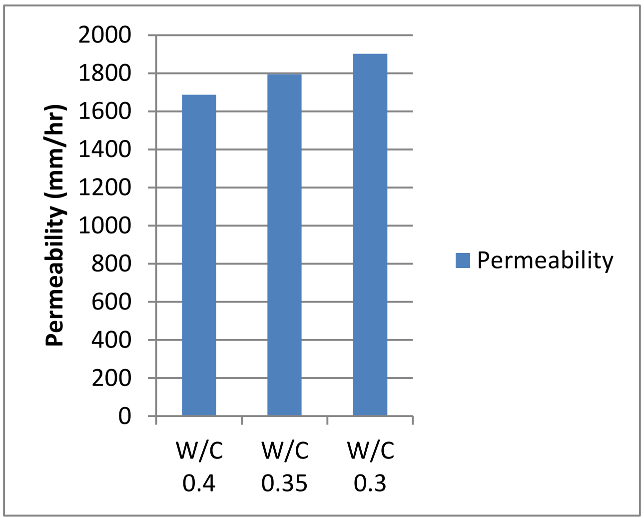

Fig. 20 Permeability of modified pervious concrete mix (MPC-4)

From figure 20, it is observed that there is slight increase in permeability of MPC-4 (w/c- 0.3) by 6% and 12.75% when compared with MPC-4 (w/c- 0.35) and MPC-4 (w/c-0.4) respectively.

Comparison of Compressive strength between CPC, MPC-1, MPC-2, MPC-3 & MPC-4 of optimum water cement ratio 0.4:

Table 21 Comparison of Compressive Strength of CPC, MPC-1, MPC-2, MPC-3 & MPC-4 for optimum water cement ratio 0.4

Curing Period (days)	Compressive Strength (N/mm^2)				
	CPC	MPC-1	MPC-2	MPC-3	MPC-4
7	7.6	7.82	7.88	7.93	7.97
28	14.87	15.87	16.02	16.17	16.23

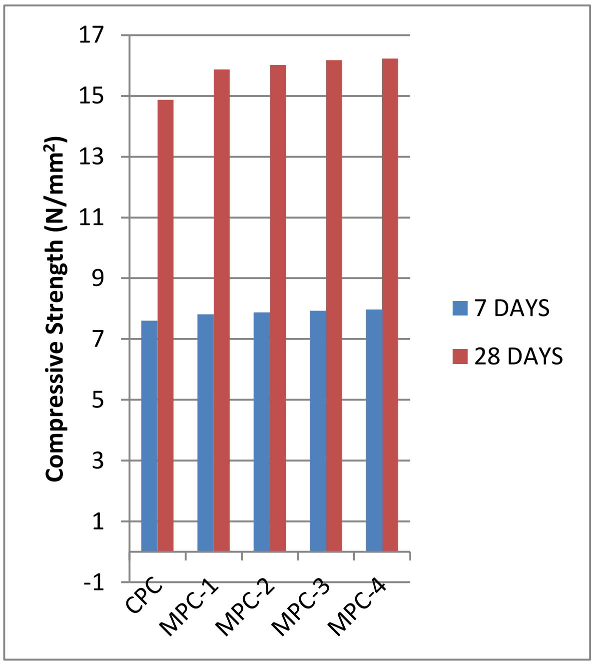

Fig. 21 Comparison of Compressive strength between CPC, MPC-1, MPC-2, MPC-3 & MPC-4 of optimum water cement ratio 0.4

From figure 21, it is observed that there is an increase in compressive strength by 2.89%, 3.62%, 4.34% and 4.86% for MPC-1, MPC-2, MPC-3 and MPC-4 respectively when compared to CPC at 7 days curing period. For 28 days curing period, observed an increase in compressive strength by 6.72%, 7.73%, 8.74% and 9.14% for MPC-1, MPC-2, MPC-3 and MPC-4 respectively when compared to CPC.

