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Experimental Study on the Durability of Polyester Resin Concrete

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Abstract

The effect of polyester resin on durability 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 have been studied for durability. The grade of concrete considered is M30. Tests are being carried out as per recommended procedures of relevant code. The results are compared with conventional concrete. It has 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 durability of polyester resin is tested for chemical resistance of sulphate, chloride acid.

Keywords*: - Polyester resin, Polyester resin concrete (PRC), conventional concrete, durability.*

INTRODUCTION

In the world, all countries are racing to be on the list of developed countries. To become a developed country, the main contribution is from the construction industry as the infrastructure plays an important role, due to this the consumption of construction material like cement mint coarse aggregate fine aggregate are also increasing in the meantime the cost of construction material will also increase. To maintain the economic balance in the construction industry, it is important to search for some alternatives for construction materials. In the present study alternative used is Polyester resin as

a replacement for coarse aggregate. The naval industry uses polyester resin in large quantities; the ships and yachts are built-in composites that intern uses polyester resin.

Polyester resin is liquid with a 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. The limitation of this polyester resin is that it cannot be preserved in gel form for a long time as it turns to a solid-state.

NEED FOR THE PRESENT WORK

The research work is carried out to produce the sustainable concrete by replacing natural coarse aggregate with 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 the specimen was carried out with a varying percentage of polyester resin from 10 % to 100% and tested at 28 days of curing period. The concrete was tested for 2.5% and 5% solution of suphate, chloride and acid, respectively.

OBJECTIVE

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

EXPERIMENTAL INVESTIGATION

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

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.

Figure 1: Polyester Resin

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.

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 $1m^3$, have been tabulated as mentioned in Table 1.

Table 1: Quantities of Materials required per m^3 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

Casting and Curing of Specimens

The size of the cubes cast is 150mm x 150mm x 150mm.

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

Testing of Cubes

After the completion of the curing period in water, concrete cubes are again cured in a solution of 2.5% and 5% solution of sulphate chloride and acid.

5. RESULTS AND DISCUSSIONS

The test results obtained are tabulated in Tables 3 to 5. The table contains the average values of compressive strengths of concrete specimens after 28 days of normal curing followed by chemical curing.

Table 3: Compressive Strength of conventional concrete and polyester resin concrete cubes cured for 28 days in 2.5% chemical solution

	Type of mix	% Resin	CC	2.5% $MgSO_4$		2.5%NaCl		2.5%H_2SO_4	
				Compression strength (MPa)	% decrease in strength	Compression strength (MPa)	% decrease in strength	Compression strength (MPa)	% decrease in strength
CC	CC	0	44.6	42.56	**4.57**	43.95	**1.45**	33.33	**25.26**
POLYESTER RESIN CONCRETE	R1	10	43.7	41.63	**4.73**	42.98	**1.64**	28.88	**33.91**
	R2	**20**	**33.03**	**31.83**	**3.63**	**32.65**	**1.15**	**25.33**	**23.31**
	R3	30	32.73	31.21	**4.64**	31.95	**2.38**	23.11	**29.39**
	R4	40	31.25	29.52	**5.53**	30.42	**2.65**	22.66	**27.48**
	R5	50	27.10	25.45	**6.08**	26.35	**2.76**	20.88	**22.95**
	R6	60	24.74	22.95	**7.23**	23.87	**3.51**	20.00	**19.15**
	R7	70	24.74	22.85	**7.63**	23.85	**3.59**	20.44	**17.38**
	R8	80	24.14	22.63	**6.25**	23.35	**3.27**	19.55	**19.01**
	R9	90	22.67	21.23	**6.35**	21.75	**4.05**	19.11	**15.70**
	R10	100	18.21	17.62	**3.23**	17.41	**4.39**	15.11	**17.02**

Table 4: Compressive Strength of conventional concrete and polyester resin concrete cubes cured for 28 days in 5% chemical solution

