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Strength Properties of Pervious Concrete Compared with Conventional Concrete

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Abstract: *Pervious concrete is a concrete which consists of coarse aggregate and cement paste with little fine aggregate or without fine aggregate. The pervious concrete also termed as no-fine aggregate is a natural choice for use in structural applications, and it is treated as "green binding". It requires less raw material than the conventional concrete. Pervious concrete helps in recharge the ground water in pavement applications, direct drainage of water and also have superior insulation properties when used in walls. Pervious concrete has a tailored-property concrete with higher water permeability which allow the passage of water to flow through the inter connected large pore structure. This paper reports the results of an experimental investigation in the development of pervious concrete with reduced cement content and coarse aggregate for sustainable permeable pavement construction. In this research, we used a super plasticizer conplast SP430 to reduce the amount of water content. The compressive strength properties of pervious concrete were determined by the age of 3, 7 and 28days. This paper gives the results about the properties like void ratio and compressive strength of concrete.*

Keywords: *Pervious concrete, super plasticizer SP430, Void ratio, Mix design.*

I. Introduction

Pervious concrete was first used in the 1800 year in Europe as pavement surfacing and load bearing walls. Cost efficiency was the main motive due to a decreased amount of cement. It became popular again in the 1920 year for two storied homes in Scotland and England. It became increasingly viable in Europe after the Second World War due to the scarcity of cement. It did not become as popular in the US until the 1970 year. Pervious Concrete has been around for hundreds of years. The Europeans recognized the insulating properties in structural buildings. As it is true with any material and construction technique, there is a science to it and a best way to conduct the construction. Education and experience is the key to success. The coastal states have experienced pervious concrete for over 20 years. The hesitation to move into the Midwest and Northern States was mainly due to freeze/thaw concerns. Now that those concerns are no longer considered a problem, the product has moved quickly across the United States. In the 1990's the U.S.

1.1 Advances in Pervious Concrete:

Pervious concrete is advantages for a number of reasons. Of top concern is its increased permeability compared with conventional concrete. Pervious concrete shrinks less, has a lower unit weight, and higher thermal insulating values than conventional concrete.

1.2 Super Plasticizer Conplast Sp430:

The Conplast SP430 is based on Sulphonated Napthalene Formaldehyde and is supplied as a brown liquid instantly dispersible in water. ConplastSP430 has been specially formulated to give high water reductions up to 25% without loss of workability or to produce high quality concrete of reduced permeability.

1.3 Properties:
Specific gravity: 1.24to1.26
Chloride content: Nil
Air entrainment: Approx.1%additionalairisentrained
Compatibility: Can be used with all types of cements except highalumina cement.Conplast SP430 is compatible with other types of Fosroc admixtures when added separately to the mix. Sitetrials should be carried out to optimize dosages.
Workability: Can be used to produce flowing concrete that requires no compaction. Some minor adjustments may be required to produce high workable mix with out segregation.
Cohesion: Cohesion is improved due to dispersion of cement particles thus minimizing segregation and improving surface finish.
Compressive Strength: Early strength is increased upto 20% if water reduction is taken advantage of. Generally, there is improvement in strength upto 20% depending upon W/C ratio and other mix parameters.
Durability: Reduction in W/C ratio enables increase in density and impermeability thus enhancing durability of concrete.
Dosage: The optimum dosage is best determined by sitetrials with the concrete mix which enables the effects of workability, strength gain or cement reduction to be measured. Site trials with Conplast SP430 should always be compared with mix containing no admixture. As a guide, the rate of addition is generally in the range of 0.5-2.0 liters/100kg cement.

1.4 Environmental Benefits:
Allows storm water infiltrate into the ground to replenish ground water aquifers.
- Retains storm water so that retention ponds are not needed for parking lots.
- Keeps pavement surfaces dry even in wet situations, such as greenhouses.
- Allows parking lots to be ice-free in freeze 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 effect.
- Can collect irrigation and retain water to be used for irrigation.

II. Test Results

Specific Gravity, Void Ratio and Porosity of Concrete Specimens

The test is conducted for dry concrete sample. Weight the dry sample, water fill up to initial mark of water container. Then immerse the concrete sample into the water up to 5min and then remove the excess water above initial level then weight it. The void ratio can be indicated as v, the specific gravity can be indicated as G.

CONCRETE TYPE	VOID RATIO	UNIT WEIGHT
Conventional concrete	0.01	2518.5 Kg/m^3
Pervious concrete	0.26	2014.8 Kg/m^3

Cement: Locally available 53 grade of Ordinary Portland Cement conforming to IS: 12269 was used in the investigations.

