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Effective Use of Steam Cured Recycled Aggregate Materials in Conventional Concrete

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Abstract – The use of recycled materials is becoming common in these days owing to the attempts made by the researchers in the direction of utilization of materials, which are available in natural abundantly. The additives fly ash, which is tried in recent times with a scientific study, was found to be satisfactory. While, there is much work to be done in order to standardize the properties of the said additives. An attempt is made in the present work to investigate of these additives on the compressive strength of conventional concrete. The experimental study of this investigation consists of partial replacement of steam-cured recycled aggregates in conventional concrete and comparing the results with same mix when fly ash is added. Two mixes were obtained with a standard grade. For each of the grade mix, Different percentages of steam cured aggregates was replaced, that is 20%, 30% and 50% by weight of coarse aggregates by keeping the additive (fly ash) as 2% by weight of cement another mix is prepared and results are compared for compressive strength test and flexural strength of concrete

1. INTRODUCTION

Concrete is the world's second most consumed material after water, and its widespread use is the basis for urban development. It is estimated that billion tonnes of concrete are manufactured each year. Twice as much concrete is used in construction around the world when compared to the total of all other building materials combined. The construction and demolition waste (C&DW) have recycling schemes to avoid dumping to landfill, as suitable landfill sites are becoming scarce particularly in heavily populated countries the reuse of hardened concrete as aggregate is a proven technology. It can be crushed and reused as a partial replacement for natural aggregate in new concrete construction. The hardened concrete can be sourced either from the demolition of concrete structures at the end of their life or from leftover fresh concrete which is purposefully left to harden. Alternatively, fresh concrete, which is leftover or surplus to site requirements, can be recovered by separating out the wet fines fraction and the coarse aggregate for reuse in concrete manufacture.

This research mainly focuses on comparing the properties of conventional cement concrete (CCV) prepared from naturally obtained aggregates and recycled concrete (RAC) made from steam cured recycled aggregates under different tests such as tensile and flexure and use as low strength concrete or a high strength concrete.

2. OBJECTIVES

The main objective of this paper is to understand the strength properties of steam cured recycled aggregate concrete. The following is an outline of the specific objectives of this research:

- To determine the strength properties of steam concrete recycled aggregate and to increase its strength by adding Mineral admixtures obtained such as fly ash with a specified dosage.
- To determine whether that the strength of recycled aggregate concrete is effected by the age of Demolition waste

In this paper, the effects of varying percentage of recycled aggregate in conventional concrete on its compressive strength are going to investigate. The goal is to achieve a Maximum compressive strength without addition of chemical admixtures. This will be accomplished through extensive experiments on test cubes/cylinders casted for determining strength. Experiments include compression tests, flexural tests, Workability tests & permeability of concrete.

3. RECYCLED CONCRETE AGGREGATES (RCA)

The use of old construction materials in new projects is not a new concept. Recycling construction waste and demolition debris dates back to the time of the Romans, who often reused stones from previous roads in rebuilding newer ones Today, recycling of construction materials is a successful research program supported by the European Commission on Management of Construction and Demolition Waste. The European Demolition Association estimates that out of the 200 million tons of waste produced annually in Europe, about 30% of this quantity is currently being recycled. Studies in this area, however, show large region differences in the amount of recycled material. Some early adapting countries, like the Netherlands and Belgium, achieve recycling rates of about 90%, but in other European countries, like Italy and Spain, the recycling rate is below 10%.

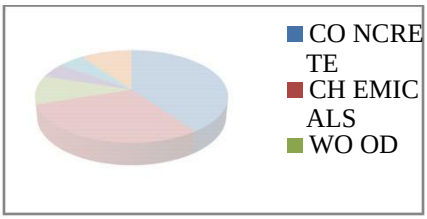

Figure 1. Basic Composition of Demolition Wastes

Since RCA is a cement-based material, there are concerns related to potentially elevate leaching patterns due to the inherent high alkalinity of RCA. In practical applications using cement-based material, wide pH ranges (7.5 to 12) due to both weathering of material and material alkalinity have been observed.

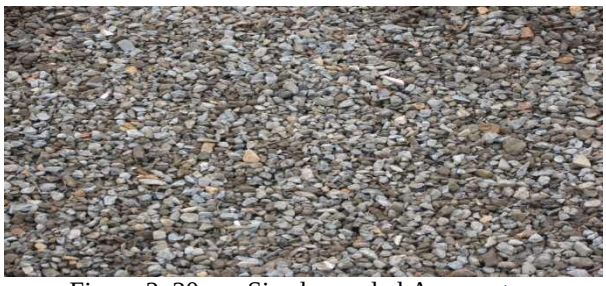

Figure 2. 20mm Sized recycled Aggregate

In this paper, the aggregates are obtained from demolition waste and cured for the stea m in accelerated curing tank.

3.1 Benefits of RC Aggregate

Recycled aggregate can be used for the following purposes

- Recycled aggregates are a way of reusing materials by keeping them from being disposed into landfills.
- They are more cost efficient than most regular aggregates.
- Recycled aggregates lower the amount of energy and raw materials used for the production of it.
- In pavements as aggregate, base and aggregate sub base.
- In pavements as surfacing (only if recycled aggregate is strong enough).

