STANDARD RECYCLED AGGREGATE CONCRETE INCORPORATE WITH MICRO SILICA

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ABSTRACT

The continuous global demand for infrastructure due to persistent increase in population growth implies that more aggregate and cement would be required in concrete production. This would eventually lead to more extraction and depletion of natural resources and increased carbon emission. This leads to more extraction, depletion of deposits of natural gravel, and increased CO_2 emission from quarrying activities. Concrete is a heterogeneous material comprising fine aggregate, coarse aggregate, water and the binder known as cement. The presence of coarse aggregates contributes more to the heterogeneity. An aggregate consumes about 60% to 75% of the overall volume of concrete. The aim of this research work was to develop high performance concrete using recycled aggregate, microsilica, and synthetic macro fibre with the object to boost higher use of recycled coarse aggregate in the construction industry. An important aspect of sustainable construction is recycling or reuse of the construction material and demolition waste. It will maintain a friendly green environment. Recycled aggregates has micro cracks on its surface causes low strength, low workability of concrete. This draw back can be avoided by using micro silica. In this paper experimental results were shown for recycled aggregate incorporating with micro silica.

Key words: -*Micro silica; Recycled aggregate; Natural aggregate; Construction and demolition waste; Recycled concrete.*

1.INTRODUCTION

Concrete is a heterogeneous material comprising fine aggregate, coarse aggregate, potable water and the binder known as cement. The presence of coarse aggregates contributes more to the heterogeneity. An aggregate consumes about 60% to 75% of the overall volume of concrete. Although, concrete is characterized by very advantageous features ranging from cost effectiveness, durability, outstanding compressive strength, and availability, the continuous use of conventional concrete, (that is concrete produced with virgin aggregates and ordinary Portland cement) has proved to be very unfriendly to the environment, as a result of depletion of the natural resources. Growing disposal problems and huge energy consumption in quarrying activities, has affects the nature. The increasing demand for infrastructure, As a result of industrialization and urbanization has lead to more consumption of concrete. Concrete is the most widely consumed resource in the world after water and also the most widely used construction material in the last few decades.
During the crushing process and due to having loose mortar cover on surface of aggregate, Recycled aggregate has micro cracks on it. As a result of this, bond between cement and aggregate is weak. This is responsible for the low concrete strength and low workability.
By using recycled aggregate compressive strength of concrete get reduced as compare to the concrete from natural aggregate Researchers found that the replacement up to 30% [2], but this replacement gives lower strength than virgin aggregate. The use of mineral admixture (i.e. micro silica) could enhance the physical and engineering properties of recycled aggregate concrete. Micro silica contributes both physically and chemically in concrete mix. The size of micro silica particles is smaller than that of cement. This will results in reduction of the average size of

pores present in cement paste. While the chemical contribution takes place mainly by acting as an efficient pozzolanic material, which enables even distribution and higher volume of hydration products.

2. EXPERIMENTAL INVESTIGATION

To work with recycled aggregate concrete standard size moulds were used, total 84 specimens were casted, out of which 39 cubes of 150mm x 150mm x 150 mm size, 39 cylinder of 150mm x300 mm size. The beams were casted for maximum results obtained from the cube & cylinder for single replacement and addition design. The size of beam was 150mm x150mm x700mm.

2.1 Materials

2.1.1 Cement

Cement used is Ordinary Portland cement. (OPC). The color of the cement is due to iron oxide. In the absence of impurities, the color of cement is gray. Ordinary Portland cement (OPC) – 53 grade (Birla Shakti Cement) is used.

2.1.2 Fine Aggregate

Crushed sand is used which is also called as artificial sand which is locally available in nearby area having specific gravity 2.63.

2.1.3 Coarse Aggregate

Natural coarse aggregate used which are locally available. Aggregates have specific gravity 2.79. 20mm & 10mm size of aggregate were use, in 60% & 40% respectively.

