

# **An Experimental Study on Performance of Pervious Concrete Using Partial Replacement of Recycled Concrete Aggregate**

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**ABSTRACT:** Pervious concrete differs from the conventional concrete since it usually contains no or smaller amount of fine aggregate. When pervious concrete is used for paving, the open cell structures allow storm water to filter through the pavement and into the underlying soils. This pavement technology creates more efficient land use by eliminating the need for retention ponds, swells, and other costly storm water management devices. Generally, it has low strength and very good permeability. Therefore, in the present study an experimental study was done on pervious concrete using two different sizes of aggregate 8-12mm and 16-20mm with partial replacement of coarse aggregate by 0%, 50%, 100% of Recycled Concrete aggregate (RCA). It is concluded that the usage of aggregate size 8-12mm with 50% RCA shows higher compressive strength and infiltration rate for both the aggregate sizes with 0% RCA shows higher values.

**KEYWORDS :** Pervious concrete, Recycled Concrete aggregate, Compressive strength, infiltration rate, Aggregate size.

## **I. INTRODUCTION**

Development of High Rise buildings and Highways forms an impervious surface on earth leading to improper recharging of groundwater, imbalance ecosystem, erosion, floods, etc.. A simple solution to avoid these problems is to stop constructing impervious surfaces and switch to pervious concrete or porous pavement, a material that offers the inherent durability and low-life cycle costs of a typical pavement while retaining storm water runoff and replenishing local water-shed systems. Generally, the sizes of connected pores in pervious concrete ranges from 2 to 8mm in diameter with void content 15% to 35% and compressive strength between 2.8 to 28 MPa. For a given set of materials, the strength and infiltration rate of pervious concrete is a function of concrete density. Greater the density, higher is the strength and lower the infiltration rate. The infiltration rate of pervious concrete lies in the range of 2 to 30mm/sec. and the densities lies between 1600 kg/m<sup>3</sup> to 2000 Kg/m<sup>3</sup>. In recent years, the demolished waste is necessary to produce new product suitable for the environment. The global construction industry uses billion tons of cement and billion tons of sand, gravel and crushed rock every year. The use of waste materials as a source of aggregate in new construction materials has become more common in recent decades. The depletion of the existing landfills and the scarcity of natural resources for aggregates encourage the use of construction and demolition waste as a source of aggregates in the production of new concrete. Hence, in the present work an attempt is made to explore the possibility of using recycled concrete aggregate as a partial replacement of coarse aggregate in pervious concrete.

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## II. LITERATURE REVIEW

In the present work, an attempt was made to collect the available literature on the performance of pervious concrete by using partial replacement of recycled concrete aggregates. Here some of the main literature review were presented.

Dr.V.L.Narasimha et al [3] studied the development of environmental friendly material-porous concrete. They concluded that the increase in variation of cement content and percentage of addition of fine aggregate leads to increase in compressive strength, flexural strength and split tensile strength. And also coefficient of permeability decreases with increase in variation of cement content. Rabiah Rizvi et al[6] studied the incorporation of recycled concrete aggregate in pervious concrete pavements. It was determined that the optimum replacement percentage for RCA is 15% as it does not significantly affect the pervious concrete. S.Deepika et al [2] studied the influence of recycled aggregate based pervious concrete with flyash. The result shows that the use of fully recycled aggregates gave desirable results in both strength and infiltration when compared to partially replaced RCA. Tejas Joshi et al [5] discusses various combination of pervious concrete with different aggregate size and w/c ratio. It was found that using 0.3 w/c ratio gives better strength and the density increases with increase in compressive strength.

Literature review indicates that pervious concrete can be used as a sustainable material. Therefore, the aim and objective of the present study is to carry out an experimental study on performance characteristics of pervious concrete by using partial replacement of recycled concrete aggregate.

## III. EXPERIMENTATION AND METHODOLOGY

### 1. Cement

Cement used in the present study was Ordinary Portland Cement (OPC) of 43Grade (chettinad cement). The physical properties of OPC are presented in Table 1.

**Table 1 Physical properties of Ordinary Portland Cement**

S.No	Properties	Observed Values
1.	Initial setting time of cement	15 minutes
2.	Final setting time of cement	315 minutes
3.	Consistency of cement	29%
4.	Specific gravity of cement	3.04

### 2. Coarse aggregate

Locally available 16-20mm and 8-12mm crushed aggregates have been used as coarse aggregates. The physical properties of coarse aggregate are presented in Table 2.