	Type of mix	% Resin	CC	5% $MgSO_4$		5%NaCl		5%H_2SO_4	
				Compression strength (MPa)	% decrease in strength	Compression strength (MPa)	% decrease in strength	Compression strength (MPa)	% decrease in strength
CC	CC	0	44.6	41.85	**6.16**	43.58	**2.28**	31.11	**30.24**
POLYESTER RESIN CONCRETE	R1	10	43.7	40.35	**7.66**	42.39	**2.99**	29.33	**32.88**
	R2	**20**	**33.03**	**30.95**	**6.29**	**32.14**	**2.69**	**23.55**	**28.70**
	R3	30	32.73	30.12	**7.97**	31.26	**4.49**	20.44	**37.54**
	R4	40	31.25	28.35	9.28	29.87	4.41	19.11	38.84
	R5	50	27.10	24.35	**10.14**	25.89	**4.46**	19.11	**29.48**
	R6	60	24.74	21.63	**12.5**	23.19	**6.26**	18.66	**24.57**
	R7	70	24.74	21.96	**11.2**	23.01	**6.99**	17.77	**28.17**
	R8	80	24.14	21.87	**9.4**	22.74	**5.79**	16	**33.71**
	R9	90	22.67	20.35	**10.23**	20.96	**7.54**	15.11	**33.34**
	R10	100	18.21	16.86	**7.41**	16.23	**10.87**	11.11	**38.98**

Sulphate Attack

The compressive strength test is conducted on a specimen of size 150mm x 150mm x 150mm. Compressive strength is recorded for 28 days of normal curing followed by curing in 2.5% and 5% solution of sulphate.

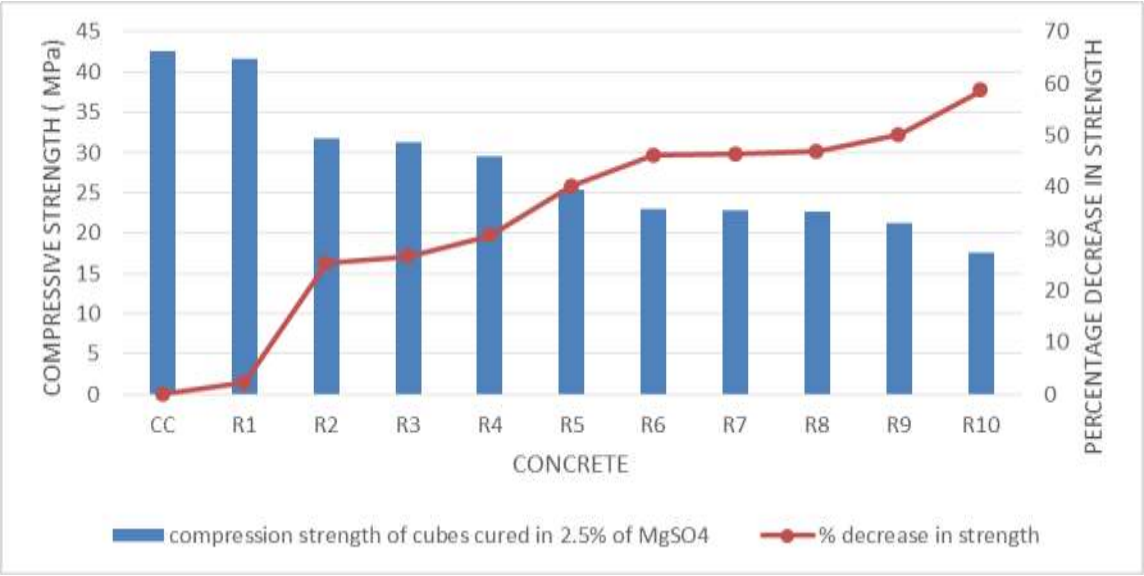

Fig. 2: Compressive Strengths of conventional concrete and polyester resin concrete cubes cured in 2.5% solution of $MgSO_4$

