

# EXPERIMENTAL STUDY ON THE PERFORMANCE OF POLYESTER RESIN CONCRETE

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## Abstract:

The effect of polyester resin on strength of concrete is been studied for varying percentages of resin from 10% to 100% by volume of coarse aggregate, with a variation of 10% (10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100%). The properties of polyester resin concrete is been studied for compressive strength, split tensile strength and flexural strength. The grade of concrete considered is M30. Tests are been carried out as per recommended procedures of relevant code. The results are compared with conventional concrete. It is been found that with the replacement of coarse aggregate by polyester resin varying percentage of resin from 10% to 100% the weight of polyester resin concrete reduces varying from 2% to 23.8%. The compressive strength of polyester resin concrete with 10% replacement of coarse aggregate by polyester resin is as good as M30 grade concrete. The compressive strength of polyester resin concrete with replacement of coarse aggregate by polyester resin varying percentage of resin from 20% to 40% we can achieve the concrete of grade M25.

## Keywords:

Polyester resin, Polyester resin concrete (PRC), conventional concrete, mechanical properties.

## 1. Introduction:

In the world all countries racing to be in the list of developed countries. To become develop country the main contribution is from construction industry as the infrastructure plays an important role, due to this the consumption of construction material like cement and coarse aggregate fine aggregate are also increasing in the meantime the cost of construction material will also increase. To maintain the economic balance in construction industry it is important to search some alternatives for construction materials. In the present study alternative used is Polyester resin as replacement for coarse aggregate. In the naval industry the use of polyester resin in large quantity the ships, yachts are built in composites which intern which intern uses polyester resin. Polyester resin is liquid with pale colour and high viscosity and it consists of a solution of polyester in a monomer which is commonly styrene. To reduce the viscosity of polyester resin styrene can be added up to 50% which makes it easy for handling. Also styrene helps polyester resin to change from solution to gel form by cross linking the molecular chains of the polyester without producing any by product. As the polyester resin changes to gel form it can be moulded into any shape without any external pressure. Hence these are called low pressure resins. Limitation of this polyester resin is that it cannot be preserved in gel form for long time as it turns to solid state.

## 2. Need for the present work:

The research work is carried out to produce the sustainable concrete by replacing natural coarse aggregate by polyester resin concrete mix proportion for M30 grade concrete with polyester resin as coarse aggregate is obtained by trial mix method once attaining the desired strength casting of specimen were carried out with varying percentage of polyester resin from 10% to 100% and tested at 7 days and 28 days of curing period this testing is carried out to find the optimal percentage of polyester resin that can be replaced in concrete without sacrificing the strength of concrete.

## 3. Objective

Knowing the properties of windmill waste polyester resin which will act as a good coarse aggregate material the present study focuses on replacing 100% of coarse aggregate by polyester resin in concrete. In this research work main findings are the strength and durability properties of polyester resin concrete.

## 4. Experimental Investigation

Experimental work is carried out to investigate the strength and durability properties of polyester resin concrete.

### 4.1 Materials

1. Cement-Ordinary Portland cement of 53 grade, specific gravity-3.15.
2. Fine aggregate- Locally available manufactured sand conforming to grading zone II of IS 383-1970 and specific gravity -2.65.
3. Coarse aggregate- Locally available crushed granite stones of size passing through 20mm sieve and retained on 4.75mm sieve.
4. Water- Ordinary portable water.

5. Polyester resin- The material is obtained from windmill waste.
6. Chemicals- Magnesium sulphate, Sodium chloride and Sulphuric acid



Polyester resin

**4.2 Mix Proportions:**

For the present study, concrete of grade M30 is adopted. The mix design obtained is 1:1.57:2.15 as per the standard procedure as outlined in IS 10262:2009.