2.1.4 Recycled Coarse Aggregate

Aggregate was obtained from college campus, the beam & cube casted for testing purpose was crushed & 20mm & 10mm aggregate were separated by sieving.

Figure1. Recycled aggregate

Aggregates having mortar layer over the surface, and having micro cracks on it so the water absorption, density and bonding with cement paste were low. This may give result in low workable concrete and low strength of concrete.

Table1: Strength of concrete

	Natural	**RCA**
Impact value	13.84%	20.2%
Abrasion value	17.2%	26.4%
Sp. gravity	2.79	2.69

2.1.4.1 Impurities in Recycled Coarse Aggregate

The performance of recycled coarse aggregate can be reduced due to the presence of impurities, which emanated from demolition process including porous mortar and cement paste attached to the parent aggregate. The effect could also lead to general reduction in characteristics of recycled aggregate concrete. Some of the impurities identified through visual inspection from the recycled coarse aggregate.

The average percentage impurities present in the recycled coarse aggregate amounted to about 5% of the total mass of the sample. However, the adhered mortar does not seem to be of significant quantity but its impact on the characteristics of recycled coarse aggregate concrete cannot be neglected.

2.1.5 Micro silica

Micro silica used is ASTM C1240 of cetex brand, having specific gravity 2.11.
When water is added to cement, hydration occurs as shown below:-
OPC + H2O → CSH (Calcium silicate hydrate) + $Ca(OH)_2$(Free lime)
The free lime does not contribute to strength, when combined with carbon dioxide; it forms a soluble salt, which leaches through the concrete causing effloresce, a familiar architectural problem. Concrete is also more vulnerable to chemical attack &detoriation, when it is added, the following reaction takes place.
$Ca(OH)_2 + SiO_2 \rightarrow H_20 + CSH$
The reaction reduces the amount of calcium hydroxide in the concrete.

Table2: Chemical property

Chemical property	Test Method	Result
Silicon Dioxide(SiO_2) % by mass	BS EN 196-2	92.0
Elemental Silicon % by mass	ISO 9286	0.12
Free Calcium Oxide %by mass	BS En 451-1	0.34
Sulphate (SO_2		0.14
Total Alkali (Na_2O_{eq}) %by mass		0.40
Chloride (Cl) %by mass	BS EN 196-2	0.03
Loss on Ignition % by mass		2.10

Figure2. Micro silica

2.1.6 Water

Water fit for drinking is generally considered fit for making concrete. Water should be free from acid, oils, alkalis, vegetables or other organic impurities. Soft water also produces weaker concrete. Water has two functions in concrete mixes. Firstly, it reacts chemically with the cement to form a cement paste in which the inert aggregates are held in suspension until the cement paste has hardened. Secondly, it serves as a vehicle or lubricant in the mixture of fine aggregate & cement.

3. Concrete Mix Design

M-30 Concrete mix was designed as per IS-10262. The 28 days characteristic strength is 30Mpa having water cement ratio 0.45.

Table3: Concrete Mixing and Placing

RCA (%)	0%	25%	50%	75%
Cement (kg/m³)	438	438	438	438
Sand (kg/m³)	703.48	703.48	703.48	703.48
Gravel (kg/m³)	1111.54	833.65	555.77	277.88
RCA. (kg/m³)	1111.54	277.88	555.77	833.65
Water (kg/m³)	197	197	197	197
Micro silica (kg/m³)				
5%	0	21.9	21.9	21.9
10%	0	43.8	43.8	43.8
15%	0	65.7	65.7	65.7

Concrete is mixed by hand mixing on concrete base which is absorbent. Hence because of absorbent surface water is sprayed over it.

Then coarse aggregate were placed after that fine aggregate was placed over coarse aggregate this is covered by cement & micro silica. firstly dry mixing was done. After proper dry mixing required quantity of water was sprayed on the dry mix and then mix it thoroughly.