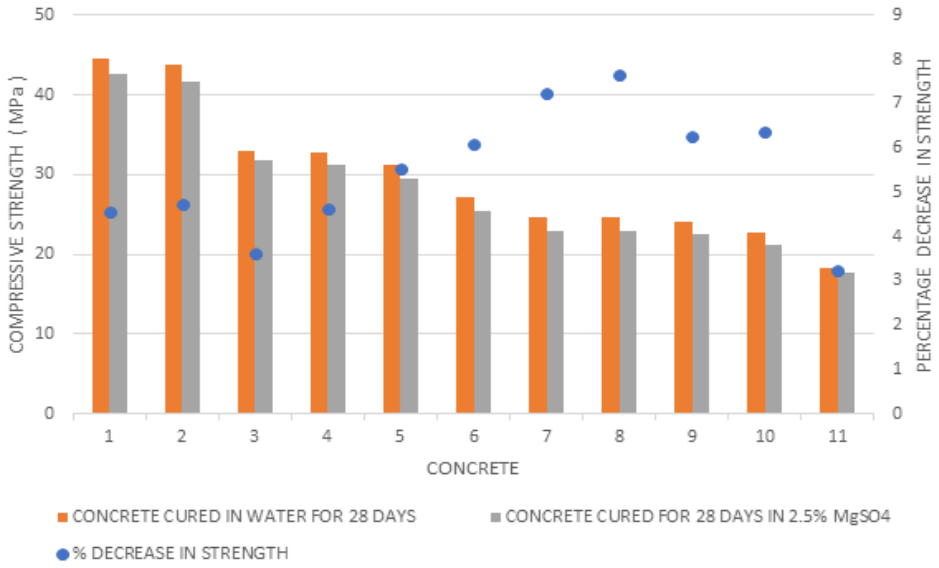

Fig. 3: Comparison of Compressive Strengths of concrete cubes cured in water and in 2.5% solution of $MgSO_4$

A marginal decrease in strength of conventional concrete and polyester resin concrete for 10% to 100% replacement of CA by polyester resin concrete cured in 2.5% solution of $MgSO_4$ is observed. The reduction for 10% to 100% variation of polyester resin is less than 10%. However, up to 20%, it shows a marginal decrease of 3.63%. The maximum decrease in compressive strength is observed for 70% replacement of coarse aggregate by polyester resin concrete of 7.63%.

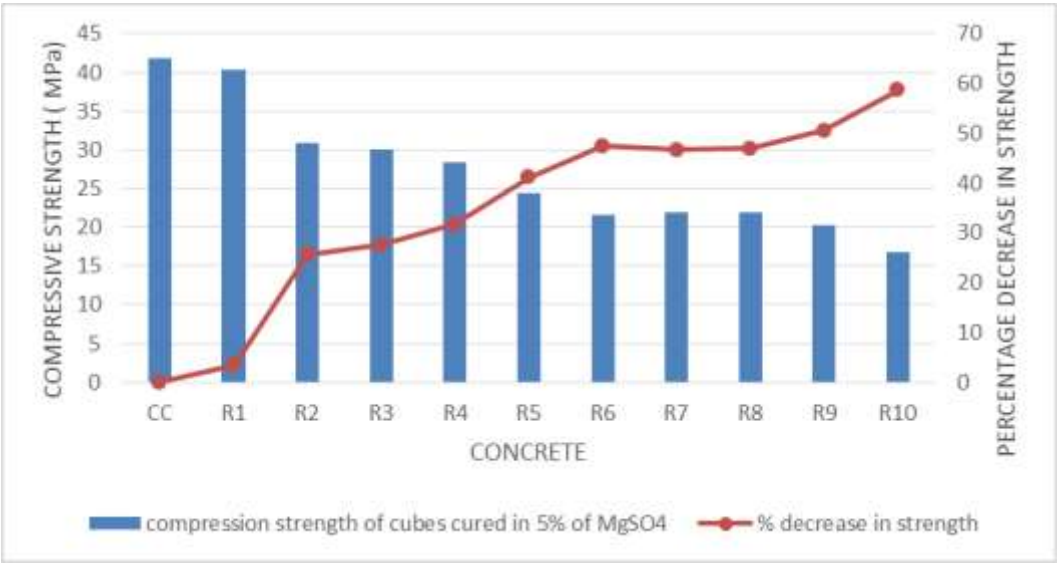

Fig. 4: Compressive Strengths of conventional concrete and polyester resin concretes cubes cured in 5% solution of $MgSO_4$

