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RESEARCH ARTICLE

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COMPARATIVE STUDY ON DURABILITY OF HIGH STRENGTH CONVENTIONAL CONCRETE AND RECYCLED AGGREGATE CONCRETE

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ABSTRACT

Population and urbanisation are increasing rapidly over the world which demands more basic needs thus increasing the demand for construction activities. The main material used in each and every construction is concrete. Concrete is a mixture of cement sand, coarse aggregate and water. The increase in demand for concrete increases the demand for its constituent materials. Most of the materials used for concrete production are from natural sources and natural sources obviously depletes by tremendous usage. Research is being carried out for finding the best suitable replacement materials. The present research deals with the study of durability of concrete made with recycled aggregates. Recycled aggregates are the aggregates obtained from demolished concrete. Previous research explained that the strength of concrete is within the limit when concrete is made by replacing natural aggregate with up to 30% of recycled aggregates. Our aim in this research is to find how durable our concrete is when natural aggregates are replaced by 30% recycled aggregates.

Keywords: Recycled aggregates, demolished concrete, durability, sustainability, weight loss, water absorption

1. INTRODUCTION

Rapid urbanisation, technological advancements and modern architecture in the present lifestyle are paving way to more and more demolition activities. About 33% solid waste is being generated from the demolished activities per year all over the world of which only 3% is being recycled and utilised for minor works and the rest is being dumped into the landfills causing an impact on the environment. To achieve sustainability in construction, researchers and companies focus on using waste concrete as a new construction material by crushing the demolished concrete suitably either by manual crushing or using machines and using them as recycled aggregates.

Recycled aggregates are being effectively used in different countries for concrete kerbs, granular base course material, embankment fill material, paving blocks, backfill materials etc but structural utilisation is very rare. Many researchers concluded that for up-to 30% replacement of natural aggregate with recycled aggregates there is considerably no reduction in compressive strength but at more percentages the strength reduced. Hence we can say that 30% replacement level is nominal. But a very little literature is available regarding the durability of recycled aggregate concrete.

Nowadays it is not just important to study the strength of concrete but durability also.

Durability of the concrete deals with the sustenance of concrete when exposed to environmental conditions. Though in controlled lab conditions the concrete specimens may exhibit good strength, in actual field, the conditions are different. The concrete building may be exposed to severe weathering and environmental conditions which may increase its degradation and cause a reduction in strength. Hence the concrete may not be able to perform as it is supposed to be.

The present investigation deals with the comparative study on durability of high strength recycled aggregate concrete and normal aggregate concrete. The concrete grade considered in this study is M60. The recycled aggregate concrete contains 30% recycled aggregates and 70% normal aggregates as 30% is nominal for attaining target strength. The durability studies conducted in this research are acid attack sulphate attack, chloride attack and water absorption. After conducting these tests the cubes are tested for compressive strength and the variation is also presented.

2. Materials

The materials used in this research are: 43 grade cement, silica fume for replacement of cement by 10% to enhance the properties of recycled aggregate as silica fume works as micro filler. Demolished concrete used in this study was obtained from the demolition activities near our locality. The demolished concrete was crushed manually to obtain the aggregates with attached mortar. These aggregates are washed thoroughly to remove the adhered mortar to maximum possible extent. Then these aggregates were dried and used as coarse aggregates in new concrete. Sand used is local river sand and super plasticizer Conplast is used to obtain the desires workability.

3. Experimental program

The durability tests conducted in this investigation are acid attack resistance, sulphate attack resistance, chloride attack resistance and water absorption test. The tests have been conducted on concrete cubes of 100mm size. The mix design was done as per Perumal's method. All the required ingredients are mixed in pan mixer and cubes are cast. These cubes are then placed on vibrator for better compaction. Cubes are demoulded after 24hrs from the time of casting. The prepared cubes are allowed to cure in curing tanks for 28 days. After curing period the cubes are taken out and allowed to dry and the initial weight is noted and then they are kept immersed in respective solutions for a period of 2 days for durability check. Weights of immersed specimens have been checked in an interval of 5 days up-to 2 days to calculate the percentage weight loss.