Comparison of Indirect tensile strength between CPC, MPC-1, MPC-2, MPC-3 & MPC-4 of optimum water cement ratio 0.4:

Table 22 Comparison of Indirect tensile strength CPC, MPC-1, MPC-2, MPC-3 & MPC-4 of optimum water cement ratio 0.4

Curing period (days)	Indirect Tensile Strength (N/mm^2)				
	CPC	MPC-1	MPC-2	MPC-3	MPC-4
7	2.3	2.32	2.36	2.38	2.4
28	3.5	3.504	3.57	3.61	3.71

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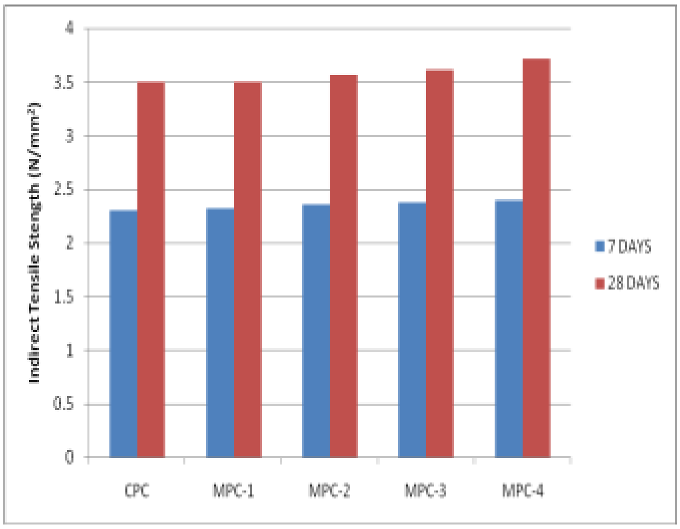

Fig. 22 Comparison of Indirect tensile strength between CPC, MPC-1, MPC-2, MPC-3 & MPC-4 of optimum water cement ratio 0.4

From figure 22, it is observed that there is an increase in indirect tensile strength by 1%, 2.6%, 3.47% and 4.34% for MPC-1, MPC-2, MPC-3 and MPC-4 respectively when compared to CPC at 7 days curing period. For 28 days curing period, observed an increase in indirect tensile strength by 0.5%, 2%, 3.14% and 6% for MPC-1, MPC-2, MPC-3 and MPC-4 respectively when compared to CPC.

Comparison of Flexural strength between CPC, MPC-1, MPC-2, MPC-3 & MPC-4 of optimum water cement ratio 0.4:

Table 23 Comparison of Flexural strength CPC, MPC-1, MPC-2, MPC-3 & MPC-4 of optimum water cement ratio 0.4

Curing period (days)	Flexural Strength (N/mm^2)				
	CPC	MPC-1	MPC-2	MPC-3	MPC-4
7	3.6	3.72	3.75	3.8	3.94
28	6.4	6.45	6.54	6.66	6.72

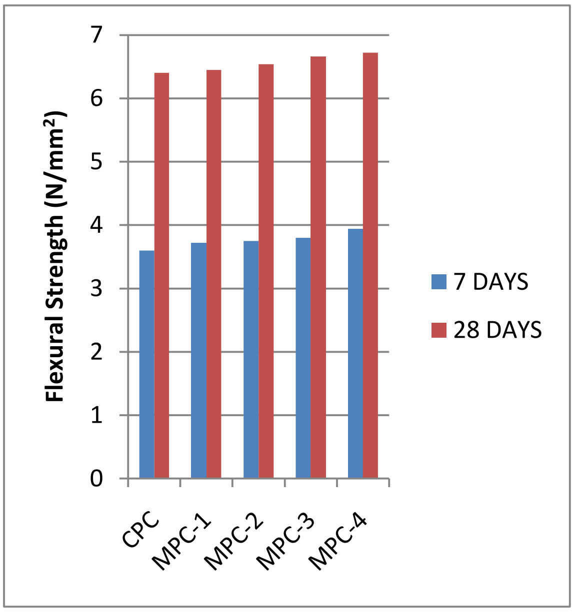

Fig. 23 Comparison of Flexural strength between CPC, MPC-1, MPC-2, MPC-3 & MPC-4 of optimum water cement ratio 0.4

From figure 23, it is observed that there is an increase in flexural strength by 3.33%, 4.1%, 5.55% and 9.44% for MPC-1, MPC-2, MPC-3 and MPC-4 respectively when compared to CPC at 7 days curing period. For 28 days curing period, observed an increase in flexural strength by 1%, 2.1%, 4.06% and 5% for MPC-1, MPC-2, MPC-3 and MPC-4 respectively when compared to CPC.