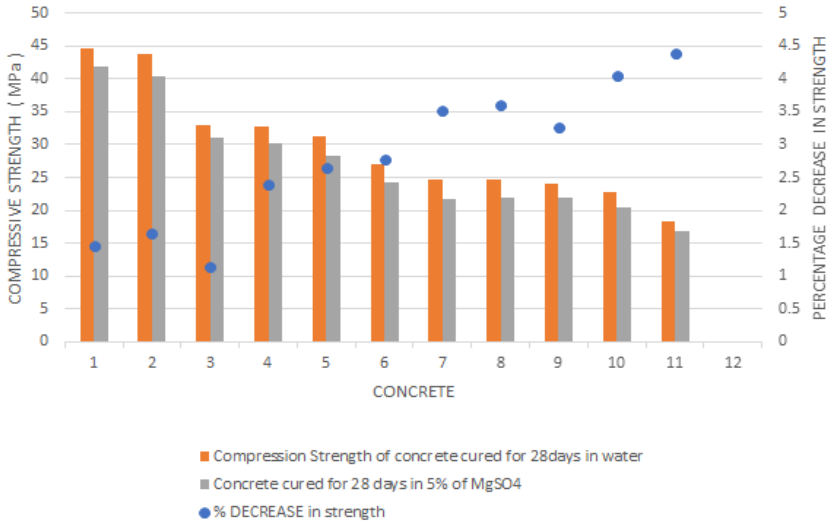

Fig. 5: Comparison of Compressive Strengths of concrete cubes cured in water and in 5% solution of $MgSO_4$

Marginal decrease in strength of conventional concrete and polyester resin concrete for 10% to 100% replacement of CA by polyester resin concrete cured in 5% solution of MgSO4is observed. The reduction for 10% to 100% variation of polyester resin is less than 13%. However, up to 20%, it is a marginal decrease of 6.29%. The maximum decrease in compressive strength is observed for 60% replacement of CA by polyester resin concrete of 12.5%.

Chloride Attack

The compressive strength test is conducted on a specimen of size 150mm x 150mm x 150mm. Compressive strength is recorded for 28 days of normal curing followed by curing in 2.5% and 5% solution of chloride.

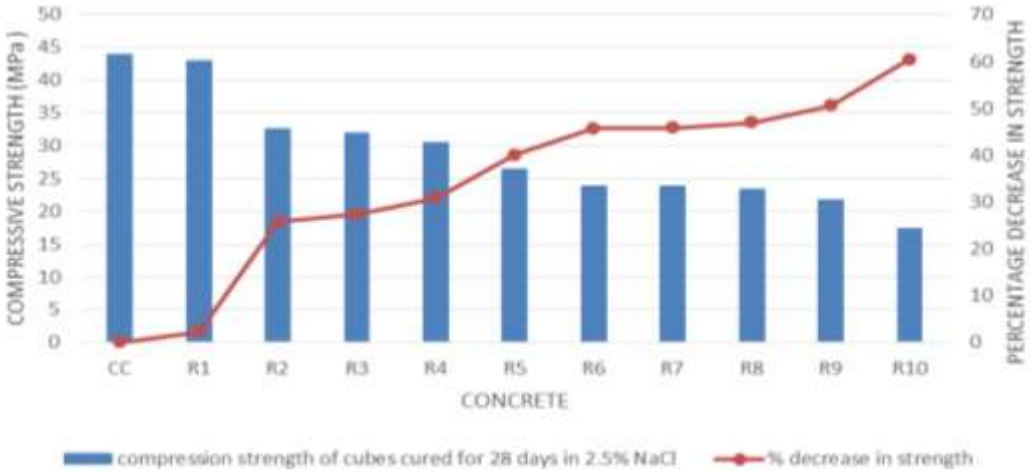

Fig. 6: Compressive Strengths of conventional concrete and polyester resin concretes cubes cured in 2.5% solution of NaCl