3.2 Characteristics of RC Aggregate

Extensive research on recycled material by different researchers helped set test limits and target value ranges foe recycled aggregate. Most of the same tests performed on virgin aggregate are necessary for recycled pavement aggregate. Here are some basic characteristics of recycled coarse aggregates:

- Gradation-Recycled aggregate can be specified to the same gradation ranges as virgin materials. The type of crushing equipment used influences fine aggregate gradation. Usually the fine material will be very angular, with an extremely high absorption rate and a low specific gravity, because the majority of the material is mortar from the old concrete.
- Specific gravity-Specific gravity of recycled coarse aggregate will be lower than of virgin aggregate. Typical value s are 2.2-2.5.
- Absorption-Recycled aggregate water absorption is much higher because of older cement mortar attached to the particle.
- Abrasion loss-Typically recycled aggregate values range from 20% to 45%, which is less than the upper limit of 50%.
- Sulphate soundness-It is not necessary to run the sulphate soundness test on recycled aggregate. Typical values are much less and are far below the maximum loss.
- Contaminants-Contamination limits for recycled aggregate used in concrete mixes should be the same as virgin coarse aggregate. Contamination usually is not a problem in rural highway pavement recycling if the pavement is prepared and removed carefully. No problem s will result from some contamination in a base course aggregate.

4. EXPERIMENTAL MET HOD

4.1 Collection of Aggregate Samples

Collection of aggregate samples is the first and foremost step involved in the project. It is the most difficult and time-consuming part of the project. Two kinds of aggregate samples are required for the project. They are:

- Fresh/Virgin aggregate sample
- Scrap/Used aggregate sample

For used aggregate samples, cement concrete cubes are collected from laboratory waste. This collected material is crushed by hammer to separate the aggregates & reduce their sizes in smaller fraction. On these separated aggregates various testes are conducted in laboratory as per Indian Standard code and their results are compared with natural aggregates. Recycled aggregate reduces the impact of waste on environment. By using some percentage in construction sector, cost is saved, due to reduction of transportation & manufacturing process.

We collected about 132kg of each aggregate sample which was required for this project

4.2 Laboratory Analysis of Aggregate Samples

The second step involved in the project after collection of aggregate samples was laboratory analysis. Laboratory analysis of aggregate samples involves a set of quality control tests t o be performed on each aggregate sample using appropriate lab equipment's to know their characteristics better.

The following quality control tests were performed on aggregate samples

- Impact Test
- Abrasion Test
- Specific Gravity Test

These tests were performed with reference to proper Indian Standard guidelines

4.3 Experimental Program

Three types of aggregates are used in this project, which includes natural coarse aggregate, natural fine aggregate and RCA. Natural coarse aggregate used is microtonalite with maximum size of 20 mm. Natural fines aggregate used is river sand and RCA used is crushed concrete from tested concrete cubes. Concrete is then produced with replacement of 20%, 30% and 50% of steam cured recycled aggregates. Tests conducted on these concretes include the slump of fresh concrete. For the hardened concrete, compressive strength was determined. Tests were conducted at the ages of 7, 14 and 28 days and the results at each testing age are reported as an average. The engineering properties of the RAC were also compared to those of the reference concrete.

The mix design is produced with the selected slump of 30~60 mm, design compressive strength of 25 MPa and the maximum aggregate size of 20 mm. Other aggregate properties available from previous tests are used in the calculation for mix design. Numerous trial mixes are carried out to produce concrete with 20% replacement of RCA. This concrete serves as reference concrete (control concrete) and tests are conducted on this concrete to determine its properties. The other two mixes are carried out to produce concretes with 30% and 50% replacement of steam cured RCA. The concretes with replacement of steam cured RCA are tested and their properties determined. For more elaborative performance fly ash of 10% is added in addition to RCA as a replacement of 10% of cement iits weigh. Directly after casting, the fresh concrete is covered with plastic sheet to avoid excess evaporation of water. The hardened concrete samples are then remoulded after 24 hours and submerged in a clean water bath for curing until the age of testing.

Figure 3. Curing of cube specimens

Figure 4. Failure Patterns in RAC

5. RESULTS

5.1 Impact Value Test

Fresh Aggregate

Weight of empty cylinder = 813 gms
Weight of aggregate + cylinder = 1118 gms
Total weight of aggregate sample filling the cylindrical measure, W_1= 305 gms
Weight of the material passing through IS sieve 2.36 mm, W_2 = 40 gms
Weight of the material retained on IS sieve 2.36 mm, W_3 = 265 gms
Aggregate Impact Value = (W_2/ W_1) ×100
% Aggregate Impact Value =40/305 × 100 %
Aggregate Impact Value = 13.10 %