S.NO.	Properties	Test Results
1	Normal consistency	32%
2	Initial Setting Time	95min
3	Final Setting Time	230min
4	Specific Gravity of Cement	3.05

5	Soundness	2mm
6	Compressive Strength at 28 days	57.3N/mm^2

Fine Aggregate: The size, shape and gradation of the aggregate play an important role in achieving a proper concrete. The flaky and elongated particles will lead to blocking problems in confined zones. The coarse aggregate chosen for Pervious Concrete is typically angular in shape, is well graded, and smaller in maximum size that suited for conventional concrete; typically conventional concrete should have a maximum aggregate size of 20mm

S.NO.	Properties	Test Results
1	Fineness modulus	2.7
2	Specific gravity	2.58
3	Specific gravity a) Loose b) Rodded	 1640Kg/m^3 1720Kg/m^3
4	Water absorption	0.6%

Sieve analysis of Fine Aggregate: Sample 1000gms

S. No.	I.S Sieve Size	Weight Retained (gms)	Cumulative Weight Retained (gms)	Cumulative % of weight Retained	% of passing
1	4.75mm	21	21	2.1	97.9
2	2.36mm	31	52	5.2	94.8
3	1.18mm	104	156	15.6	84.4
4	600µ	405	561	56.1	43.9
5	300µ	350	911	91.1	8.9
6	150µ	86	997	99.7	0.3
7	<150µ	3	1000	100	0
	Total	**1000**	--	**270**	--

Fineness modulus fine aggregate = 270/100 =2.7

Coarse Aggregate: Machine crushed angular granite metal of 20mm nominal size from the local source is used as coarse aggregate. It is free from impurities such as dust, clay particles and organic matter etc. The coarse aggregate is also tested for its various properties. The specific gravity, bulk density, fineness modules and water absorption of coarse aggregate are found to be 2.76, 1760 Kg/m^3, 6.85 and 1% respectively.

S. NO.	PROPERTIES	TEST RESULTS
1	Fineness modulus	6.85
2	Specific gravity	2.7
3	Bulk density A) Loose B) Rodded	1660Kg/m^3 1740Kg/m^3
4	Impact value	19%
5	Water absorption	0.8%

Sieve Analysis of 20mm Aggregate: Sample 5000gm

S. No	IS Sieves size	Wt. Retained (gm.)	Cumulative wt. Retained (gm.)	Cumulative % of wt. Retained	% passing
1	40mm	0	0	0	100
2	20mm	350	350	7	93
3	10mm	3550	3900	78	22
4	4.75mm	1100	5000	100	0
5	2.36mm	0	5000	100	0
6	1.18mm	0	5000	100	0
7	600µ	0	5000	100	0
8	300µ	0	5000	100	0
9	150µ	0	5000	100	0
	Total	**5000**		**685**	

Fineness modulus of Coarse aggregate = 685/100 =6.85

III. Mix Design

Concrete type	W/C Ratio	Cement	F.A	C.A
Conventional concrete	0.35	1	1.3	2.436
Pervious concrete	0.35	1	-	4

Quantities of Material Require per $1m^3$

Concrete type	W/C Ratio	Cement (kg)	F.A (kg)	C.A (kg)	Water (lit)	Super plasticizer (ml/cement)
Conventional concrete	0.35	531	672	1133	186	-
Pervious concrete	0.35	531	-	2124	186	5310

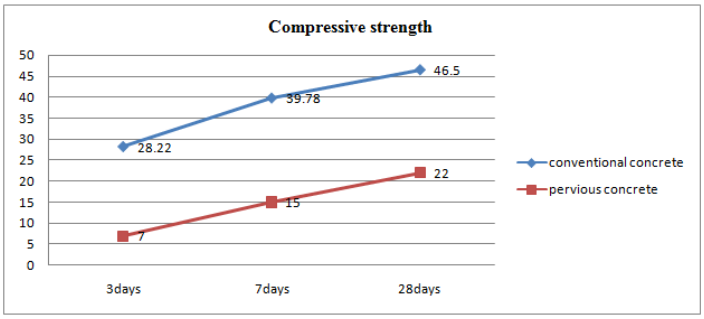
Workability for Different Concretes

Concrete type	W/C	Slump value	Compaction factor	Degree of workability	Dosage of Super Plasticizer in ml/100Kg of Cement
Conventional concrete	0.35	70mm	0.85	Medium	-
Pervious concrete	0.35	80mm	0.82	medium	1000

Compressive strength results for 3days, 7days and 28days:

The compressive strength values for pervious concrete and conventional concrete of 0.35W/C ratio for 3days, 7days and 28days. These values are observed for pervious concrete were 7MPa, 15MPa and 22MPa respectively and for conventional concrete were 28.22MPa, 39.78MPa and 46.5MPa respectively.