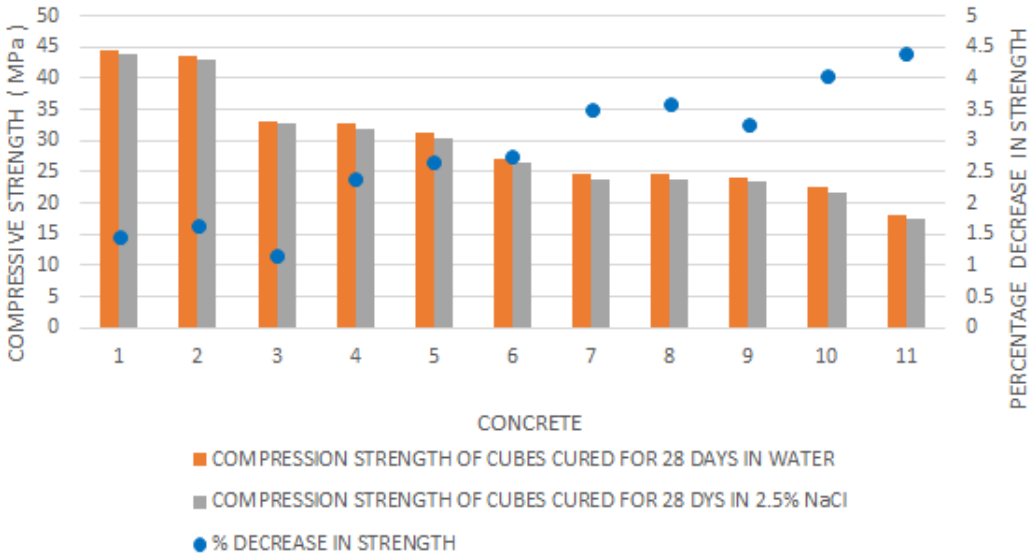

Fig. 7: Comparison of Compressive Strengths of normal concrete cubes and cubes cured in 2.5% NaCl solution

A marginal decrease in strength of conventional concrete and polyester resin concrete for 10% to 100% replacement of CA by polyester resin concrete cured in 2.5% solution of NaCl is observed. The reduction for 10% to 100% variation of polyester resin is less than 5%. However, for 20%, it is a marginal decrease of 1.15%. The maximum decrease in compressive strength is observed for 100% replacement of CA by polyester resin concrete of 4.39%.

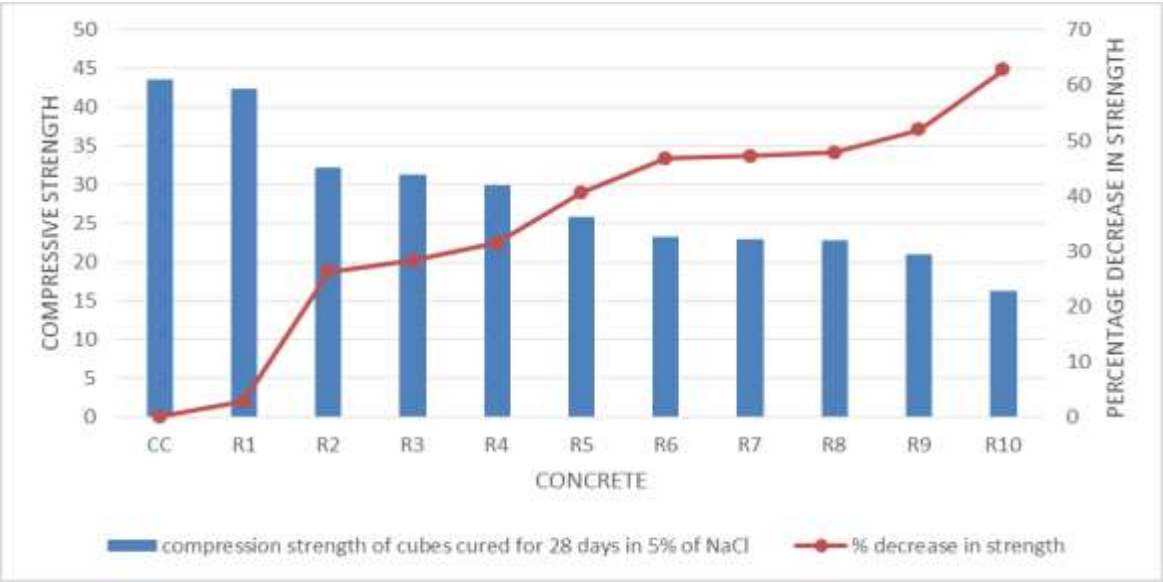

Fig. 8: Compressive strengths of conventional concrete and polyester resin concrete cubes cured in 5% solution of NaCl