**4.3 Quantities of Different Materials Required.**

The quantities of different materials such as cement, fine aggregate, coarse aggregate, polyester resin& water for M30 grade concrete, considering for 1m<sup>3</sup> have been tabulated as mentioned in Table 1

**Table1: Quantities of Materials Required per m<sup>3</sup> of Concrete**

Designation	Percentage of Resin (%)	Cement (Kg)	Fine aggregate (Kg)	Coarse aggregate (Kg)	Water (lts)	Polyester Resin (Kg)
CC	0	414	652.23	1089.20	186.0	0
R1	10	414	652.23	980.28	186.0	52.96
R2	20	414	652.23	871.36	186.0	105.92
R3	30	414	652.23	762.44	186.0	158.88
R4	40	414	652.23	653.52	186.0	211.84
R5	50	414	652.23	544.6	186.0	264.82
R6	60	414	652.23	435.68	186.0	331.26
R7	70	414	652.23	326.76	186.0	397.23
R8	80	414	652.23	217.84	186.0	463.43
R9	90	414	652.23	108.92	186.0	529.64
R10	100	414	652.23	0	186.0	595.85

**4.4 Casting and Curing of Specimens.**

- The size of the cubes casted is 150mm x 150mm x 150mm
- The size of the cylinders casted 150mm x 300mm
- The size of the prisms casted 100mm x 100mm x 500mm

**Table 2: Total Number of specimens Casted**

Specimens	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	total
Cube	24	24	24	24	24	24	24	24	24	24	240
Cylinder	6	6	6	6	6	6	6	6	6	6	60
Prism	6	6	6	6	6	6	6	6	6	6	60

**4.5 Testing of Cubes**

After the completion of curing period, concrete specimens were tested for compressive strength, split tensile strength and flexural strength.

**5. Results and Discussions**

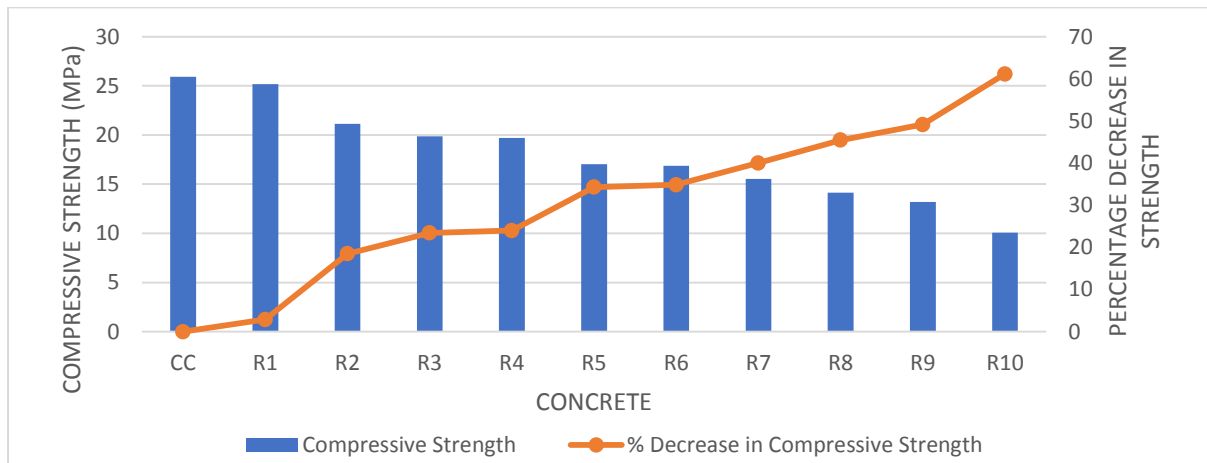
The test results obtained are tabulated in the table 3 to 5. The table contains the average values of compressive strengths, split tensile strength and flexural strength of concrete specimens after 28 days of normal curing.

