Strength Characterstics of Pervious Concrete Based on W/C Ratio

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Abstract- *Pervious concrete or no-fine concrete is a concrete containing little or no-fine aggregates, it mainly consists of coarse aggregate & cement paste. By this paper, the study of strength characteristics, physical properties of pervious concrete are done with partial replacement of cement with waste glass powder and coarse aggregates by waste Ceramic tile chips and to increase strength small quantity of Polypropylene fibre is added. The study is conducted by replacing 10% cement & 10% of ceramic tiles, 20% cement & 20% of ceramic tiles, 30% cement & 30% of ceramic tiles cumulatively. By casting cubes of 150X150X150 mm dimensions and cylinders of 150mm diameter, 300mm height are used to calculate compressive strength and split tensile strength respectively.*

Keywords- Pervious concrete, Glass powder, Ceramic tiles, Polypropylene fibre, Compressive strength, Split Tensile strength.

I. INTRODUCTION

1.1 CONCRETE

Concrete can be considered as a composite material and for reducing the cost of concrete, greater use of pozzolanic materials like fly-ash; waste glass powder and blast furnace slag were suggested. The replacement of these materials as a substitute material in concrete would decrease the disposal problem that was generally faced by many thermal power plants and industrial plants and also achieving the required strength of concrete.

1.2 PERVIOUS CONCRETE

1.2.1 History

Pervious concrete is made using large aggregates with little to no fine aggregates. The cement paste then coats the aggregates and allows water to pass through the concrete slab. Pervious concrete is traditionally used in parking areas, areas with light traffic, residential streets, pedestrian walkways, and greenhouses. It is an important application for sustainable construction and is one of many low impact development techniques used by builders to protect water quality.

Pervious concrete may also be called permeable concrete, porous concrete, no-fines concrete or gap graded concrete. Carefully controlled amounts of water and cement combine to form a thick paste around the aggregate particles while eliminating all, or most of, the sand, creating a substantial void content. Typically, 15% to 25% voids are achieved, allowing a high flow rate of water through the concrete.

1.2.2 Construction

Pervious concrete consists of cement, coarse aggregate and water with little to no fine aggregates. The addition of a small amount of sand will increase the strength. The mixture has a water-to-cement ratio of 0.28 to 0.40 with a void content of 15 to 25 percent.

The correct quantity of water in the concrete is critical. A low water to cement ratio will increase the strength of the concrete, but too little water may cause surface failure. Proper water content gives the mixture a wet-metallic appearance.

1.2.3 Benefits of Pervious concrete

- Helps in saving precious water which otherwise goes to drains.
- Helps in keeping earth below wetter, greener and cooler.
- Recharging ground water level.
- Replace costly water harvesting systems.
- Eliminates use of asphalt which normally causes environmental pollution.
- Eliminates the need of costly water drainage systems.
- Rough texture thus avoiding skidding of vehicles.
- Low maintenance cost.
- Stronger and durable for light traffic loads.

1.3 GLASS

Glass has number of properties that make it a very attractive for a variety of concrete products. Because it has zero water absorption, it is one of the most durable materials known to man. The excellent hardness of glass gives the concrete an abrasion resistance that can be reached only with few natural stone aggregates.

1.4 POLYPROPYLENE FIBRE

Polypropylene fibre is a type of synthetic fibre which is man-made materials that can withstand the long term alkaline environment of concrete. It is added to concrete before or during the mixing operation. The use of synthetic fibers at a typical addition rates does not require any mix design changes. The most widely available plastic fibre in construction is polypropylene and polyester. While polyester fibres are potentially susceptible to alkaline hydrolysis, no such adverse effects have been reported in the field.

1.5 CERAMIC TILES

A ceramic is an inorganic, nonmetallic, solid material comprising metal, nonmetal or metalloid atoms primarily held in ionic and covalent bonds. Varying crystalline and electron consumption in the ionic and covalent bonds cause most ceramic materials to be good thermal and electrical insulators (extensively researched in ceramic engineering). With such a large range of possible options for the composition/structure of a ceramic (e.g. nearly all of the elements, nearly all types of bonding, and all levels of crystalline), the breadth of the subject is vast, and identifiable attributes (e.g. hardness, toughness, electrical conductivity, etc.) are hard to specify for the group as a whole.