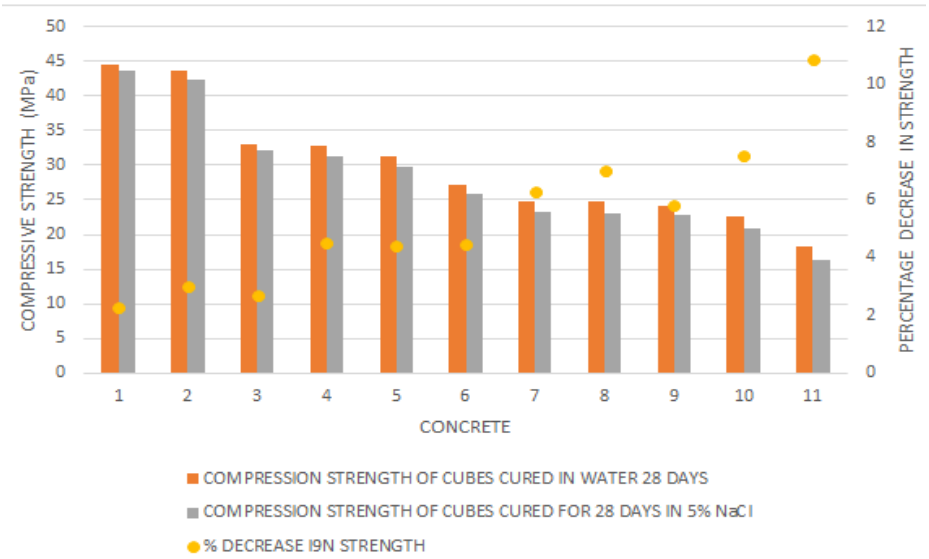

Fig. 9: Comparison of Compressive Strengths of concrete cubes cured in water and in 5% solution of NaCl

A marginal decrease in strength of conventional concrete and polyester resin concrete for 10% to 100% replacement of CA by polyester resin concrete cured in 5% solution of NaCl is observed. The reduction for 10% to 100% variation of polyester resin is less than 11%. However, for 20%, it is a marginal decrease of 2.69%. The maximum decrease in compressive strength is observed for 100% replacement of CA by polyester resin concrete of 10.87%.

Acid Attack

The compressive strength test is conducted on a specimen of size 150mm x 150mm x 150mm. Compressive strength is recorded for 28 days of normal curing followed by curing in 2.5% and 5% solution of Acid.

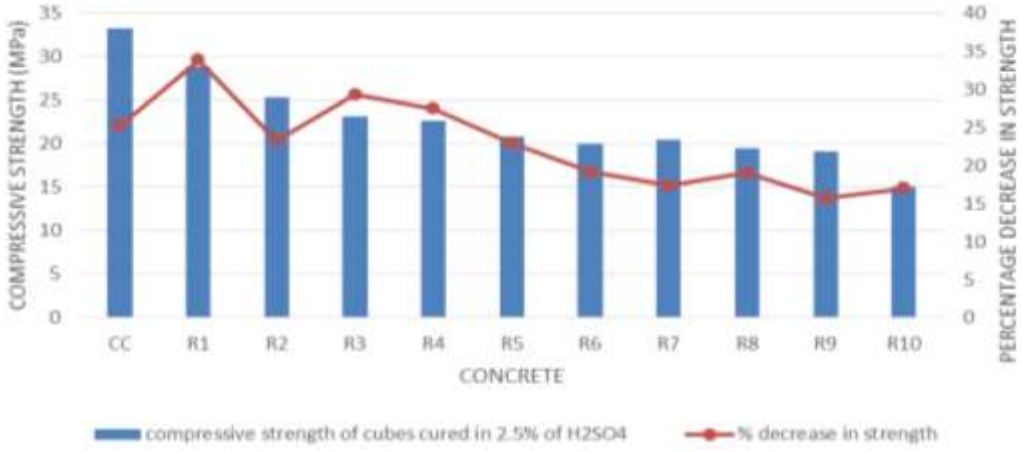

Fig. 10: Compressive strength of cubes of different types of concrete after curing in 2.5% solution of H_2SO_4