**5.1 COMPRESSIVE STRENGTH**

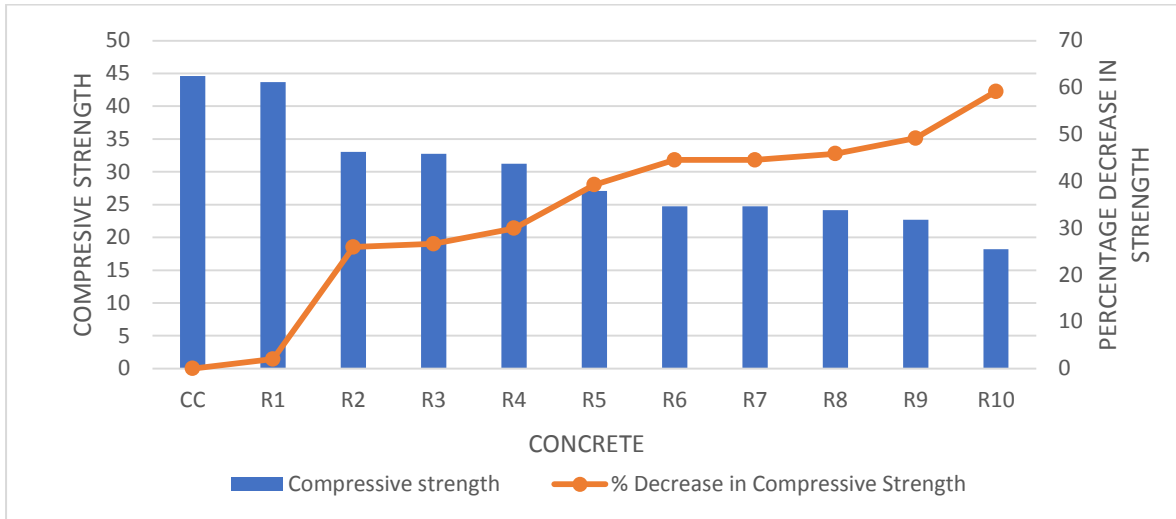
The test is conducted as per IS: 516-1959. The compressive strength test is conducted on a specimen of size 150mm x 150mm x 150mm. Compressive strength is recorded for 7 and 28 days of curing.

**Table 3 : Compressive strength of polyester resin concrete for 7 and 28 days curing**

	Description of concrete	% of Resin	Compressive strength for 7 days (MPa)	% decrease in strength	Compressive strength for 28 days (MPa)	% decrease in strength
CC	Conventional Concrete	0	25.92	<b>0.00</b>	44.6	<b>0</b>
POLYESTER RESIN CONCRETE	R1	<b>10</b>	<b>25.17</b>	<b>2.89</b>	<b>43.7</b>	<b>2.01</b>
	R2	20	21.13	<b>18.47</b>	33.03	<b>24.94</b>
	R3	30	19.85	<b>23.41</b>	32.73	<b>26.61</b>
	R4	<b>40</b>	<b>19.70</b>	<b>23.99</b>	<b>31.25</b>	<b>29.93</b>
	R5	50	17.03	<b>34.29</b>	27.10	<b>39.23</b>
	R6	60	16.88	<b>34.87</b>	24.74	<b>44.52</b>
	R7	70	15.55	<b>40.00</b>	27.74	<b>37.80</b>
	R8	80	14.14	<b>45.44</b>	24.14	<b>45.87</b>
	R9	<b>90</b>	<b>13.18</b>	<b>49.15</b>	<b>22.67</b>	<b>49.17</b>
	R10	100	10.07	<b>61.14</b>	18.21	<b>59.17</b>



**Fig 1. Variation of 7 days Compressive Strength of polyester Resin concrete along with conventional concrete**



**Fig 2. Variation of 28 days Compressive Strength of polyester Resin concrete along with conventional concrete**

The compressive strength of (Coarse aggregate replaced by Polyester Resin concrete) polyester resin concrete for 7 and 28 days curing are tabulated in table3. The polyester resin concrete with 10% replacement of coarse aggregate by polyester resin (R1) compared with conventional concrete the compressive strength decreases marginally by 2.03%. Hence the polyester resin concrete with replacement of 10% coarse aggregate by polyester resin is as good as conventional concrete of M30 grade. The polyester resin concrete with 20% to 40% replacement of coarse aggregate by polyester resin the compressive strength reduces by 25% to 30%. With this we can conclude that upto 40% replacement of coarse aggregate by polyester resin we can achieve M25 grade of concrete.