**Table 2 Physical Properties of coarse aggregate**

S.No	Properties	Observed Values	
		Aggregate size 8-12mm	Aggregate size 16-20mm
1.	Specific gravity of coarse aggregate	2.57	2.92
2.	Water absorption of coarse aggregate	1.42%	1.50%

### 3. Recycled concrete aggregate

The recycled concrete aggregate used for the present study was taken from a demolished building site. The aggregate sizes used are 16-20mm and 8-12mm size. The physical properties of recycled coarse aggregate are presented in Table 3.

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**Table 3 Physical Properties of Recycled Concrete Aggregate**

S.No	Properties	Observed Values	
		Aggregate size 8-12mm	Aggregate size 16-20mm
1.	Specific gravity of recycled aggregate	2.69	2.62
2.	Water absorption of recycled aggregate	3.66%	4.04%

#### 4. Super plasticizer

The super plasticizer used in the present study was ceraplast300 which is available from local market.

#### 5. PROPORTIONING OF PERVIOUS CONCRETE

The mix proportioning for pervious concrete is different than the usual mix design of normal concrete. For pervious concrete mix design codal provision is not available, the mix design is adopted based on the journals and literature review. Based on workability criteria, water- cement ratio was obtained. The mixture was reviewed for consistency by taking a handful of pervious concrete mix and creating a ball shape, the mixture was considered as too dry. If the ball had a lot of paste, the aggregate was running off and sticking to the glove, and then the mixture was considered as too wet. The range was found to be from 0.32 to 0.45. Although this was subjective, it has been considered a common practice in the industry. Therefore the mix design data used in the present work are Cement: aggregate = 1:5; W/C ratio = 0.36 ; Cement: aggregate: water = 1: 5: 0.36; Super plasticizer = 2% by weight of cement. For Conventional Concrete, M20 Grade (1: 1.5: 3) was used.

#### 6. TESTING OF SPECIMENS

##### (a) Compressive Strength Test

The compressive strength of pervious concrete has been evaluated on hydraulic testing machine. For the compressive strength test, cubes of size 150mm x 150mm x 150mm are tested in compression testing machine according with the test procedures given in IS: 516-1959.

$$\text{Compressive strength} = \text{load/area in (N/mm}^2\text{)}$$

##### (b) Infiltration Rate Test

The size of the cylinder specimen used was 200mm height and 120mm diameter. The falling head permeability method was used. The specimens were wrapped with a rubber membrane to ensure that the water only flows through the cross section of the specimen without any leaks along its edges. Water was allowed to flow through the sample, through a connected standpipe which provides the water head. Then the test started by allowing water to flow through the sample until the water in the standpipe reached a given lower level. A constant time of 5secs was taken for the water to fall from one head to another head in the standpipe. The standpipe was refilled and the test was repeated when water reached a lower level. The permeability of the pervious concrete sample was evaluated from the expression given below:

$$k = 2.303 aL /At \log (h1/ h2) \text{ in (mm/s)}$$

### IV RESULTS AND DISCUSSIONS

#### 1. Compressive strength of cubes for aggregate size 8-12mm

The values obtained from the compressive test on cube for aggregate size 8-12mm at 7<sup>th</sup> day, 14<sup>th</sup> day and 21<sup>st</sup> day are shown in table5 and figure1.