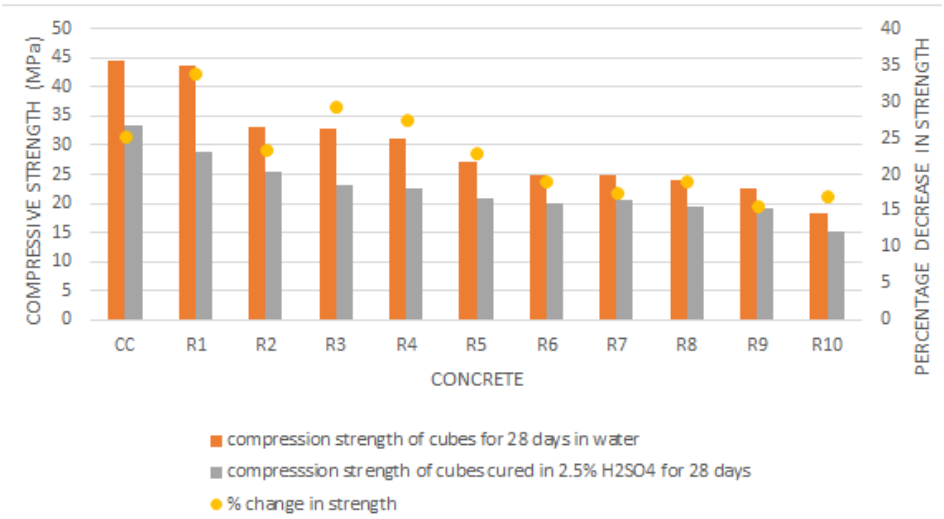

Fig. 11: Comparison of Compressive Strengths of normal concrete cubes and cubes cured in 2.5% H_2SO_4 solution

Comparatively, more reduction in strength of conventional concrete and polyester resin concrete for 10% to 100% replacement of CA by polyester resin concrete cured in 2.5% solution of H_2SO_4 is observed. The reduction for 10% to 100% variation of polyester resin is less than 35%. However, for 20%, it is a marginal decrease of 23.31%. The maximum decrease in compressive strength is observed for 10% replacement of CA by polyester resin concrete of 33.91%. Conventional concrete and polyester resin concrete cubes are affected most by sulphuric acid curing, and the strength decreases almost by 35%.

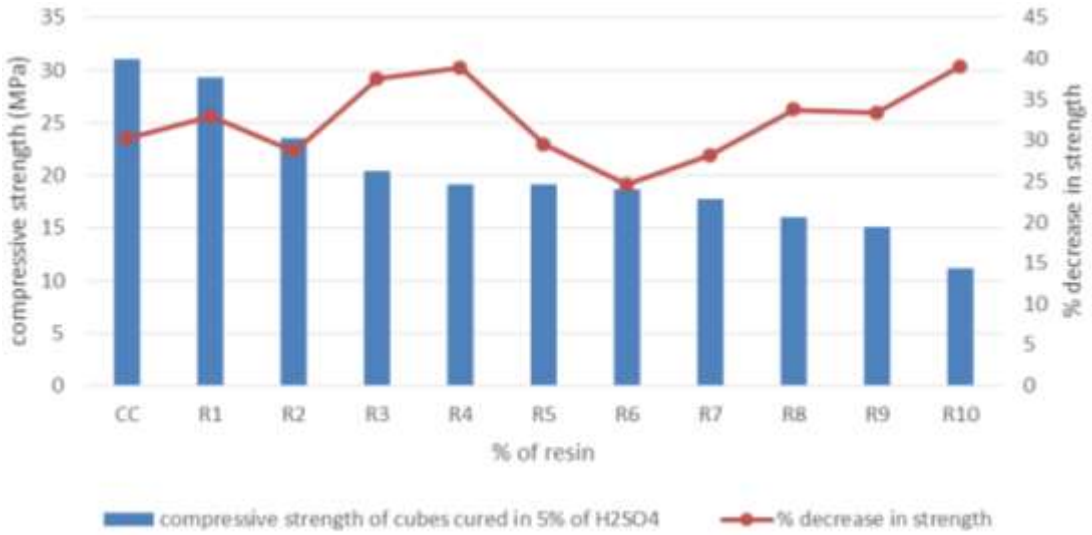

Fig. 12: Compressive strength of cubes of different types of concrete after curing in 5% solution of H_2SO_4