**5.2 FLEXURAL STRENGTH**

The test is conducted as per IS:516-1959. The flexural strength test is conducted on a specimen of size 100mm x 100mm x 500mm. Flexural strength is recorded for 7 and 28 days of curing.

**Table 4 : Flexural strength of polyester resin concrete for 7 and 28 days curing**

	Description of concrete	% of Resin	Compressive strength for 7 days (MPa)	% decrease in strength	Compressive strength for 28 days (MPa)	% decrease in strength
CC	Conventional Concrete	0	6.50	0.00	7.33	0
POLYESTER RESIN CONCRETE	R1	10	6.16	5.23	6.17	15.82
	R2	20	5.75	11.53	4.17	43.11
	R3	30	3.41	47.53	4.83	34.10
	R4	40	2.33	64.15	3.42	53.34
	R5	50	2.0	69.23	3.10	57.70
	R6	60	1.91	70.61	3.08	57.98
	R7	70	1.58	75.69	3.00	59.07
	R8	80	1.47	77.38	2.0	72.71
	R9	90	1.41	78.30	1.58	78.44
	R10	100	1.25	80.76	1.83	75.03

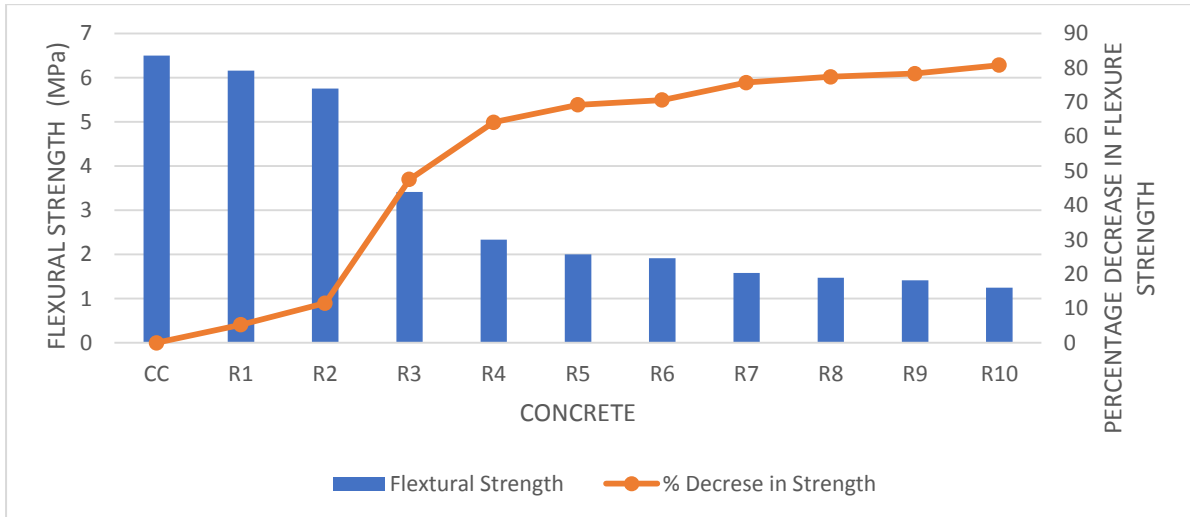


Fig 3. Variation of 7 days Flexural Strength of polyester Resin concrete along with conventional concrete

