International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-04, Issue-08, Nov 2018

Feasibility Study of Engine Coolant as Replacement of Water in Concrete

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Abstract: Most of the waste is not recycled which ultimately makes the environment unhealthy. Using different wastes weather solid or liquid in concrete as partial or full replacement of some of its ingredients is not only be an environment friendly option but different properties of concrete also gets enhanced. This paper presents a study on properties of concrete like workability, compressive, tensile and flexural strength for both normal and the accelerated curing for M_{30} concrete mix at 7 & 28 days for (0%, 0.25%, 0.5%, 0.75%, 1%, 1.25%, 1.5%, 2%, 3%, 4% & 100%) partial replacement of water by used engine coolant in concrete. All the tests for finding different properties of concrete and its mix design were done using the Indian standard guidelines. Comparative study revealed that the coolant alone cannot form the best paste with the cement; hence, the optimum percentage which can be added to the concrete will be 1.25% of the used coolant which exhibited the strength of 26.3 N/mm^2 for normal curing and 34.15 N/mm^2 for accelerated curing. (1.849% increase in strength). The study suggest that the accelerated curing helps in the completion of the hydration reaction between the cement, water and coolant which otherwise was halted by normal curing.

Keywords---Used Engine Coolant, admixture, Concrete, Environment, Waste, Compressive Strength, Tensile Strength, Flexural Strength, Slump Value, Curing.

I. INTRODUCTION

Concrete is deliberated as the pillar of a today's world. Without this it is not possible to build a structure which is strong, durable and capable enough to resist earthquake shocks and other loads like dead load, imposed loads, snow load etc. To withstand vibrations structure made up of concrete has dominance over structures made of different materials. Mixture of Water, fine and course aggregates along with cement after merging them together into stone like hard material is known as concrete [2]. Concrete can be fresh as well as hard depending on different properties. The different properties of concrete include strength, density, chemical and thermal resistance in pure and hard state are achieved by resulting materials through which concrete is formed [3]. These ingredients differ in amount the properties do not continue to be same. Mixing of concrete should be properly done as this will make it strong and workable and it will be able to withstand different loads [4]. The ultimate strength of the concrete is generally exaggerated by the water cement ratio and the appropriate mixing. In making of the concrete contains of 15-20% water of the total volume.

Nowadays a lot of the liquid wastes are being produced which are becoming a threat to the environment which could be used effectively to achieve the desired results to encompass a greener technology. Liquid and solid wastes which are illegally discharged on the land or into the water bodies violates the environmental regulations as the chemicals used in them may hazard the environment in the long run [5]. For years now various researches are being carried out for the possible solution to the environmental concerns of waste production and pollution and it was finally concluded that replacement with the raw materials may reduce the environmental impacts and at the same time reduces the cost and the energy consumptions. Meanwhile, the number of the vehicles are increasing worldwide thus leading to the increased production of the used coolant. The annual production of the waste coolant all over world is consumption is in million tonnes. So, with the increased sale of automobiles, the demand for the coolant will also increase and thus ultimately lead to the increase in the waste production.

Since the oil and water are miscible and have appealing sweet taste so a small percentages can lead to the pollution. Although if, adequate campaign for safe disposal of coolants will conducted yet, illegal disposal can be detrimental to the people and the environment. The lethal dose is 100 millilitres for adults and even less for children [6].Used engine oil has been used as admixture in concrete which enhances the fluidity of fresh concrete, increases the slump value, increases the air content, reduces the porosity and also enhances the compressive strength and reduces the permeability of the concrete [7] [8]. The optimum percentage of the UEO was kept as 0.15% compared to the control mix [9]. Another study suggested that soy bean oil can be used in concrete to reduce the moisture loss from the fresh concrete and

 DOI : 10.18231/2454-9150.2018.1092

ISSN : 2454-9150 Vol-04, Issue-08, Nov 2018

improve the scaling resistance [10]. The waste paint has found to increase the workability of the fresh concrete and maintain the compressive strength without drying shrinkage [11]. The used cooking oil can be used as the water reducer and hence doubles the workability of the fresh concrete. The highest compressive strength was achieved with inclusion of 1.5% UEO. The transition zone and the air voids are reduced due to the incorporation of used engine oil (UEO) [9]. This study is aimed at understanding the feasibility of used engine coolant as replacement of water in concrete. The used coolants in the concrete can be advantageous for not only the environment but also to the concrete technology as there are some other properties in the coolants which can be used effectively (corrosion inhibitor, antifreeze & admixture) in the near future and could also serve as another technique for the safe disposal of the waste coolants. The principle objectives of this research paper were to investigate the effects of the used engine coolants on the fresh and the hardened properties of the concrete and to provide the eco-friendly material for the construction.