Comparison of Permeability between CPC, MPC-1, MPC-2, MPC-3 & MPC-4 of water cement ratio 0.4:

Table 24 Comparison of Permeability CPC, MPC-1, MPC-2, MPC-3 & MPC-4 of water cement ratio 0.4

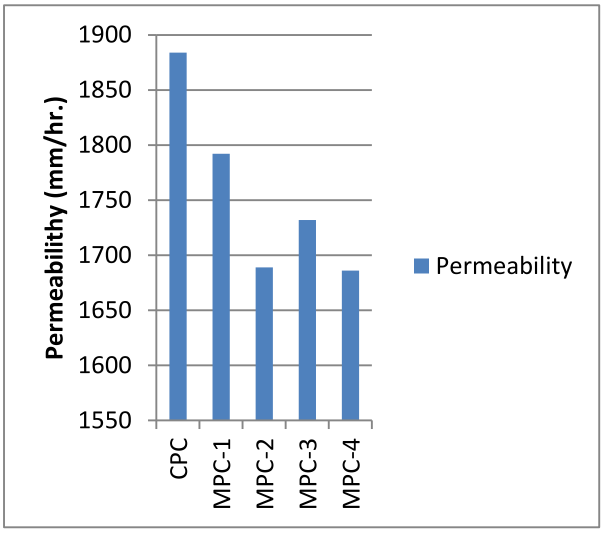

Fig. 24 Comparison of Permeability CPC, MPC-1, MPC-2, MPC-3 & MPC-4 of water cement ratio 0.4

From figure 24, it is observed that there is an increase in permeability by 5.1%, 11.54%, 8.77% and 11.74% for CPC respectively when compared to MPC-1, MPC-2, MPC-3 and MPC-4.

I. CONCLUSION

1. A water cement ratio of 0.4 is found to be optimum in strength point of view for control pervious concrete mix and modified pervious concrete mixes.

2. Among all the consideral w/c ratios, the w/c ratio increased, the degree of lubrication in the pervious concrete mix increased, which help in better densification of the mix and hence resulted in lower permeability.

3. Compressive Strength increased by 2.89%, 3.62%, 4.34% and 4.86% for MPC-1, MPC-2, MPC-3 and MPC-4 respectively when compared to CPC at 7 days curing period. For 28 days curing period, observed an increase in compressive strength by 6.72%, 7.73%, 8.74% and 9.14% for MPC-1, MPC-2, MPC-3 and MPC-4 respectively when compared to CPC.

4. Indirect tensile strength increased by 1%, 2.6%, 3.47% and 4.34% for MPC-1, MPC-2, MPC-3 and MPC-4 respectively when compared to CPC at 7 days curing period. For 28 days curing period, observed an increase in indirect tensile strength by 0.5%, 2%, 3.14% and 6% for MPC-1, MPC-2, MPC-3 and MPC-4 respectively when compared to CPC.

5. Flexural strength increased by 3.33%, 4.1%, 5.55% and 9.44% for MPC-1, MPC-2, MPC-3 and MPC-4 respectively when compared to CPC at 7 days curing period. For 28 days curing period, observed an increase in flexural strength by 1%, 2.1%, 4.06% and 5% for MPC-1, MPC-2, MPC-3 and MPC-4 respectively when compared to CPC.

6. Permeability decreased by 5.1%, 11.54%, 8.77% and 11.74% for MPC-1, MPC-2, MPC-3 and MPC-4 respectively when compared to CPC.

7. Compressive strength, split tensile strength and flexural strength properties of modified pervious concrete are increased due to the presence of fines. As the fine percentage increases, strength properties increases and permeability decreases.

8. From the study it is concluded that using of fine aggregate and waste tyre rubber powder as partial replacement material in coarse aggregate shows significant improvement in the mechanical properties (i.e. compressive strength, indirect tensile strength and flexural strength) with maintaining required permeability. Among all the considered modified mix, MPC-4 (i.e. 10% waste tyre rubber powder as partial replacement material in coarse aggregate) performs better. Due to the presence of higher percentage of fines.

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