After ascertaining consistency, the concrete was placed in various lubricated moulds (cubes, cylinders) in three layers with each layer compacted by 25 times using tamping rod & the vibrating table in order to expel any entrapped air.

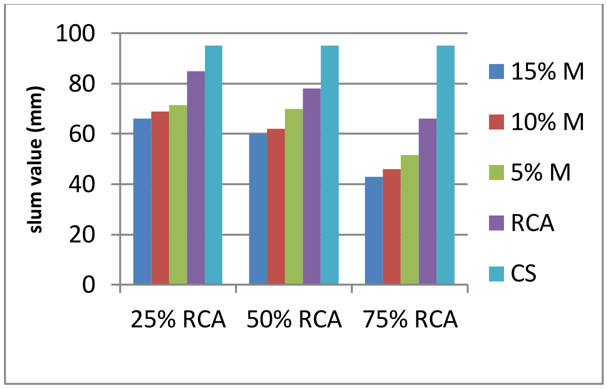
The surface was gradually levelled with steel hand trowel. The concrete samples were thereafter de-moulded and cured in the water tank at about 20°C.

4. RESULTS AND DISCUSSION

Different tests were conducted on fresh and hardened concrete like on fresh concrete slum test and compaction factor test were carried out to know the workability of concrete, and compressive strength test, split tensile strength and flexure test were carried out on hardened concrete to know the properties of hard concrete having recycled aggregates incorporating with micro silica the graph shows the variations with respect to percentage variation of recycled aggregate and microsilica.

4.1 Workability test: slum test-

The result shows that as the percentage of recycled coarse aggregate, incorporating with increasing percentage of microsilica decreases the water-cement ratio. The percentage decrease in water cement ratio for 25%, 50% and 75% are 36.02%, 45.16% and 75.36% respectively for addition of 15% microsilica.



Graph 1: slum value experimental results

Table4: Result of slump test for concrete mix

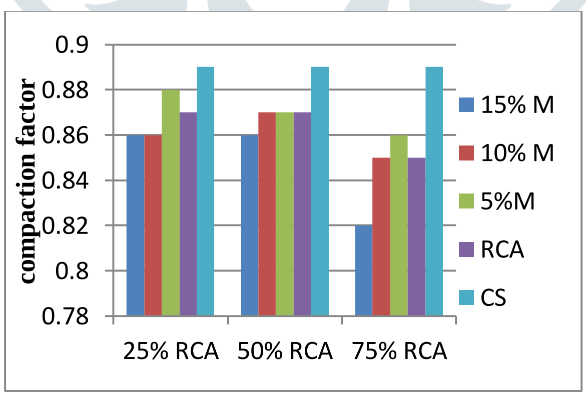
RCA (%)	0%M (mm)	5% M (mm)	10% M (mm)	15% M (mm)
0	95	-	-	-
25	82	71.5	69	66
50	78	70	62	60
75	66	51.5	46	43

RCA --- Recycled Coarse Aggregate, M --- Microsilica

The incorporation of microsilica in the mix significantly affects the characteristics of fresh concrete due to the strong cohesiveness of the concrete mix which result in very little bleeding or absence of bleeding in the concrete mix.

4.2 Workability test: compaction factor test

Compaction factor test also gives low results; were shown by graph for compaction factor test,



Graph 2: compaction factor experimental results

Table5: Result of compaction factor test for concrete mix

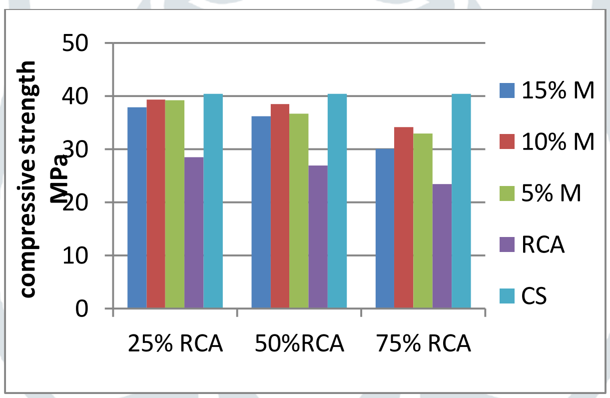
RCA (%)	0% M	5% M	10% M	15% M
0	0.89	-	-	-
25	0.87	0.88	0.86	0.86
50	0.87	0.87	0.87	0.86
75	0.85	0.86	0.85	0.82

