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Experimental Investigation on Maximum Strength of Pervious Concrete Using Different Size of Aggregates

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Abstract

Concrete is an important material in construction. The main properties desired in concrete are that it should have high strength, low permeability and good workability etc. Due to urbanization, large area is being converted from bare land to concrete surface with the construction of buildings, roads, parking areas etc. Therefore, runoff occurs with greater peak flow causes flooding, choking of sewerage line. Due to which maintenance cost of infrastructure increases. So there is need to have concrete with more porosity having adequate strength so that lesser runoff is generated from areas paved with concrete. Pervious concrete is a concrete mixture comprised of cement, controlled amounts of water and uniformly graded coarse aggregate, little or no sand and sometimes other additives. Pervious concrete offers an attractive solution to the problem of excessive runoff. Experimental investigation on tensile strength and compressive strength will be conducted to find out the maximum strength of pervious concrete by varying sizes of coarse aggregates and water cement ratio.

Keywords: *Pervious concrete, porosity, permeability, runoff*

1. Introduction

Over the last few years, pervious concrete has become a very relevant topic in the construction industry. More and more specifications call for pervious concrete in different applications. Some of these applications include parking lots, sidewalks and even pavers where in the past these were solely the domain of conventional concrete or black top. The popularity of pervious concrete continues to rise with the increased awareness of environmental protection and preservation. Pervious concrete is recognized by United States Green Building Council (USGBC), which sets the green building rating system known as the LEED program (The Leadership in Energy and Environmental Design).

Pervious concrete, sometimes referred to as “no-fines concrete,” is a mixture of hydraulic cement, coarse aggregate of smaller size, admixtures and water. Pervious concrete allows the water to percolate through the concrete into the sub-base and recharge the underground water level. Typically, pervious concrete does not contain any sand and its air void content varies between 15 and 30%. A small amount of sand can be used for compressive strength improvement but air void content will be reduced and permeability lowered. It is important to maintain the proper volume of paste/mortar in the mix design so that the aggregate is equally coated but the excess of paste/mortar does not fill the void space within coarse aggregate. Voids within the pervious concrete should be interconnected so they create channels through which water can freely flow.

Pervious concrete can be used for light-duty pavement in situations where it is desirable to have storm water percolate through the pavement into the permeable base. Drainage rate will vary with aggregate size and density of the mix, but will commonly fall into the range of 3 to 5 gallons per minute, per square foot. It is particularly useful in areas where state or local regulations require that storm water be retained on site to recharge the groundwater system. Admixtures can be added to the concrete mixture to enhance strength, increase setting time, or add other properties. The thickness of pervious concrete ranges from 4 to 8 inches depending on the expected traffic loads.

2. Experimental Materials

Pervious Concrete is a mixture of Cement, Coarse Aggregate / Gravel and Water. Ordinary Portland cement is used in all mixes and crushed gravel is used as coarse aggregate. Potable water was used for the experimentation. Four sized coarse aggregate namely, 4.75mm to 9mm, 9mm to 12.5mm, 12.5mm to 16mm and 16mm to 20mm is used. Pervious Concrete has been casted with different water cement ratio 0.35, 0.4 and 0.45. The properties of OPC 53 grade cement is given in table 1.

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Table -1: Physical Properties of Cement

Properties	*Value*	*IS Specification*	*IS Code*
Specific gravity	3.13	3.15	IS 12269:1976
Standard consistency (%)	31%	30-35	IS 12269:1976
Initial setting time in minutes	90	>30 min	IS:4031 & IS1489
Compressive strength (N/mm^2)	51.8	>37	IS 12269:197 6

Aggregate occupies more than 70% of the volume of concrete and contributes significantly to the structural performance of concrete, especially strength, durability and volume stability. Four sizes of coarse aggregates are used in this study, 4.75mm to 9mm, 9mm to 12.5mm, 12.5mm to 16mm and 16mm to 20mm. Fine aggregates generally consist of natural sand or crushed stone with, most of which passes 4.75mm IS sieve. And the properties of aggregates are tabulated in table 2 and 3.

Table-2: Properties of Coarse Aggregates

Properties	*Coarse aggregate (mm)*				*IS specifications*	*IS code*
	16 to20	*12.5 to 16*	*9 to 12.5*	*4.75 to 9*		
Specific gravity	2.67	2.67	2.67	2.67	2.5-2.9	IS 383-1970
Bulk density	1.56	1.55	1.54	1.53	2	IS 383-1970

Table-3: Properties of Fine Aggregates

Properties	*Fine aggregate*	*IS specifications*	*IS code*
Specific gravity	2.73	2.5-2.9	IS 383-1970
Fineness modulus	4.31	2.6-2.9	IS 383-1970
Bulk density	1.55	2	IS 383-1970

2. Experimental Investigations

Twelve mixes of pervious concrete are been made as per Cosic *et al* [1] and specimens are casted to test for compressive strength and tensile strength.