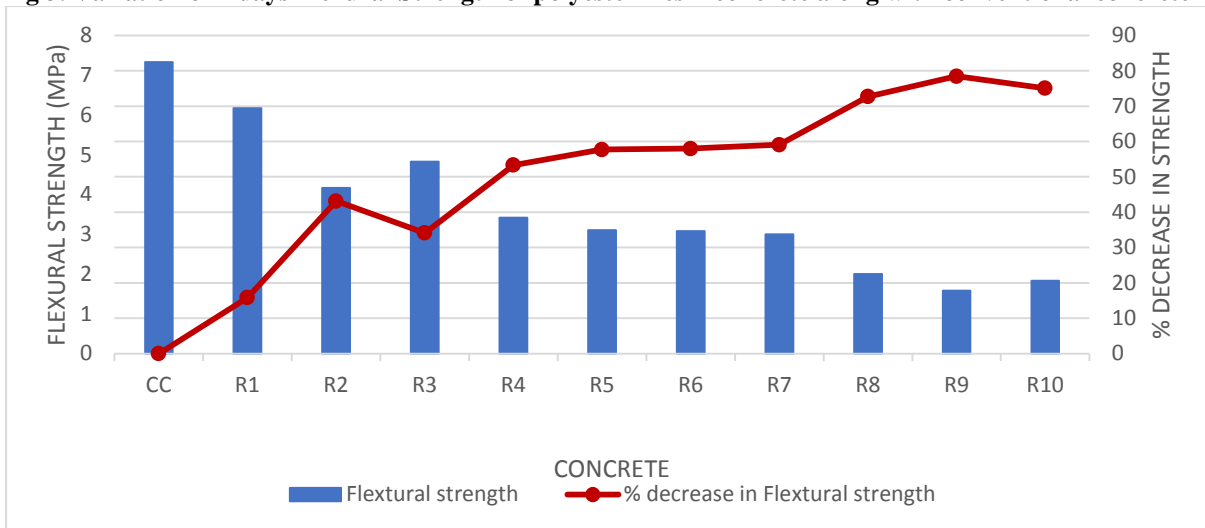


Fig 4. Variation of 28 days Flexural Strength of polyester Resin concrete along with conventional concrete

The Flexural strength of (coarse aggregate replaced by polyester Resin concrete) polyester resin concrete for 7 and 28 days curing are tabulated in table 4. Concrete with coarse aggregate replaced by polyester resin varying from 10% to 100% compared to conventional concrete the flexural strength decreases and it varies from 5.23% to 80.76% respectively. Figure 5.5 shows the variation of 28 days flexural strength of polyester resin concrete along with the conventional concrete. From the figure it is observed that with replacement of coarse aggregate (CA) by polyester resin the flexural strength decreases compared to conventional concrete. Concrete with coarse aggregate replaced by polyester resin varying from 10% to 100% compared to conventional concrete the flexural strength decreases and it varies from 15.82% to 75.03% respectively. The polyester resin concrete with 10% replacement of coarse aggregate by polyester resin the flexural strength reduces by 13% and 15% respectively. The polyester resin concrete with 20% to 40% replacement of coarse aggregate by polyester resin the flexural strength reduces by 50%. Reduction in flexural strength is higher compared to compressive strength. This may be due to the less bonding between polyester resin coarse aggregate and mortar.

**5.3 SPLIT TENSILE STRENGTH**

The test is conducted as per IS: 5816-1999. The split tensile strength test is conducted on a specimen of size 300mm length and 150mm dia. Split tensile strength is recorded for 7 and 28 days of curing.

Table 5 : Split tensile strength of polyester resin concrete for 7 and 28 days curing

	Description of concrete	% of Resin	Compressive strength for 7 days (MPa)	% decrease in strength	Compressive strength for 28 days (MPa)	% decrease in strength
CC	Conventional	0	2.52	0.00	3.41	0

	Concrete					
POLYESTER RESIN CONCRETE	R1	10	1.83	<b>27.38</b>	2.96	<b>13.19</b>
	R2	<b>20</b>	<b>1.62</b>	<b>35.71</b>	<b>2.25</b>	<b>34.01</b>
	R3	30	1.59	<b>36.90</b>	2.21	<b>35.19</b>
	R4	40	1.55	<b>38.49</b>	2.16	<b>36.65</b>
	R5	50	1.53	<b>39.28</b>	2.15	<b>36.95</b>
	R6	60	1.55	<b>38.49</b>	1.84	<b>46.04</b>
	R7	70	1.41	<b>44.04</b>	1.50	<b>56.01</b>
	R8	80	1.10	<b>56.34</b>	1.33	<b>60.99</b>
	R9	90	0.98	<b>61.11</b>	1.35	<b>60.41</b>
	R10	100	0.98	<b>61.11</b>	1.00	<b>70.67</b>