Table 1.1 Interfacial Bond Strengths For Synthetic Fibers

Fibre	Fibre Geometry	Shear Bond Strength (M)
Polypropylene	Monofilaments	0.7 – 1.2
	Roving	0.1
	Fibrillated	0.2 – 0.4
Polyacrylic	Monofilaments	3 – 4
Polyester	Monofilaments	0.1 – 0.2
Polyamide(Nylon)	Monofilaments	0.1 – 0.2
Polyaramid(Kevlar)	Roving	3.8

II. MIX DESIGN

2.1 TEST DATA FOR MATERIALS

Specific gravity of cement = 3.15
Specific gravity of coarse aggregate = 2.66
Specific gravity of polypropylene fibre = 0.9

2.2 WATER CEMENT RATIO

Assumed water-cement ratio = 0.3
Assumed water content =160
liters =0.16m^3

2.3 CEMENT

Cement content =533kgs
Volume of cement = 0.169m^3

2.4 COARSE AGGREGATES

Volume of aggregate =1-0.16-0.169 = 0.671m^3
Volume of coarse =0.670m^3
Volume of fiber =0.001m^3
Weight of water =0.16 X 1000 = 160kgs
Weight of cement=0.169 X 3.15 X 1000 = 532.5kgs =533kgs
Weight of coarse =0.670 X 2.66 X 1000 = 1782.2kg = 1782kgs
Weight of fiber =0.001 X 0.9 X 1000 = 0.9kg = 1kgs

Table 2 Materials required for normal pervious concrete per m^3

Material	kg/m^3	Ratio
Water	160	0.3
Cement	533	1
Coarse aggregate	1782	3.343
Polypropylene fibre	1	0.001

2.5 BATCHING FOR CUBES

Volume of cube = 150*150*150 = 0.003375m^3

2.5.1 Weight per 1 cube:

Material for single cube (in kg) = (Volume of cube)*(Weight of material per m^3)

Water =0.54kg
Cement =1.8kgs
Aggregate =6.01kgs
Polypropylene fibre =6 grams

Table 3 Quantity of materials per Cube without replacements

Water	540 ml
Cement	1800grams
Coarse aggregate	6000grams
Fiber	6grams

Table 4 Quantity of materials per Cube with 10% ceramic tiles & 10% glass

Water	540 ml
Cement	1620 grams
Glass powder	180 grams
Coarse aggregate	5400 grams
Ceramic tiles	600 grams
Fiber	6grams

Table 5 Quantity of materials per Cube with 20% ceramic tiles & 20% glass

Water	540 ml
Cement	1440 grams
Glass powder	360 grams
Coarse aggregate	4800 grams
Ceramic tiles	1200 grams
Fiber	6grams

Table 6 Quantity of materials per Cube with 30% ceramic tiles & 30% glass

Water	540 ml
Cement	1220 grams
Glass powder	540 grams
Coarse aggregate	4200 grams
Ceramic tiles	1800 grams
Fiber	6grams

2.6 BATCHING FOR CYLINDERS

Volume of cylinder $=\pi r^2 * h = 0.0053m3$

2.6.1 Weight per 1 cylinder:

Material for single cylinder (in Kg) = Volume of cylinder X Weight of material per m^3

Water = 0.848kg= 850 ml

Cement =2.83kg= 2830gr

Aggregate =9.5kg = 9500gr

Table 7 Quantity of materials per cylinder without replacements

Water	850 ml
Cement	2830 grams
Coarse aggregate	9500 grams
Fiber	10 rams

Table 8 Quantity of materials per cylinder with 10% ceramic tile & 10% glass

Water	850 ml
Cement	2547grams
Glass powder	283grams
Coarse aggregate	8500 grams
Ceramic tiles	950 grams
Fiber	10 rams

Table 9 Quantity of materials per cylinder with 20% ceramic tile & 20% glass

Water	850 ml
Cement	2264 grams
Glass powder	566 grams
Coarse aggregate	7600 grams
Ceramic tiles	1900 grams
Fiber	10 rams