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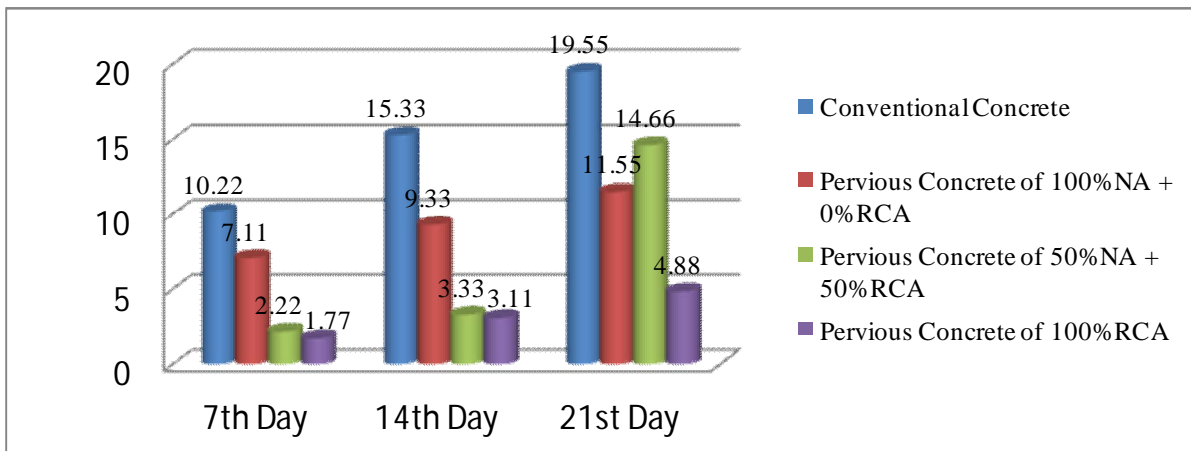
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**Table 5 Compressive strength of cubes of aggregate size 8-12mm**

Type of concrete	7 <sup>th</sup> day (N/mm <sup>2</sup> )	14 <sup>th</sup> day (N/mm <sup>2</sup> )	21 <sup>st</sup> day (N/mm <sup>2</sup> )
Conventional concrete	10.22	15.33	19.55
Pervious concrete of 100% NA + 0% RCA	7.11	9.33	11.55
Pervious concrete of 50% NA + 50% RCA	2.22	3.33	14.66
Pervious concrete 100% RCA	1.77	3.11	4.88

It is found that compressive strength increases for (50%NA + 50%RCA) as the age of the concrete increases when compared to (100%NA and 100%RCA). The pervious concrete showed significantly lower strength as compared to the normal concrete because of its high void content.



**Figure 1 Compressive strength of cubes of aggregate size 8-12mm**

### 2. Compressive strength of cubes for aggregate size 16-20mm

The values obtained from the compressive test on cube for aggregate size 16-20mm at 7<sup>th</sup> day, 14<sup>th</sup> day and 21<sup>st</sup> day are shown in table6 and figure2.

**Table 6 Compressive strength of cubes for aggregate size 16-20mm**

Type of mix	7 <sup>th</sup> day(N/mm <sup>2</sup> )	14 <sup>th</sup> day (N/mm <sup>2</sup> )	21 <sup>st</sup> day (N/mm <sup>2</sup> )
Conventional concrete	9.33	14.88	19.11
Pervious concrete of 100% NA + 0% RCA	6.22	8.88	10.66
Pervious concrete of 50%NA +50%RCA	2.00	3.11	8.88
Pervious concrete of 100% RCA	1.55	2.88	4.44

It is found that compressive strength increases for 100%NA as the age of the concrete increases when compared to (50%NA + 50%RCA) and 100%RCA. With the increase in the aggregate size, the bulk density of aggregate is

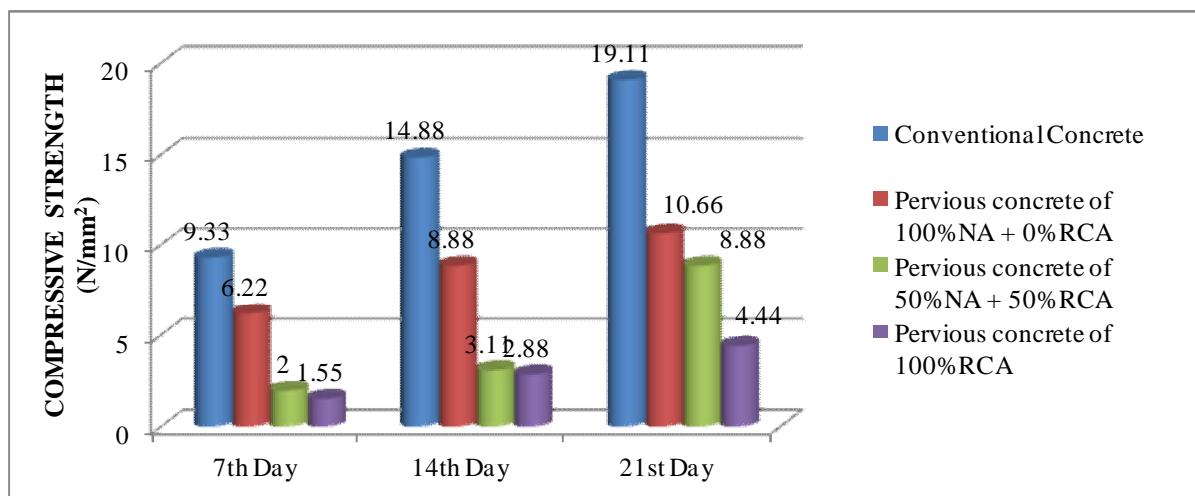
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decreased and this in turn increases the porosity of concrete. With the increase in the porosity, the strength of the pervious concrete is reduced.