S.NO.	No. of days	Compressive strength of Conventional Concrete (MPa)	Compressive strength of Pervious concrete (MPa)
1	3	28.22	7
2	7	39.78	15
3	28	46.5	22

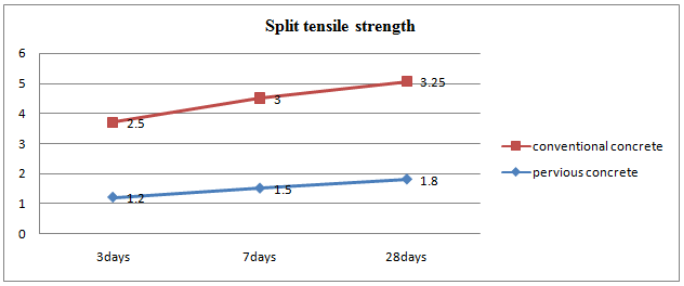


On X-axis -No. of days
On Y-axis – compressive strength in MPa

Split Tensile strength results for 3days, 7days and 28days:

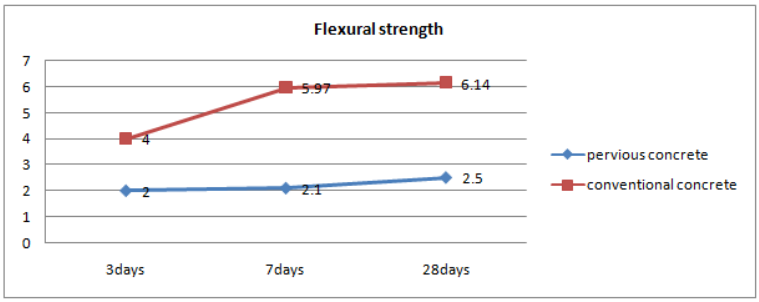
The split tensile strength values for pervious concrete and conventional concrete of 0.35W/C ratio for 3days, 7days and 28days. These values are observed for pervious concrete were 1.2MPa, 1.5MPa and 1.8MPa respectively and for conventional concrete were 2.5MPa, 3MPa and 3.25MPa respectively.

S.NO.	No. of days	Split tensile strength of Conventional concrete (MPa)	Split tensile strength of Pervious concrete (MPa)
1	3	2.5	1.2
2	7	3	1.5
3	28	3.25	1.8



On X – axis: No. of days
On Y- axis: Split tensile strength in MPa
Flexural strength results for 3days, 7days and 28days

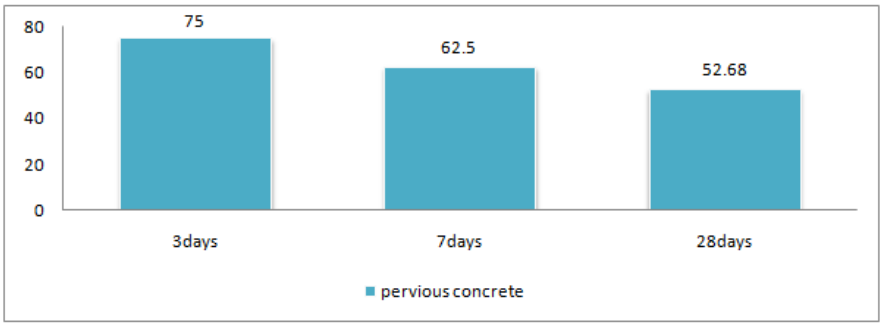
No. of days	Flexural strength of Conventional concrete (MPa)	Flexural strength of Pervious concrete (MPa)
3	4	2
7	5.97	2.1
28	6.14	2.5



On X-axis: No. of days
On Y-axis: Flexural strength in MPa

Percentage decrease in Compressive Strength of Pervious concrete w.r.t Conventional concrete: The decrease in compressive strength of pervious concrete compared with conventional concrete. The variations in compressive strength for 0.35W/C ratio at 3days, 7days and 28days were observed, these values are decreased.