Table 10 Quantity of materials per cylinder with 30% ceramic tile & 30% glass

Water	850 ml
Cement	1981 grams
Glass powder	849 grams
Coarse aggregate	6650 grams
Ceramic tiles	2850 grams
Fiber	10 rams

III. RESULTS AND DISSCUSIONS

3.1 7-DAYS' COMPRESSIVE STRENGTH

Table-11 7-Days' compressive strength

S. No	Replacement (%)	Trail – 1 (N/mm^2)	Trail – 2 (N/mm^2)	Trail – 3 (N/mm^2)	Average value (N/mm^2)
1	0%	8.70	8.62	8.49	8.60
2	10%	8.87	8.79	8.65	8.7
3	20%	9.48	9.40	9.17	9.35
4	30%	8.43	8.35	8.23	8.33

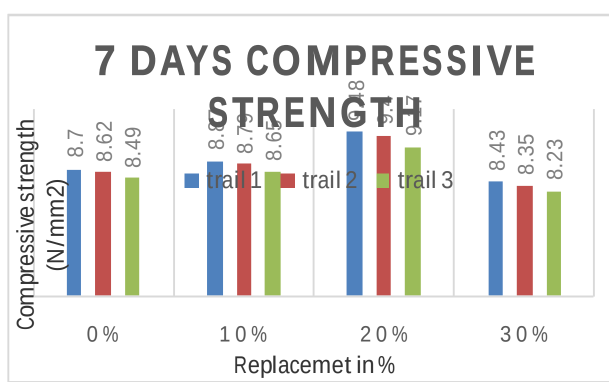

Fig 1 Graphical representation for 7 days' compressive strength

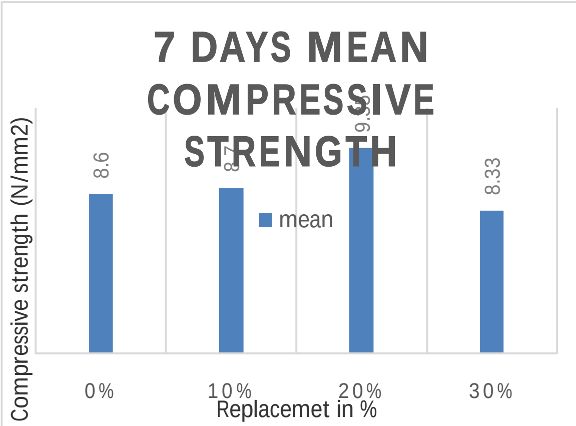

Fig 2 Graphical representations for 7 Days' mean compressive strength

3.2 28-Days' compressive strength

Table-12 28-Days' compressive strength

S.No	Replacement (%)	Trail – 1 (N/mm^2)	Trail – 2 (N/mm^2)	Trail – 3 (N/mm^2)	Average value (N/mm^2)
1	0%	14.49	14.36	14.15	14.33
2	10%	15.07	14.94	14.86	14.96
3	20%	16.37	16.51	16.13	16.40
4	30%	13.91	13.93	13.73	13.86