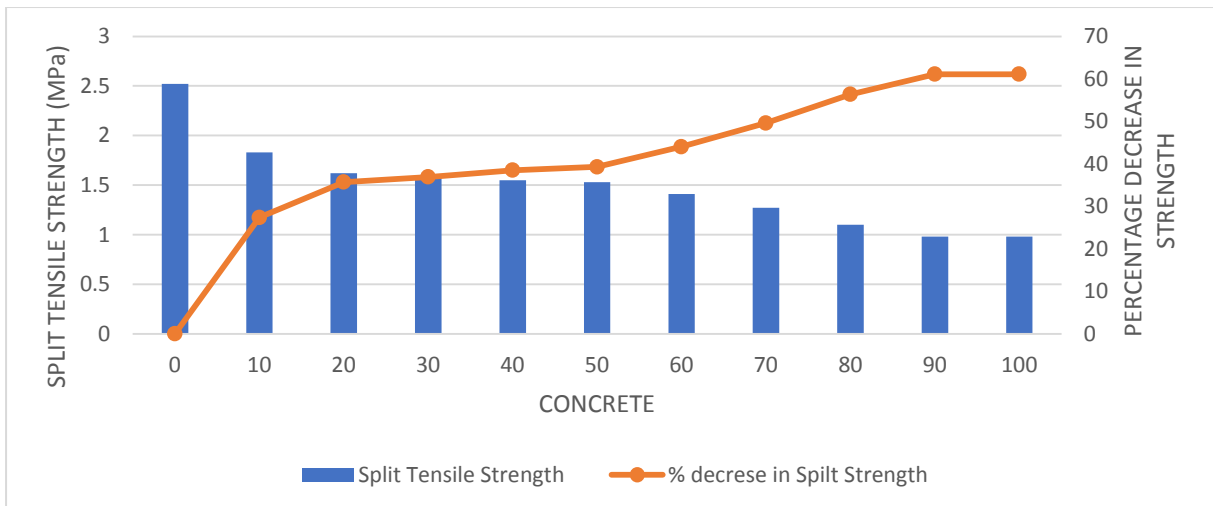


Fig 5. Variation of 7 days Split Tensile Strength of polyester resin concrete along with conventional concrete

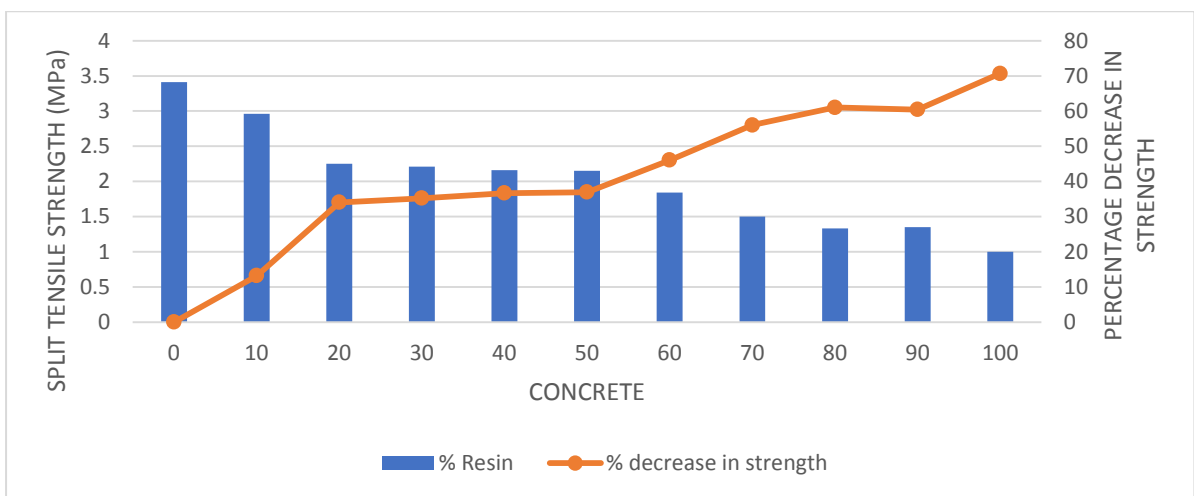


Fig 6. Variation of 28 days Split Tensile Strength of polyester Resin concrete along with conventional concrete