1. Materials

The materials used in the study were cement, fine aggregates (sand), course aggregate, Water, Used engine Coolant. Tests on these materials were conducted as per Indian Standard (IS) guidelines to determine different properties which are explained as follows

1.1. Cement:

Ordinary Portland cement (Ultra tech) was used. OPC was preferred over PPC due fast setting, high early strength and being environment friendly. All important properties of cement like standard consistency, initial and final setting time, specific gravity were determined according to IS guidelines. Table 1 shows properties of cement and Figure 1 shows the cement used

Figure 1: Cement used.

Table 1: Properties of Cement

1.2. Fine aggregate:

S.no.	Description	Values obtained	Requirements as per IS-1489, 1991
01	Standard consistency	35%	-
02	Initial setting time, min	45 min	>30 min
03	Final setting time, min	350 min	<10 hrs
04	Specific gravity	3.14	3.0-3.15

Locally available sand confirming to zone 3 was used in the experimental work. Sieve analysis was carried out and particles retained on IS sieve 480(4.75mm) was used. Particles retained on IS sieve 480(4.75mm) was used. Specific gravity and Moisture content of Sand were found to be 2.7 and 2.5% respectively. Figure 2 Shows Fine aggregates

1.3. Coarse aggregate:

Locally available crushed coarse aggregate of 20mm size were used. Table 3 shows Properties of Course aggregates and figure 3 shows the course aggregate

1.4. Water:

Portable water with pH value < 6 conforming to IS code was used

Figure 2: Fine Aggregates

Table 3: Properties of Course aggregates

Properties	Coarse aggregate
Specific gravity	2.68
Water absorption	1.11%
Free surface moisture	1.976
Water content	1.4%

Figure 3: Course Aggregates

DOI : 10.18231/2454-9150.2018.1092

1.5. Used engine coolant:

Engine coolants are generally used to extract the excess heat and need to be replaced after some specific period. Coolant which is the waste now can be used in the concrete so as to mitigate the disposal problems and to get benefited using the antifreeze and anticorrosive properties. Green glycol based coolant was used during the whole procedure which was obtained from a local car workshop (Ali-cars-noida sector 66).

II. METHODOLOGY/EXPERIMENTAL PROGRAM

Machine mixing was done. Slump test was carried on fresh concrete. While as compressive strength, tensile strength and flexural strengths were carried out on the hardened concrete for normal and accelerated curing. These tests were carried to determine the mechanical properties of concrete at 7 & 28 days for compressive, tensile, flexural strengths.

Weight batching being superior to volume batching was used in the whole experimental setup.

1.6. Testing of specimen:

Workability, compressive strength, tensile strength and flexural strengths were determined by following the Indian standards guidelines. Microstructure analysis was also done.

1.6.1. Workability:

Slump test was conducted to check the workability of the concrete with and without replacement at 0%, 0.25%, 0.5%, 0.75%, 1%, 1.25%, 1.5%, 2%, 3%, 4% & 100% following the IS Standards.

1.6.2. Compressive strength:

A total of 6 cubes each of size (150x150x150) mm were casted for M_{30} at 7 & 28 days for various percentages (0%, 0.25%, 0.5%, 0.75%, 1%, 1.25%, 1.5%, 2%, 3%, 4% & 100%) by partial replacement of water by coolant. Both normal curing and the accelerated curing procedures were followed. CTM was used for determining the compressive strength of concrete in accordance with the IS Standards. Figure 4 shows compressive strength moulds (cubes)

Figure 4: Cube Molds

1.6.3. Tensile strength:

6 cylindrical specimens were casted with 150mm dia & 300mm height each for 7 and 28 days. Standard split tensile test conforming to IS Codes was used for the cylinders with varying percentages of coolant (0%, 0.25%, 0.5%, 0.75%, 1%, 1.25%, 1.5%, 2%, 3% & 4%). Figure 5 shows Cylindrical Molds

Figure 4: Cylindrical Molds

1.6.4. Flexural strength:

6 beams each of size (100x100x500)mm were casted at 0%, 0.25%, 0.5%, 0.75%, 1%, 1.25%, 1.5%, 2%, 3% & 4% for 7 & 28 days respectively. FTM in accordance with IS Standards was used to determine the flexural strength of concrete. Figure 5 shows beam molds

Figure 5: Beam Molds

III. RESULTS & DISCUSSIONS:

1.7. Workability

Workability of concrete is defined as the capability to work alongside concrete. Concrete is said to be workable if it can be taken care of without isolation and loss of uniformity. Slump Value was obtained to check the workability of concrete. The slump value of M30 concrete grade having mix of 1:0.963:2.276 (Cement: Fine aggregates: Course Aggregates), with W/C ratio of 0.37 was found to be 28 mm for control mix. While, 29.5mm for 0.25% UC, 31.534mm for 0.5%UC, 33mm for 0.75%UC, 34mm for 1%UC, 35.8mm for 1.25%UC, 37.3mm for 1.5%UC, 39mm for 2%UC, 43mm for3%UC and 44mm for 4%UC and 54mm for 100% replacement.