2.1 Compressive Strength on Cube

The main aim is to determine the compressive strength of concrete specimen. The test specimens, cubical in shape of size 150x150x150 mm are used. Compression tests are conducted at 28 days of the casting of specimens. Specimens cured in the water where tested immediately on removal from water and while they are still in wet condition.

The load applied without shock and continuously at a rate approximately 140 kg/cm/minute until failure of the specimen. The maximum load applied to the specimen until a failure recorded. Then based on the load value the compressive strength of the concrete specimen calculated as follows.

Compressive strength=ultimate load/contact area of the cube

2.2 Tensile Strength on Cylinder

A standard test cylinder of concrete specimen of size 300mm x 150mm is used to determine the split tensile strength. The test is done using compression testing machine.

3. Results and Discussions

Specimen are been tested to obtain the results and are shown in table 2. Result shows that pervious concrete with aggregate size 12.5 to 16mm have higher compressive strength and tensile strength. And there is a fall in strength on further increased size of aggregate i.e, for pervious concrete with aggregate size 16 to 20mm.

Table -4: Test Result of pervious concrete

Aggregate Size (mm)	*Water-Cement Ratio*	*Compressive Strength (N/mm^2)*	*Tensile Strength(N/mm^2)*
4.75 to 9	0.35	18.45	1.71
	0.4	20.26	1.97
	0.45	21.11	2.42
9 to 12.5	0.35	19.81	1.84
	0.4	22.43	2.12
	0.45	27.64	2.87
12.5 to 16	0.35	27.69	2.53
	0.4	34.71	2.55
	0.45	35.46	3.13
16 to 20	0.35	23.43	2.41
	0.4	26.35	2.52
	0.45	34.42	2.87

The relation between compressive strength and w/c, flexural strength and w/c, tensile strength and w/c and

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porosity and w/c are plotted below. Figure 1 shows that compressive strength of pervious concrete with aggregate size 12.5 to 16mm is higher with w/c 0.45 compared to other aggregate sizes.

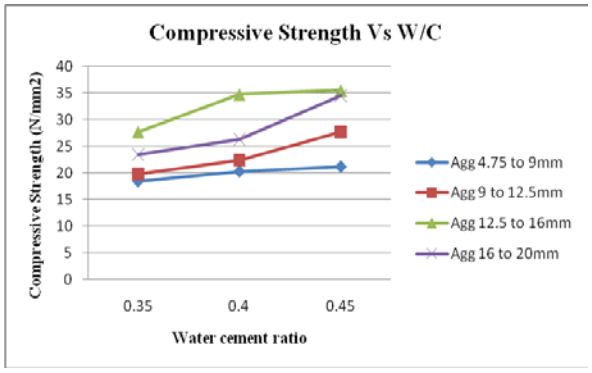

Fig.1 Compressive Strength Vs W/C

Figure 2 shows that tensile strength of pervious concrete with aggregate size 12.5 to 16mm is higher with w/c 0.45 compared to other aggregate sizes.

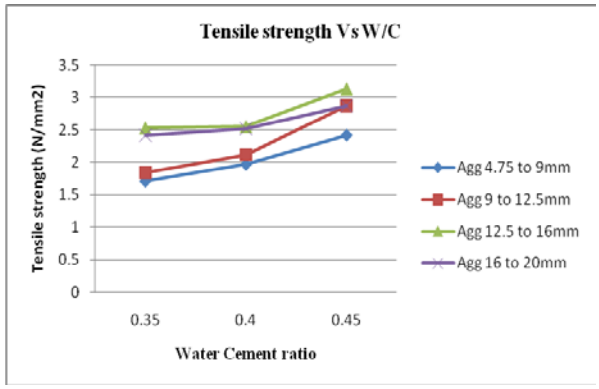

Fig.2 Tensile Strength Vs W/C

4. Conclusions

1. Compressive strength and tensile strength of four sized coarse aggregate namely, 4.75mm to 9mm, 9mm to 12.5mm, 12.5mm to 16mm and 16mm to 20mm with w/c ratio 0.35, 0.4 and 0.45 are investigated.
2. It was found that by increasing w/c, strength of pervious concrete is increased.
3. For the same w/c, strength of pervious concrete increases with increase in aggregate size.
4. And the maximum strength is obtained for the aggregate with size 12.5mm to 16mm for all w/c in comparison to other sizes of aggregate.

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