For acid attack test cubes are immersed in HCl (Hydrochloric acid) solution which is highly corrosive, for sulphate attack test cubes are immersed in magnesium sulphate solution prepared by mixing 5% by weight of magnesium sulphate with potable water and for chloride attack test the cubes are immersed in NaCl solution prepared by mixing 5% by weight of sodium chloride in potable water.

At respective ages the cubes are taken out, surface dried and weight is noted. At the end of 28 days the cubes were checked for percentage loss of compressive strength.

4. Results and Discussion

Three cubes are prepared for each set and the average value of weight in each set is calculated for comparative analysis. The results and the corresponding discussion is given below:

4.1. Acid resistance test

Table 1: Average weight loss of NAC and RAC cubes subjected to acid attack

DAYS	0	5	10	15	20	25	28
% LOSS FOR NAC	0	2.079	2.487	2.569	2.768	2.65	2.773
% LOSS FOR RAC	0	1.857	2.311	2.352	2.517	2.558	2.558

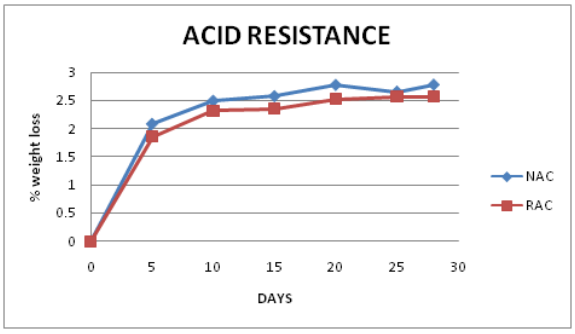

Figure 1: **Percentage weight loss with days for NAC and RAC**

From the above figure it can be conclude that exposure to acidic environment causes severe degradation in concrete. As the age of concrete in acidic solution increases, the weight loss also increases as seen in graph. It can also be inferred from the graph that the weight loss in recycled aggregate concrete is less than normal aggregate concrete.

4.2 Sulphate resistance test:

The negative sign indicates weight gain when subjected to sulphate attack.

Table 2: Average weight loss of NAC and RAC cubes subjected to sulphate attack

DAYS	0	5	10	15	20	25	28
% LOSS FOR NAC	0	-0.329	-0.228	-0.329	-0.329	-0.371	-0.329
% LOSS FOR RAC	0	-0.362	-0.282	-0.321	-0.282	-0.362	-0.321

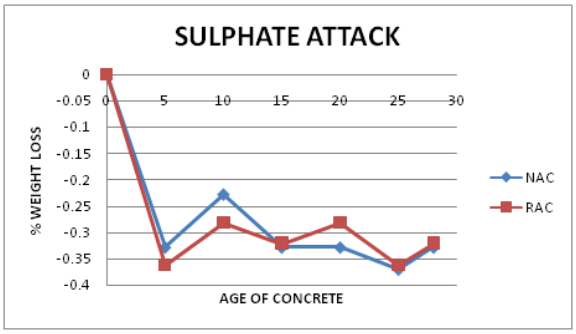

Figure 2: Percentage weight loss with days in NAC and RAC subjected to sulphate attack

It can be concluded from the above figure that in case of specimens subjected to resistance against sulphate attack, the specimens have gained weight with age. In this case the weight gained in case of recycled aggregate concrete is more compared to the weight gained in case normal aggregate concrete. Thus we can assume that recycled aggregates are more prone to sulphate attack than natural aggregates.

4.3 Chloride resistance test:

The negative sign indicates that there is weight gain in the samples when subjected to chloride attack.

In case of resistance to chloride attack, the trend is similar to that of sulphate attack. With increase in age of immersion in the solution, there is progressive weight gain in the concrete specimens. In this case the weight gained by natural aggregate concrete is more than the recycled aggregate concrete. The results indicate that RAC is more resistant than NAC when subjected to chloride attack. The graph clearly explains the high variation in weight gain between RAC and NAC. Thus a conclusion can be given that RAC can be used in marine environments.