 DOI : 10.18231/2454-9150.2018.1092

Figure 1 shows the slump values for different percentages of coolant in concrete.

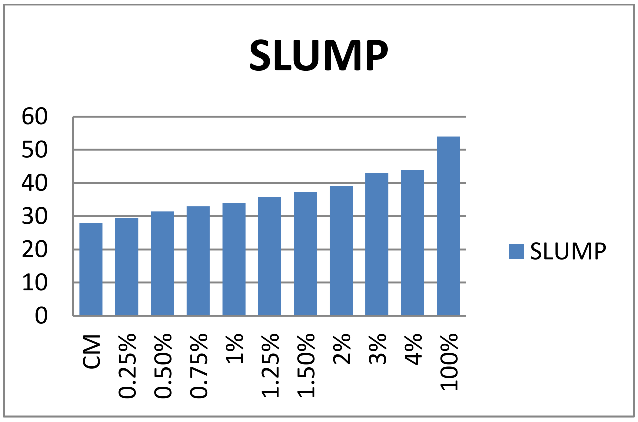

Figure 6: Slump results

1.8. Compressive strength:

1.8.1. Normal curing

The compressive, split tensile and flexural strength were all determined by using M30 mix of 1:0.963:2.276 (Cement: Fine aggregates: Course Aggregates), W/C ratio 0.37. Compressive strength is the ability of a material to bear up loads having tendency to decrease size of material. A total of 6 cube molds of concrete were tested to determine the load at which failure will occur for 7 and 28 days. The compressive strength was determined corresponding to average of failure loads of three specimens.

Table 4: compressive strength tests results

	7 days	28 days	Average
Control mix	21.090 N/mm^2	33.530 N/mm^2	27.310 N/mm^2
0.25% used coolant	20.980 N/mm^2	27.430 N/mm^2	24.205 N/mm^2
0.5% UC	20.040 N/mm^2	26.730 N/mm^2	23.385 N/mm^2
0.75% UC	19.872 N/mm^2	26.496 N/mm^2	23.184 N/mm^2
1% UC	19.500 N/mm^2	26.460 N/mm^2	22.980 N/mm^2
1.25% UC	19.490 N/mm^2	26.300 N/mm^2	22.895 N/mm^2
1.5% UC	18.510 N/mm^2	25.010 N/mm^2	21.760 N/mm^2
2% UC	18.570 N/mm^2	24.160 N/mm^2	21.365 N/mm^2
3% UC	17.330 N/mm^2	23.210 N/mm^2	20.270 N/mm^2
4% UC	17.240 N/mm^2	22.500 N/mm^2	19.870 N/mm^2
100% UC	2.384 N/mm^2	14.723 N/mm^2	8.553 N/mm^2

The effect of different percentages of used coolant on compressive strength of concrete is presented in table 4. The compressive strength of concrete goes on decreasing with an increase in the percentage of used coolant in the concrete mix at 7 and 28 days for normal curing. The best comparable results after replacement were at 1.25% for 7 & 28 days as after this, the water starts decreasing and the quantity of coolant alone doesn't form the best paste with cement. For 1.25% of used coolant the average decrease in compressive strength is 21.56% of the conventional concrete

1.8.2. Accelerated **curing**

The accelerated curing showed an increase in the overall strengths after replacements as it is believed that the heat may help in the completion of the hydration reaction between the coolant, water and cement which otherwise was prevented by normal curing.

Table 5: compressive strength with accelerated curing results

% UC	**7 DAYS**	**28 DAYS**	**AVG**
0.25%	22.320N/mm^2	34.970 N/mm^2	28.635 N/mm^2
1.25%	21.866 N/mm^2	34.516 N/mm^2	28.191 N/mm^2
100%	14.650 N/mm^2	27.330 N/mm^2	20.990 N/mm^2