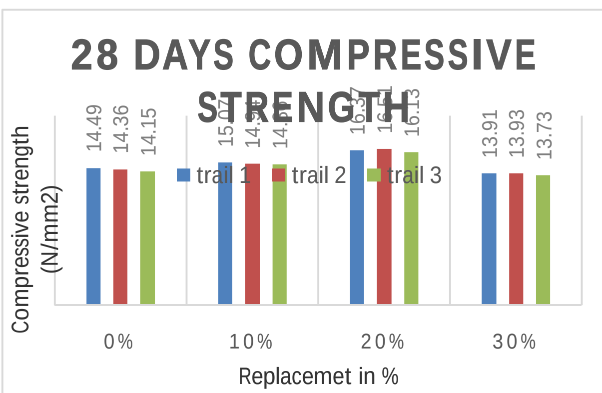

Fig 3 Graphical representation for 28 days' compressive strength

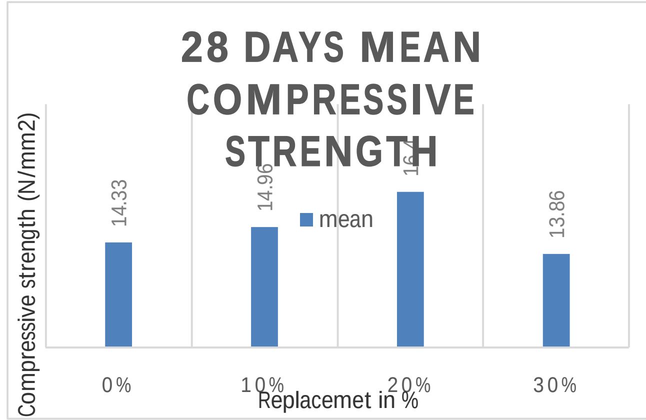

Fig 4 Graphical representations for 28 Days' mean compressive strength

3.3 7-Days' Split tensile strength

Table-13 7-Days' split tensile strength

S.No	Replacement (%)	Trail – 1 (N/mm^2)	Trail – 2 (N/mm^2)	Trail – 3 (N/mm^2)	Average value (N/mm^2)
1	0%	0.203	0.192	0.186	0.194
2	10%	0.211	0.199	0.192	0.200
3	20%	0.221	0.210	0.204	0.212
4	30%	0.190	0.183	0.180	0.185

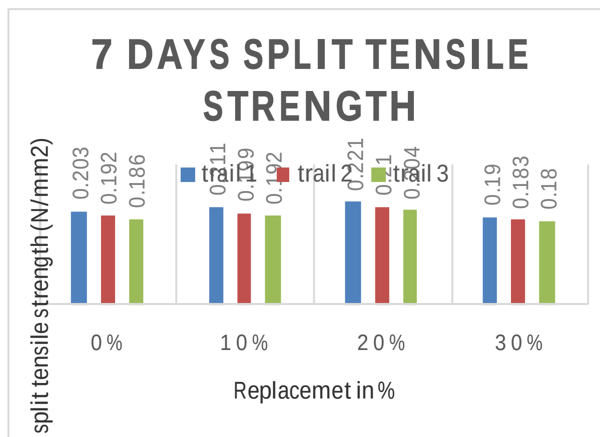

Fig 5 Graphical representation for 7 days' split tensile strength

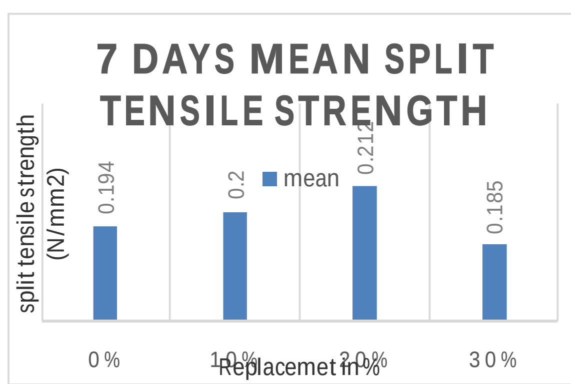

Fig 6 Graphical representation for 7 days' mean split tensile strength

3.4 28-Days' split tensile strength

Table-13 28-Days' split tensile strength

S. No	Replacement (%)	Trail – 1 (N/mm^2)	Trail – 2 (N/mm^2)	Trail – 3 (N/mm^2)	AveragegValue (N/mm^2)
1	0%	0.338	0.319	0.310	0.322
2	10%	0.347	0.332	0.326	0.335
3	20%	0.378	0.361	0.356	0.365
4	30%	0.314	0.306	0.300	0.306

