Experimental Investigation on Enhancing the Strength of Porous Concrete by adding Polypropylene Fiber

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Abstract. Porous concrete has its application in many fields. Mainly for drainage purpose porous concrete can be used as a covering as well as to drain the liquid. Strength is only drawback in the porous concrete as the surface area contact between the coarse aggregates is less. In order to enhance the strength properties, polypropylene was used in layers. Various no of layers was introduced in the prism as well as for cube to determine the strength enhancement properties. Through experimental study it was found that strength due compressive force of the pervious concrete increases up to placing 3 layers of polypropylene geo textile fabric and get decreased after that. Similar to the compression test, the flexural strength also showed similar behaviour in the increase in strength up to the 3no of layers. Similarly, porosity test was carried to find the effect of porosity due to PP layers. It was found that 18.5% reduction in porosity was noted when 3 layers of PP were incorporated.

Keywords. Concrete, Properties, Strength, Layers, Experimental study.

1. Introduction
Porous concrete is a pervious material used for paving, and that which allows rain water, storm water runoff and other run-off water to drain through it, without allowing the water to surround the area. Porous concrete, sometimes referred as pervious concrete or Enhanced Porosity Concrete (EPC) is a macro-porous concrete that is rapidly gaining fame around the world because of its beneficial applications in sustainable construction considering cost and application. [1]

It is lucid, evident fact that, mechanical behaviour of a building material solely depends on the properties of its composted structure. The presence of voids can contribute adversely to the material’s mechanical properties such as strength at failure, elasticity and creep strains. [3]

Pervious concrete differs from the conventional concrete in terms of no. of voids present in it. In the current scenario, it is intensively utilized in permeable pavements and beds for infiltrating the run-off drainage. For enhancing the benefit of its strength, numerous research studies have been done to expose the affiliation between porosity features and the hydraulic or acoustic conductivity of pervious concrete. [2]

Nevertheless, as a material for construction, pervious concrete also desires to be able to endure the various traffic loads. It is furthermore imperative to regulate how; mechanical performance is effected by the incidence of pores. In a preceding experimental exploration, the strength due to compression of pervious concrete has been tried. [6] This testing might be sighted as a key to portray the mechanical capacity of pervious concrete in this research. Conversely, the pore arrangement of a
pervious material can be considered by a number of constraints comprising size of the pore, pore connectivity, roughness of the surface pore and porosity. Generally, the strength of a pervious material is prejudiced by porosity, the other constraints having less impact. [7]

2. Geo Textile Fabric
Nonwoven geo textiles are pervious geo synthetics, comprised of nonwoven materials used with soil, rock, or other soil-associated material as an fundamental part of a construction project, structure, or system. These are made recurrently made from synthetic polymers like as polypropylene, polyester etc.along with natural fibers such as jute, sisal, and coir. [5]

Moreover, the geo textile aspects , which are unswervingly associated to the functions include tensile strength and elongation index, resistance to puncture, resistance to dynamic perforation, water permeability characteristics like opening size, water flow capacity and diverse durability for several solicitations.[10]

3. Materials used
Ordinary Portland cement of grade 53 was used for the experimental purpose. The specific gravity of the cement was found to be 3.15 with fineness of about 9.5%. Consistency was found to be 33% with the initial setting time 38 and final setting time 613 minutes respectively. [1]

Coarse aggregate occupies 70 to 80 percent of the volume of concrete. The crushed stone aggregates were poised from the native quarry. The characteristics of coarse aggregate were assessed as per the procedures given in IS:383-1970 and IS2386-1963 (part I, II, and III). [15] The aggregate used were having specific gravity value of about 2.66. A major proportion of the coarse aggregates were in the size of about 20mm and 12.5mm. The fineness modulus of the aggregates was 7.1.

The density of poly propylene (PP) ranges around 0.895 and 0.92 g/cm³. [7] Consequently, PP is a low density commodity plastic. With lesser density, moulding can easily plausible. Like, polyethylene, crystalline and amorphous sections diverge only marginally in their density. Nevertheless, the density of polyethylene can considerably vary with fillers.