Recycled Aggregate

Weight of empty cylinder = 813 gms
Weight of aggregate + cylinder = 1135 gms
Total weight of aggregate sample filling the cylindrical measure, W_1 = 322 gms
Weight of the material passing through IS sieve 2.36 mm, W_2= 60 gms
Weight of the material retained on IS sieve 2.36 mm, W_3 = 262 gms
Aggregate Impact Value =(W_2/ W_1) ×100
% Aggregate Impact Value =60/262 × 100
%
Aggregate Impact Value = 18.63 %

5.2 Abrasion Test

Fresh aggregate

Original weight of the sample, W1 = 5000 gms
Weight of aggregate retained on 1.70mm IS sieve, W2 = 4100 gms
Loss in weight due to wear, W1-W2 = 900 gms

Los Angeles Abrasion Value = $\frac{W1-W2}{W1} \times 100$

$= \frac{900}{5000} \times 100$

$=$ **18 %**

Recycled aggregate
Original weight of the sample, W1 = 50 00gms
Weight of aggregate retained on 1.70mm IS sieve, W2 = 3950 gms
Loss in weight due to wear, W1-W2 = 1000 gms

Los Angeles Abrasion Value = $\frac{W1-W2}{W1} \times 100$

$= \frac{1000}{5000} \times 100$

$=$ **21 %**

S.No	Particulars	Values	
		Natural Agg.	Recycled Agg.
1	Impact Test	13.10 % Loss	18.63 % Loss
2	Abrasion Test	18%	21%

5.3 Slump Cone Test

Table 1. Natural Aggregate Concrete

S.NO	W/C	HEIGHT OF CONE (SLUMP) cm
1	0.45	30
2	0.50	26
3	0.55	17
4	0.60	6

Table 2. Recycled Aggregate Concrete (20% Recycled Aggregate)

S.NO	W/C	HEIGHT OF CONE (SLU MP) cm
1	0.45	29
2	0.50	28
3	0.55	27
4	0.60	25

Table 3. Recycled aggregate concrete (50% Recycled Aggregate)

S.NO	W/C	HEIGHT OF CONE (SLU MP) CM
1	0.45	29
2	0.5	25
3	0.55	23
4	0.60	17

5.4 Compressive Strength Test

Table 4. Natural Aggregate Concrete

S.NO	AGE OF CONCRETE	LOAD in kN	AREA in mm^2	COMPRESSIVE STRENGTH IN N/mm^2
1.	7 days	331.5	22500	14.73
2.	14 days	434	22500	19.28
3.	28 days	556	22500	24.71

Table 5. Recycled Aggregat e Concrete (20% Recycled Aggregate)

S.NO	AGE OF CONCRETE	LOAD IN kN	A REA IN mm^2	COMPRESSIVE STRENGTH IN N/mm^2
1.	7 days	550	22500	24.45
2.	14 days	620	22500	27.56
3.	28 days	750	22500	33.34

Table 6. Recycled Aggregate Concrete (50% Recycled Aggregate)

S.NO	AGE OF CONCRETE	LOAD IN kN	AREA IN N/mm^2	COMPRESSIVE STRENGTH IN N/mm^2
1.	7 days	310	22500	13.77

2.	14 days	410	22500	18.22
3.	28 days	499	22500	22.17

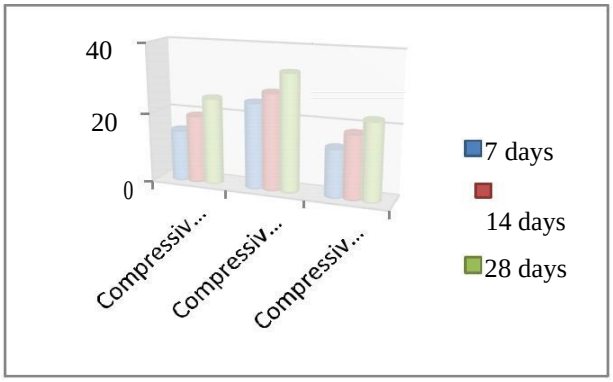

Figure 5. STRENGTH COMPARISON OF RAC AND RAC (50%) WITH CVC

6. CONCLUSION

1. Aggregate Impact Value is enhanced by 42% .
2. Los Angeles Abrasion Value is enhanced by 16.66%.
3. Slump value increase with the increase of water cement ratio on an average of 10%.
4. Comphressive strength of concrete decreases its strength with the increase of addition of recycled material but achieves some higher strength than conventional concrete because of angularity of recycled aggregates and addition of fly ash in the cement, it can be observed from tables 5.4.
5. 7 day strength is enhanced by 67% in the case of replacement of 20% of recycled materials
6. 14 day strength is enhanced by 42% in the case of replacement of 20% of recycled materials.
7. 28 day strength is enchaned by 34% in the case of replacement of 20% of recycled materials

7. SCOPE OF WORK

1. There are multiple application are there with recycled aggregate by replacing with various proportions with various chemical and natural admixtures.
2. The impact of recycled aggregate can be studied thru age variation, shape of aggregates, treating the material with mild acids such and 0.1 normality of H_2So_4, High strength and performance of concrete etc .

In this paper a common grade of concrete is applied since M20 is widely used but it can be tested with pre-stressed and post-stressed concrete

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