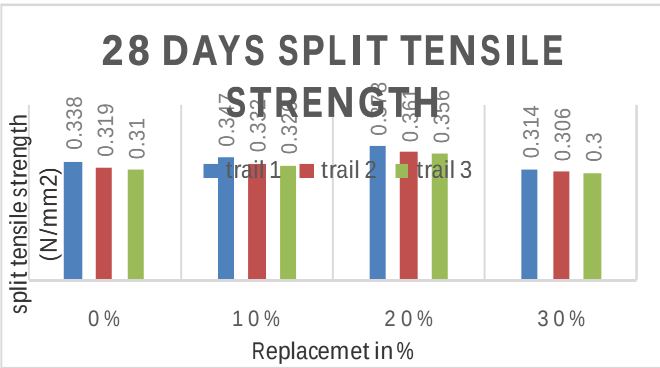

Fig 7 Graphical representation for 28 days' split tensile strength

Fig 8 Graphical representation for 28 days' mean split tensile strength

3.5 Mean Compressive strength values for replacement of cement by glass powder & coarse aggregate by ceramic tile.

S. No	Replacement (%)	7-days				28-days			
		Trail-1	Trail-2	Trail-3	Avg value	Trail-1	Trail-2	Trail-3	Avg value
1	0%	8.70	8.62	8.49	**8.60**	14.49	14.36	14.15	**14.33**
2	10%	8.87	8.79	8.65	**8.7**	15.07	14.94	14.86	**14.96**
3	20%	9.48	9.40	9.17	**9.35**	16.37	16.51	16.13	**16.40**
4	30%	8.43	8.35	8.23	**8.33**	13.91	13.93	13.73	**13.86**

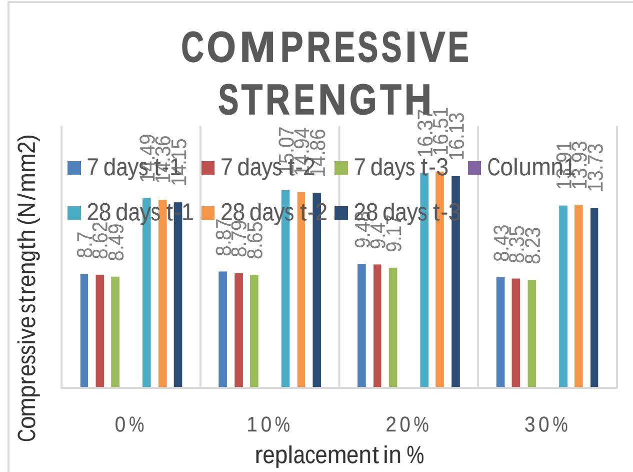

Fig 9 Graphical representation for compressive strength values

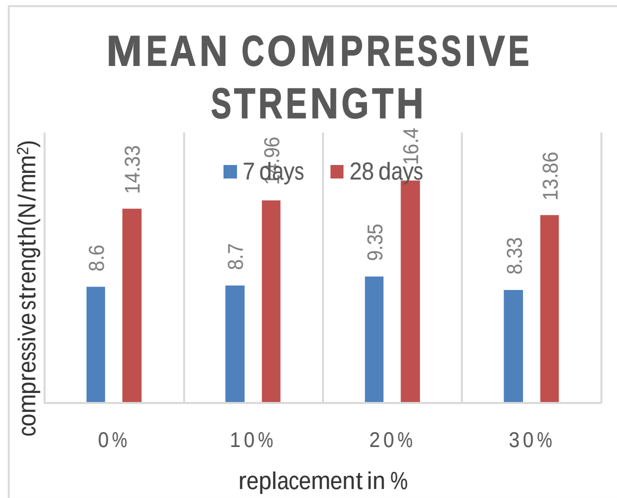

Fig 10 Graphical representation for mean compressive strength

3.6 Discussions

From the above results for compressive strength of concrete after 28 days curing we can conclude that the results are satisfactory as no loss in compressive is observed.

While to standard pervious concrete with no replacements the obtained results are as follow:

- With replacement of 10% we observe 5% increases in compressive strength.
- With replacement of 20% we observe 14% increases in compressive strength.
- With replacement of 30% we observe 3% decreases in compressive strength.

3.7 SPLIT TENSILE STRENGTH VALUES FOR REPLACEMENT OF CEMENT BY GLASS POWDER & COARSE AGGREGATE BY CERAMIC TILE.

Table 6.6 Split tensile strength Values

S. No	Replacement (%)	7-days				28-days			
		Trail-1	Trail-2	Trail-3	Avg value	Trail-1	Trail-2	Trail-3	Avg value
1	0%	0.203	0.192	0.186	**0.194**	0.338	0.319	0.310	**0.322**
2	10%	0.211	0.199	0.192	**0.200**	0.347	0.332	0.326	**0.335**
3	20%	0.221	0.210	0.204	**0.212**	0.378	0.361	0.356	**0.365**
4	30%	0.190	0.183	0.180	**0.185**	0.314	0.306	0.300	**0.306**