S. No.	No. of days	Conventional Concrete Compressive Strength (Mpa)	Pervious concrete Compressive Strength (Mpa)	% Decrease
1	3	28.22	7	75
2	7	39.78	15	62.5
3	28	46.5	22	52.68

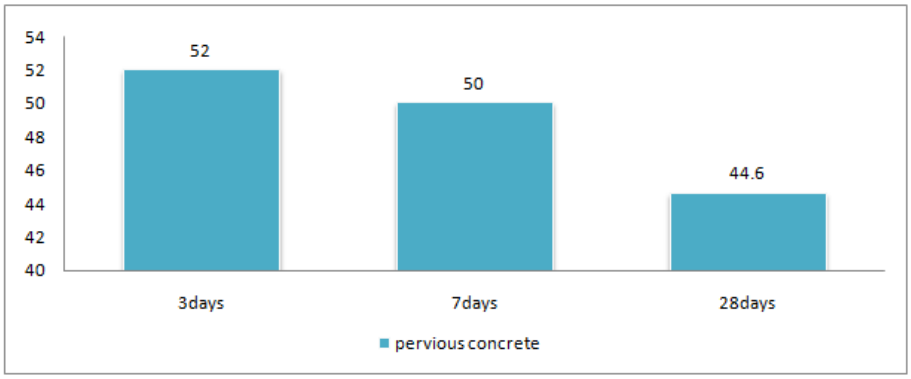


On X-axis: no. of days
On Y-axis: percentage

Percentage decrease in Split tensile Strength of Pervious concrete w.r.t Conventional concrete:

The decrease in split tensile strength of pervious concrete compared with conventional concrete. The variations in split tensile strength for 0.35W/C ratio at 3days, 7days and 28days were observed, these values are decreased.

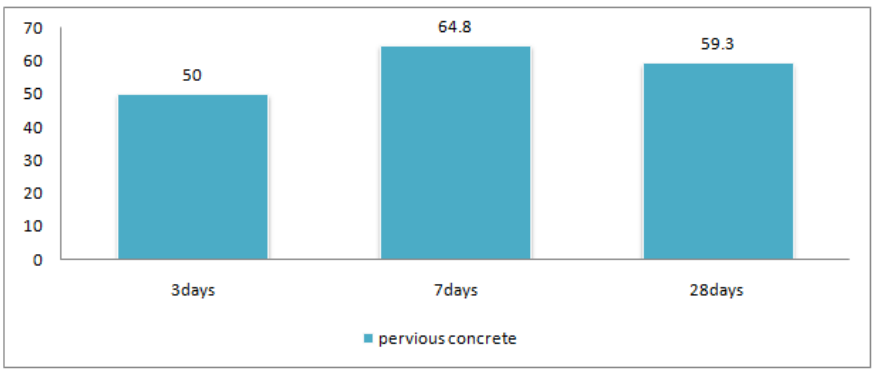
S. No	No. of days	Conventional concrete Split Tensile Strength in MPa	Pervious concrete Split Tensile Strength in MPa	% Decrease
1	3	2.5	1.2	52
2	7	3	1.5	50
3	28	3.25	1.8	44.6



On X-axis: No. of days
On Y-axis: percentage

Percentage decrease in Flexural Strength of Pervious concrete w.r.t Conventional concrete: The flexural strength values for pervious concrete and conventional concrete of 0.35W/C ratio for 3days, 7days and 28days. These values are observed for pervious concrete were 2MPa, 2.1MPa and 2.5MPa respectively and for conventional concrete were 4MPa, 5.97MPa and 6.14MPa respectively.

S. No	No. of days	Conventional concrete Flexural Strength in MPa	Pervious concrete Flexural Strength in MPa	% Decrease
1	3	4	2	50
2	7	5.97	2.1	64.8
3	28	6.14	2.5	59.3



On X-axis: no. of days
On Y-axis: percentage

IV. Conclusions

The following Conclusions are made from the Experimental investigation in present thesis:

- The percentage decrease in compressive strength in pervious concrete is 50 to 75% compared with conventional concrete.
- The percentage decrease in split tensile strength in pervious concrete is 45 to 50% compared with conventional concrete.

- The percentage of void ratio is increased to 4% in pervious concrete as compared with conventional concrete. So that the permeability also high.
- Density is 30% decreases in pervious concrete compared with conventional concrete.
- By observing the all parameters comparing between pervious concrete and conventional concrete both are quite different.

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List of referred Indian Standard (IS) code books:

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2. I.S. 383-1970 Specification for Coarse and Fine Aggregate from Natural sour for concrete
3. I.S. 456-2000 Indian Standard Plain Reinforced Concrete- code of Practice
4. I.S. 10262-1982 Recommended concrete Mix Design.