4. Mixing and Placing
Concrete was mixed by handing. Initially materials were weighted and taken as per mixed design specifications. The ratio of cement mortar used was maintained in the ratio of 1:3. Layers of PP was placed at specific heights in cube and prism.

| Mix Ratio | No. of Layers | Spacing Between Layers (Cm) |
|-----------|---------------|-----------------------------|
| 1:3       | 2             | 5                           |
| 1:3       | 3             | 4                           |
| 1:3       | 4             | 3                           |
5. Mechanical Properties

5.1 Compressive strength

For compression test, 150mm x 150mm x 150mm cubes were used. All cubes were tested in unsaturated condition, after wiping tout the surface moisture. All the specimens were tested after 28 days of curing.

Table 2. Compressive strength test results

| Sample | Spacing Between Layers | No. of Layers | Load (KN) | Compressive Strength (28 Days) (N/mm²) |
|--------|------------------------|---------------|-----------|---------------------------------------|
| S0     | -                      | -             | 217       | 9.65                                  |
| S1     | 5                      | 2             | 230       | 10.2                                  |
| S2     | 4                      | 3             | 251       | 11.01                                 |
| S3     | 3                      | 4             | 245       | 10.85                                 |

It can be referred from the above table that the strength due to compression of the pervious concrete upsurges up to placing the 3 layers of polypropylene geo textile fabric and get decreased after that. The maximum compressive strength attained in 3 nos of polypropylene geo textile fabric layer. A 11% strength increase was found when placing 3 no of layers.
5.2 Flexural strength
For flexural strength test, 100mm x 100mm x 50mm prism were used. All prism was tested in unsaturated condition, after wiping tout the surface moisture.

| Sample | Spacing Between Layers | No of Layers | Load (KN) | Flexural Strength(28 Days) (N/mm²) |
|--------|------------------------|--------------|-----------|-----------------------------------|
| S0     | -                      | -            | 1.6       | 0.8                               |
| S1     | 5                      | 2            | 2.6       | 1.3                               |
| S2     | 4                      | 3            | 3.6       | 1.8                               |
| S3     | 3                      | 4            | 3.0       | 1.6                               |

It can have referred from the above table that the flexural strength of the pervious concrete also increases up to placing the 3 layers of poly propylene geo textile fabric and get decreased after that similar to that of the compression test results. The maximum flexural strength attained in 3 no’s of poly propylene geo textile fabric layer. A 50% strength enhancement was found in placing 3 no of layers.

5.3 Porosity Test Results
The active porosity was found out by testing the volume of water exiled by samples. The sample was primarily oven dried at 110 °C followed by immersing in water for up to 24 h. By gauging the difference in the level of the water before and then after submerging the sample, the volume of water deterred by the sample (Vd) can be gladly determined. Deducting Vd from the sample bulk volume (Vb) yields the volume of open pores. This volume is then articulated as a percentage as an active porosity. [11]

| Sample | No of Layers | Porosity% |
|--------|--------------|-----------|
| S0     | 0            | 37.2      |
| S1     | 2            | 34.85     |
| S2     | 3            | 30.31     |
| S3     | 4            | 29.56     |

The porosity was found to be reducing with each no PP layers being placed. The main reason for the reduction in the porosity is that the PP layers’ act as a filter layer arresting water molecule to penetrate into the voids of the concrete. A 18.5% reduction in porosity was noted when placing 3 no PP layers.
6. Conclusion

Pervious concrete commonly uses polypropylene Geo textile fabric for durability improvements. Polypropylene Geo textile fabric, a more reliable material can be used pervious concrete to improve flexibility. [8] Preceding to this investigation, no direction occurred in the addition of ideal dosage rates or the effect Geo fabric length on porous concrete attributes. Precise concern for this investigation were mainly due to the impacts on durability and on the resistance to abrasion. Layers of Geo textile were added to assess the impact of compression and flexure. [15]

Comparative analysis was carried out to determine the porosity nature altered by the usage of Geo textiles. Permeation ability was 3–8 times fewer than the dignified permeability for the identical mixture, with permeability outcomes much more inconstant. [14] The accumulation of Geo textile fabric declined both the permeability and infiltration capacity to a definite percentage. Approvingly, the layer of fibres improved the strength parameters, due to the higher percentage of material compaction. However, the optimised dosage level was determined with respect to strength and porosity parameter. [2]

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