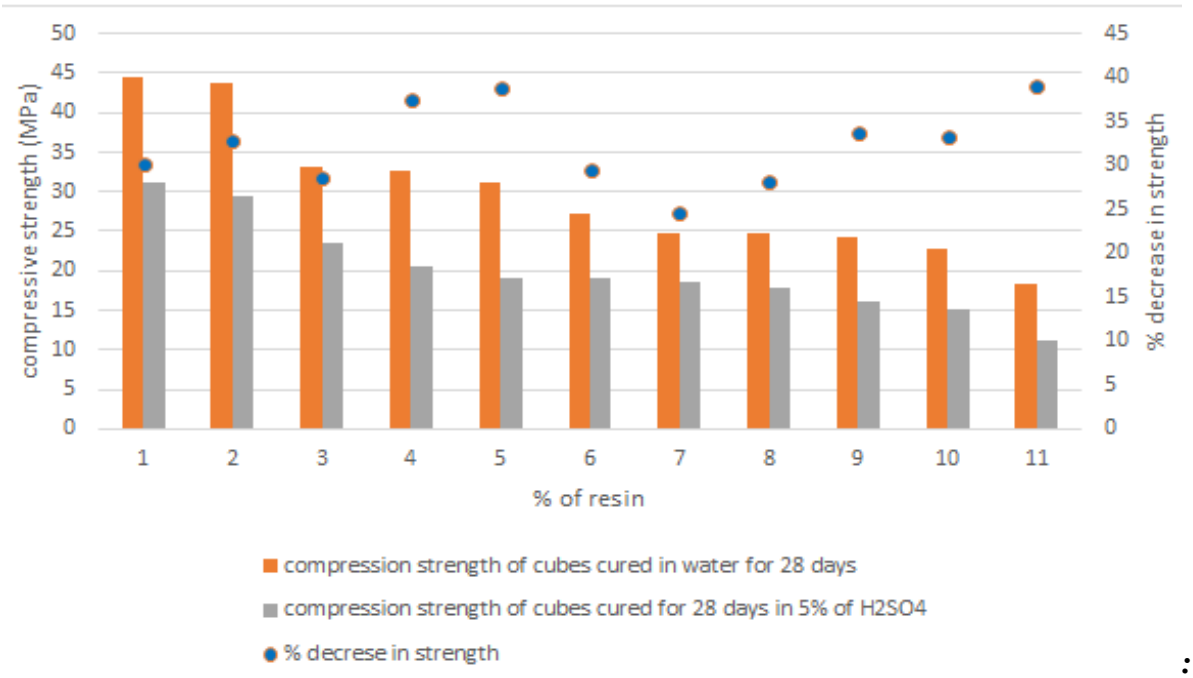

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Fig. 13: Comparison of Compressive Strengths of normal concrete cubes and cubes cured in 2.5% H_2SO_4 solution

Comparatively, more reduction in strength of conventional concrete and polyester resin concrete for 10% to 100% replacement of CA by polyester resin concrete cured in 5% solution of H_2SO_4 is observed. The reduction for 10% to 100% variation of polyester resin is less than 35%. However, for 20%, it is a marginal decrease of 28.70%. The maximum decrease in compressive strength is observed for 10% replacement of CA by polyester resin concrete of 32.88%. Conventional concrete and polyester resin concrete cubes are affected most by sulphuric acid curing, and the strength decreases almost by 35%.

CONCLUSIONS

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% when cured in 2.5% and 5% solution of MgSO4 and NaCl for 28 days compared with conventional concrete, the compressive strength of polyester resin concrete reduces by less than 13%, it varies from 3.63% to 12.5%, shows a marginal decrease in

compressive strength when affected by sulphate and chloride attack.

4. The polyester resin concrete with varying percentage of resin from 10% to 100% and conventional concrete when cured in 2.5% and 5% solution of H2SO4 for 28 days. The compressive strength of polyester resin concrete compared with conventional concrete reduces by a maximum of 40% varying from 24.57% to 38.98%. The polyester resin concrete affects highly when cured in a solution of sulfuric acid.

5. It can be a good alternative material for normal coarse aggregate.

6. The inherent properties of natural waste and industrial waste can be effectively utilized in increasing the strength of concrete efficiently instead of destroying its useful inherent properties. Also, intern reducing the problem of disposal.

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