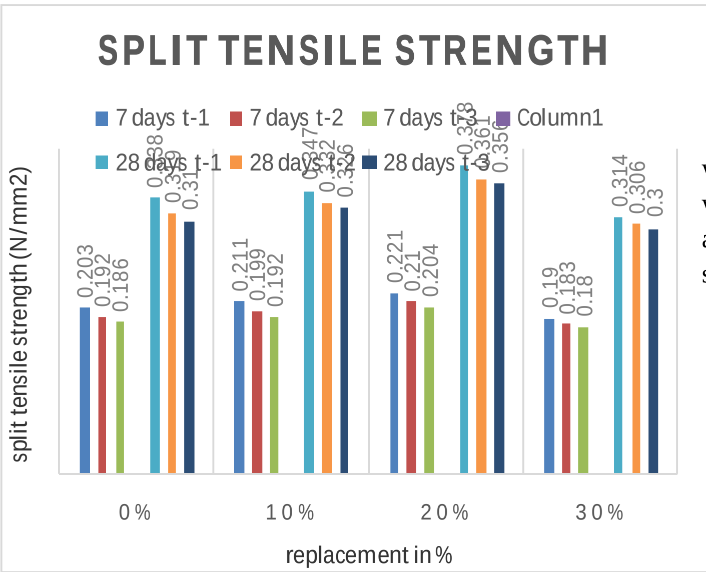

Fig 11 Graphical representation for split tensile strength values

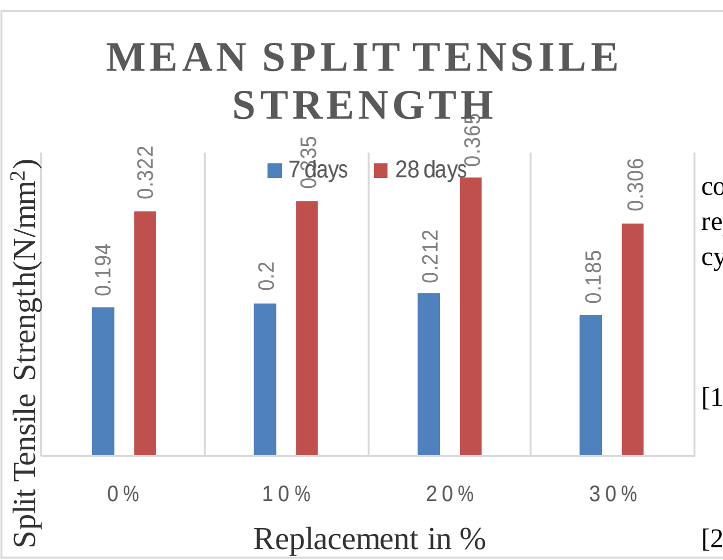

Fig 12 Graphical representations for mean split tensile strength

3.8 Discussions

From the above results for split tensile strength of concrete after 28 days curing we can conclude that the results are satisfactory as no heavy loss is observed.

While to standard pervious concrete with no replacements the obtained results are as follow:

- With replacement of 10% we observe 4% increases in split tensile strength.
- With replacement of 20% we observe 13% increases in split tensile strength.
- With replacement of 30% we observe 5% decreases in split tensile strength.

IV. CONCLUSIONS

From the above investigation by replacing cement with glass powder and coarse aggregate with ceramic tiles with replacement of 10%, 20% and 30% cumulatively and addition of polypropylene fibre (low content) to increase the strength we have derived following observations:

- With replacement of 10% we observe 5% increases in compressive strength.
- With replacement of 20% we observe 14% increases in compressive strength.
- With replacement of 30% we observe 3% decreases in compressive strength.
- With replacement of 10% we observe 4% increases in split tensile strength.
- With replacement of 20% we observe 13% increases in split tensile strength.
- With replacement of 30% we observe 5% decreases in split tensile strength.

From the above study, we conclude that the compression strength of concrete has attained peak value at replacement of 20%, split tensile strength of concrete cylinders has also attained peak value at replacement of 20%.

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