The split tensile strength of (coarse aggregate replaced by Polyester Resin concrete) polyester resin concrete for 7 and 28 days curing are tabulated in table 5. The polyester resin concrete with 10% replacement of coarse aggregate by polyester resin the split tensile strength reduces by 13% and 15% respectively. The polyester resin concrete with 20% to 40% replacement of coarse aggregate by polyester resin the split tensile strength reduces by 50%. Reduction in split tensile strength is higher compared to compressive strength. This may be due to the less bonding between polyester resin coarse aggregate and mortar. Concrete with coarse aggregate replaced by polyester resin varying from 10% to 100% compared to conventional concrete the split tensile strength decreases and it varies from 13.19% to 70.67% respectively.

**5.4 DENSITY OF POLYESTER RESIN CONCRETE**

Density of polyester resin is calculated and presented in table 5.6.

**Table 6: Density of polyester resin concrete**

Description of concrete	Designation	% of Resin	Density of concrete (kg/m <sup>3</sup> )	% decrease in Density
Conventional Concrete	CC	0	2341.43	0
R1	R1	10	2285.47	2.38
R2	R2	20	2229.51	4.76
R3	R3	30	2173.55	7.14
R4	R4	40	2117.59	9.52
R5	R5	50	2061.63	11.9
R6	R6	60	2005.67	14.28
R7	R7	70	1949.71	16.66
R8	R8	80	1893.75	19.04
R9	R9	90	1837.79	21.42
R10	R10	100	1781.83	23.8

The density of polyester resin is very less, it is 1200 kg/m<sup>3</sup>. Because of low density of polyester resin weighing batching is not desirable. The coarse aggregate is replaced by polyester resin by volume. As a result of low density of polyester resin, the density of polyester resin concrete reduces. With the replacement of coarse aggregate by polyester resin varying % of resin from 10 % to 100%, the % density of polyester resin reduces from 2.38% to 23.8%. For every 10% replacement of coarse aggregate by polyester resin the density of the polyester resin concrete is reduced by an average of 2.38%.

**6. Conclusion**

1. The water absorption of polyester resin is almost zero.
2. The polyester resin concrete is lighter compared to conventional concrete.
3. The polyester resin concrete with varying percentage of resin from 10% to 100% the reduction in weight compared with conventional concrete varies from 2.38% to 21% respectively, with variation of 2.38% for every 10% replacement of coarse aggregate by polyester resin.
4. The polyester resin concrete with varying percentage of resin from 10% to 100% the decrease in mechanical properties such as compressive strength, split tensile strength and flexural strength compared to conventional concrete, varies from 2% to 59.%, 15.82% to 75% and 13.19% to 71% respectively.
5. The polyester resin concrete with 10% replacement of coarse aggregate by polyester resin (R1) compared with conventional concrete the compressive strength decreases marginally by 2.03%. Hence the polyester resin concrete with replacement of 10% coarse aggregate by polyester resin is as good as conventional concrete of M30 grade.
6. The polyester resin concrete with 20% to 40% replacement of coarse aggregate by polyester resin the compressive strength reduces by 25% to 30%. With this we can conclude that upto 40% replacement of coarse aggregate by polyester resin we can achieve M25 grade of concrete.
7. The polyester resin concrete with 10% replacement of coarse aggregate by polyester resin the flexural strength and split tensile strength reduces by 13% and 15% respectively.

8. The polyester resin concrete with 20% to 40% replacement of coarse aggregate by polyester resin the flexural strength and split tensile strength reduces by 50%. Reduction in flexural strength is higher compared to compressive strength. This may be due to the less bonding between polyester resin coarse aggregate and mortar.

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