RCA --- Recycled Coarse Aggregate, M --- Microsilica

as the percentage of RCA and microsilica increased in mix the workability of concrete were reduced. The percentage of reduction is 3.84%, 3.84% and 8.18% for 25 %, 50% and 75% respectively as compare to control specimen.

4.3 Compressive strength

The results of the compression tests carried out at age 28 days for the recycled concretes and for the conventional for the different replacement percentages are shown Fig. 3. Each of the reported values represents the average of three tests. Fig. 3 shows that for recycled concretes, the compressive strength of recycled concrete is lower to that of the original concrete.



Graph 3: compressive strength experimental results

Table 6: Result of compressive strength (Mpa) test for concrete mix

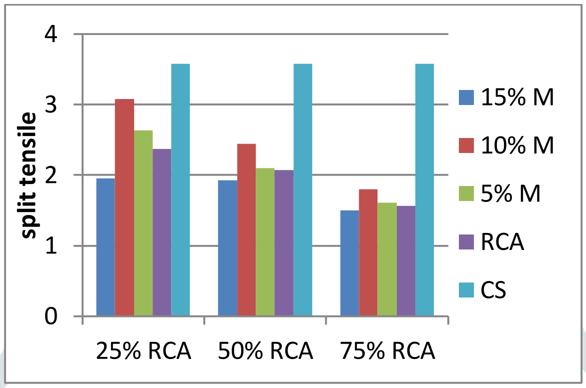
RCA (%)	0% M	5% M	10% M	15% M
0	40.38	-	-	-
25	28.49	39.16	39.37	37.93
50	26.92	36.72	38.52	36.16
75	23.47	32.98	34.18	30.05

RCA --- Recycled Coarse Aggregate, M --- Microsilica

But as compare to target strength the 25% replacement with addition of 10% micro silica gives more compressive strength. As the percentage of replacement of aggregate and addition of micro silica were increased the compressive strength got decreased to 6.25%, 11.02% and 29.33% for 25%, 50% and 75% replacement respectively for max microsilica dose.

4.4 Splitting Tensile Strength

The splitting tensile strengths of recycled concretes and of conventional concretes as the average of three tests in each case are presented in Fig. 4. For RCA concretes,



Graph 4: split tensile experimental results

Table 7: Result of split tensile strength (Mpa) test for concrete mix

RCA (%)	0% M	5% M	10% M	15% M
0	3.58	-	-	-
25	2.37	2.63	3.08	1.95
50	2.07	2.10	2.44	1.93
75	1.56	1.61	1.80	1.5

RCA --- Recycled Coarse Aggregate, M --- Microsilica

The splitting tensile strengths of recycledconcretes were decreased as the percentage of recycled aggregate and microsilica increased, whereas the concretemade with 75% of recycled aggregate exhibits a very low strength thatis 81.80% lower.

5. CONCLUSION

The graph plotted using the results are shows results with addition of microsilica. Hence from the results we can conclude that Micro silica improves the strength as discussed before.

1) The water absorption of recycled aggregate is more as compare to the natural aggregate.
2) As the percentage of microsilica increases workability of concrete get decreases.
3) The incorporation of microsilica, significantly improves properties of recycled aggregate concrete up to 10% beyond which it get declines.
4) The outcome of research suggests potential to increase current recommended fraction of recycled aggregate in concrete.

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