Table 3: Average weight loss of NAC and RAC cubes subjected to chloride attack

DAYS	0	5	10	15	20	25	28
% LOSS FOR NAC	0	-0.407	-0.692	-0.488	-0.733	-0.733	-0.651
% LOSS FOR RAC	0	-0.329	-0.37	-0.329	-0.329	-0.246	-0.287

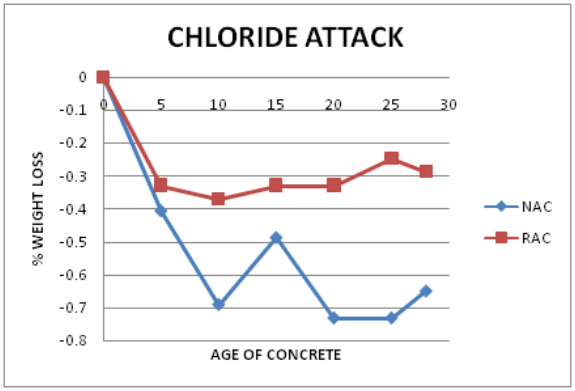

Figure 3: Percentage weight loss with age for NAC and RAC subjected to chloride attack

4.4 Water Absorption Test

This test is done as per ASTM standards. Two cubes each of normal aggregate concrete and recycled aggregate concrete are tested. The cubes are named as NAC1 and NAC2 for normal aggregate concrete and RAC1 and RAC2 for recycled aggregate concrete. The results are presented below:

Table 4: Percentage gain of weight of cubes subjected to water absorption

Water absorption	
Specimen	**% water absorption**
NAC 1	4.269
NAC 2	4.412
RAC 1	4.949
RAC 2	4.863

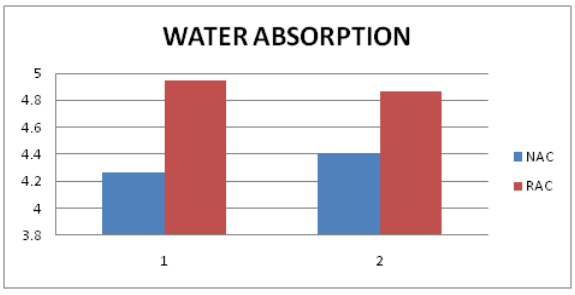

Figure 4: Percentage water absorption for NAC and RAC

From the above figure it can be concluded that recycled aggregates have more water absorption than natural aggregate concrete. This can be attributed to the adhered mortar present in the recycled aggregates which have the tendency of absorbing extra water.

4.5 Compressive strength at 28 days after testing for durability:

Table 5: Compressive strength for specimens subject to durability tests

Specimen	**Compressive Strength at 28 days- N/mm^2**
Acid attack-NAC	42
Acid attack-RAC	36
Sulphate attack-NAC	68.67
Sulphate attack-RAC	56.67
Chloride attack-NAC	48
Chloride attack-RAC	71

From the above results it can be said that the resistance to acid attack is less in both the concretes. There has been considerable reduction in the target mean strength. For NAC the reduction in strength is 39% and for RAC it is 46.36% which is very high. In case of sulphate attack normal concrete is more resistant. The reduction in strength is only 0.766% which is negligible but in RAC the reduction is 15.57% however less than the value for acid attack but quite considerable. When subjected to chloride attack the strength of NAC reduced by 30.6365 where as the strength of RAC followed a reverse pattern. It increased by 4.1%. Thus we can conclude that recycled aggregate concrete can resist chloride attack.

5. Conclusion

The following conclusions can be drawn from the present experimental investigations:

- From the test results of acid attack resistance test it can be concluded that under the effect of concentrated hydrochloric acid the weight loss is rapid and considerable and also there is drop in compressive strength.
- RAC have just 50% of their expected strength left after being subjected to acid attack showing very poor performance.
- In case of sulphate attack the strength increased for NAC and decreased for RAC. The reason for increment is sulphate forms ettringite which helps in good strength and bond development.

- In case of chloride attack strength increased for RAC. Thus we can say that RAC is more resistant to chloride attack.
- In case of water absorption RAC exhibits higher water absorption value due to the attached mortar present in the aggregates.

We can conclude that although the performance in acid attack is poor it is better under sulphate attack and chloride attack. From the above discussions and conclusions we can say that demolished concrete wastes can be easily used not only in non structural construction but also in structural concrete too. In fact it can be used in the production of high strength concrete which gives way for new possible research and opportunities in this topic

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