**Figure 2 Compressive strength of cubes of aggregate size 16-20mm**

### 3. Infiltration rate for aggregate size 8-12mm and 16-20mm

The infiltration rates for different % of RCA are tabulated below. It is found that the infiltration rate for 100% NA increases when compared to others. The infiltration rates of cylinder for aggregate size 8-12mm are presented in table 7 and figure 3.

**Table 7 Infiltration rate of cylinder for aggregate size 8-12mm & 16-20mm**

Type of Concrete	PERMEABILITY VALUE @ 21ST DAY(mm/s)	
	Aggregate size 8-12mm	Aggregate size 16-20mm
Pervious concrete of 100% NA + 0% RCA	12.46	15.87
Pervious concrete of 50% NA + 50% RCA	12.21	14.67
Pervious concrete of 0% NA + 100% RCA	12.28	15.49

It has been observed that 16-20mm sizes of aggregate shows higher permeability values compared to 8-12mm size of aggregate. This is because of water permeability of pervious concrete is significantly influenced by pore structure which is affected by compaction and grading. And also, compressive strength and permeability are inversely proportional to each other i.e. as the compressive strength increases, permeability decreases and vice-versa.

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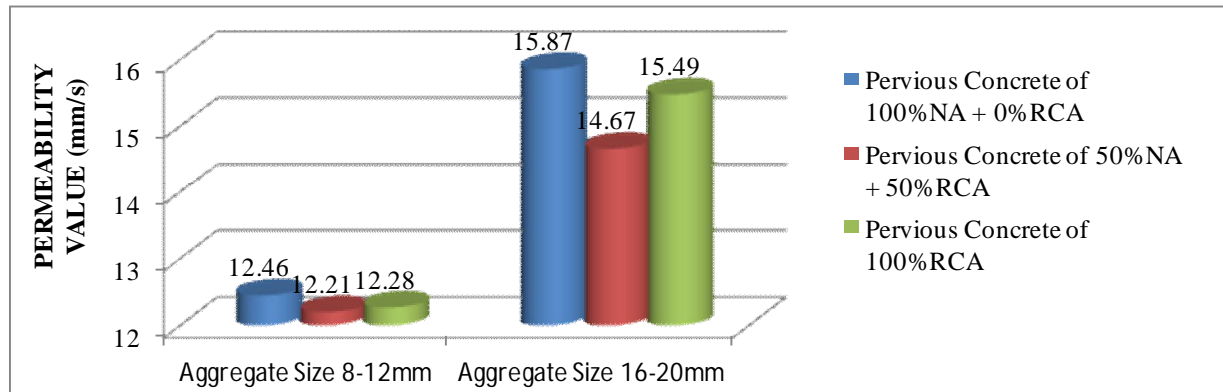


Figure 3 Infiltration rate of cylinder for aggregate size 8-12mm & 16-20mm

### V. CONCLUSIONS

The following conclusions are drawn based on the experimental investigations carried out on pervious concrete:

- The use of 8-12mm size aggregate with 50% replacement of RCA shows higher compressive strength when compare to 0% and 100% RCA.
- In case of aggregate size 16-20mm, 0% RCA shows higher compressive strength when compare to 50% and 100% RCA.
- The test on infiltration rate for both aggregate size 8-12mm and 16-20mm shows higher value for 0% RCA.
- It is clearly seen from the experimental result that pervious concrete has very low compressive strength, so it cannot be used for structural application but it should be significantly used for so many other applications such as sidewalks, parking lots, sports surfaces, swimming pool decks, driveways, etc.
- Hence, Pervious concrete is considered as an eco friendly system.

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