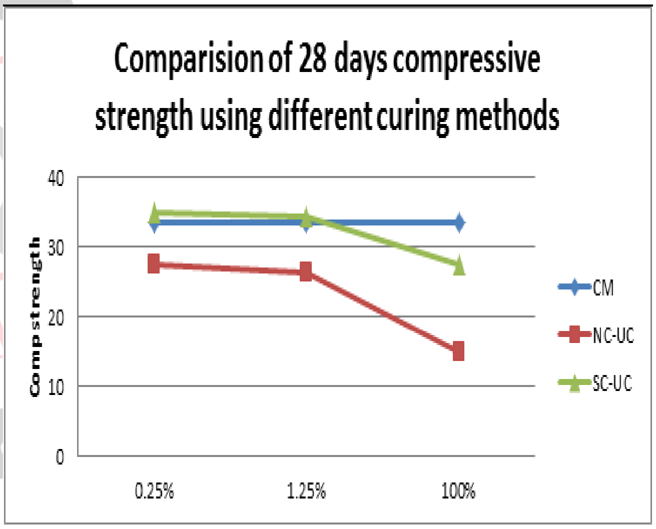

Figure 7: 28 days comparison between compressive strength

1.9. Tensile strength:

A similar decreasing trend was observed while calculating the split tensile strength of the cylindrical concrete specimens. Since, the tensile strength is 10% of the compressive strength so decrease in compressive strength is directly related to decrease in tensile strength. The optimum percentage for the replacement is same as that for compressive strength which is 1.25% of the weight of water.

Table 6: Tensile strength tests results.

	7 days	28 days	Average
Control mix	2.286 N/mm^2	3.372 N/mm^2	2.829 N/mm^2
0.25% used coolant	2.246 N/mm^2	2.680 N/mm^2	2.463 N/mm^2

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0.5% UC	2.088 N/mm^2	2.613 N/mm^2	2.350 N/mm^2
0.75% UC	1.970 N/mm^2	2.580 N/mm^2	2.275 N/mm^2
1% UC	1.976 N/mm^2	2.525 N/mm^2	2.250 N/mm^2
1.25% UC	1.860 N/mm^2	2.500 N/mm^2	2.180 N/mm^2
1.5% UC	1.817 N/mm^2	2.450 N/mm^2	2.133 N/mm^2
2% UC	1.805 N/mm^2	2.486 N/mm^2	2.145 N/mm^2
3% UC	1.767 N/mm^2	2.310 N/mm^2	2.038 N/mm^2
4% UC	1.673 N/mm^2	2.280 N/mm^2	1.976 N/mm^2

1.10. Flexural strength:

The results show that with the increase in the percentage of the used coolant the flexural strength also decreased because of the direct relation between the compressive and the flexural strengths (flexural strength=0.75√fck). The optimum percentage which gives the comparable results was kept as 1.25%.

Table 7: Flexural strength tests results.

	7 days	**28 days**	**Average**
Control mix	2.140 N/mm^2	3.230 N/mm^2	2.685 N/mm^2
0.25% used coolant	3.210 N/mm^2	3.541 N/mm^2	3.375 N/mm^2
0.5% UC	3.126 N/mm^2	3.500 N/mm^2	3.313 N/mm^2
0.75% UC	3.103 N/mm^2	3.473 N/mm^2	3.288 N/mm^2
1% UC	3.090 N/mm^2	3.420 N/mm^2	3.255 N/mm^2
1.25% UC	3.070 N/mm^2	3.336 N/mm^2	3.203 N/mm^2
1.5% UC	3.011 N/mm^2	3.250 N/mm^2	3.132 N/mm^2
2% UC	3.008 N/mm^2	3.150 N/mm^2	3.079 N/mm^2
3% UC	2.830 N/mm^2	2.990 N/mm^2	2.910 N/mm^2
4% UC	2.640 N/mm^2	2.870 N/mm^2	2.755 N/mm^2

IV. CONCLUSION

- Following conclusions were made from this study
- The workability of the used coolant replaced concrete has been found to increase with an increase in the concentration of used coolant in the concrete mix.
- The addition of the used coolant to the concrete showed the comparable results upto certain percentages (1.25%) for the compressive, tensile and flexural strengths.
- The accelerated curing showed even more increase in the strengths when compared to the normal curing. (1.849% increase in compressive strength than normal curing at 1.25% replacement)
- The addition of low concentration of the used coolant can be adventitious for both concrete and to the environment as the waste will be no longer exposed to the environment hence protecting the land and the ground water which otherwise was affected for aprox. 200 years.
- Comparative study revealed that the coolant alone cannot form the best paste with the cement hence, the optimum percentage which can be added to the concrete will be 1.25% of the used coolant which exhibited the strength of 26.3 N/mm^2 for normal curing and 34.15 N/mm^2 for accelerated curing. (1.849% increase in strength). The studies suggest that the accelerated curing helps in the completion of the hydration reaction between the cement, water and coolant which otherwise was halted by normal curing.

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