Standard Recycled Aggregate Concrete in Corporate with Micro Silica

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Abstract— Concrete is most important material used in the construction industry. Large amount of natural aggregates were used in concrete, this causes the nature. Now a day's many structures are demolished & rebuilt, demolishing of structures causes problem with dumping of waste material. An important aspect of sustainable construction is recycling or reuse of the construction material and demolition waste. It will\7poi 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.

Keywords: Micro silica; Recycled aggregate; Natural aggregate; Construction and demolition waste; Recycled concrete

I. 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.

The continuous global demand for concrete comprises that more aggregate and cement requirement. This leads to more extraction, depletion of deposits of natural gravel, and increased CO_2 emission from quarrying activities. Partial substitution of natural aggregate with recycled aggregate would lead to reduction in construction cost and carbon emission of the construction industry.

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.

A. Research aim and objectives

1) Aim

The major aim of this research is to develop conventional standard concrete using recycled coarse aggregates as substitute for natural coarse aggregate and mineral admixture (micro silica), in order to improve the properties of recycled aggregate concrete. With an additional goal to boost the potential of increasing its uses from the recommended 30% level from some past researchers. Adequate factual scientific information is thereby required to establish the mechanical and physical characteristics of concrete incorporating above-mentioned materials.

2) Objectives

The objectives are to;

1) Determination of fresh and hardened properties of concrete incorporating various percentage of recycled coarse aggregate content;
2) Evaluate the effect of addition of mineral admixture (micro silica) on concrete produced in (1) above;
3) Determine the optimal use of micro silica required to achieve good strength concrete produced in (2) above;
4) Evaluate the flexural performance of nominal reinforced concrete incorporating micro silica which produced the optimal effect in above.

B. Significance of Research

The following listed are potential benefits from this research work to the construction industry and the environment. These are;

1) Reduction of pressure on landfills from construction and demolition debris;
2) Potential to increase the use of recycled coarse aggregate beyond the maximum recommended 30%;
3) Conservation of natural resources through reduction in the use of natural coarse aggregate for concrete work;
4) Mitigation of performance issue like low strength associated with recycled aggregate by incorporating micro silica (mineral admixture) in the concrete mix;
5) Potential application of recycled coarse aggregate in structural concrete.

II. EXPERIMENTAL INVESTIGATION

To work with recycled aggregate concrete standard size moulds were used, total 84 specimens were casted, out of which 42 cubes of 150mm x 150mm x 150 mm size, 21 standard beams of 150 x 150 x 700 mm. The beams were

casted for maximum results obtained from the cube for single replacement and addition design.

A. Materials

1) Cement

Cement used is Ordinary Portland cement. (OPC). The colour 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) 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.

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.

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.

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.

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

a) 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. Although there is visual evidence to show the presence of adhered mortar on the parent material, it was practically impossible to estimate their percentage. 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.

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:-

$$OPC + H2O \rightarrow CSH \text{ (Calcium silicate hydrate)} + Ca(OH)_2 \text{(Free lime)}$$

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.

Typical properties of microsilica

Form	Description
Colour	Grey
Odour	Odorless
Solubility	Insoluble
Specific gravity	2.11
Bulk density	0.416

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	BS EN 196-2	0.40
Chloride (Cl) %by mass		0.03
Loss on Ignition % by mass		2.10

Chemical properties

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.

III. 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.

RCA (%)	0%	25%	50%	75%
Cement (kg/m³)	350.00	350.00	350.00	350.00
Sand (kg/m³)	663.83	663.83	663.83	663.83
Gravel (kg/m³)	1270.76	953.07	635.38	317.69
RCA. (kg/m³)	0.00	317.69	635.38	953.07
Water (kg/m³)	154.00	154.00	154.00	154.00

Micro silica (kg/m³)

5%	0	17.5	17.5	17.5
10%	0	35.00	35.00	35.00
15%	0	52.50	52.50	52.50

A. Concrete Mixing and Placing

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.

1) Sequence of laboratory work

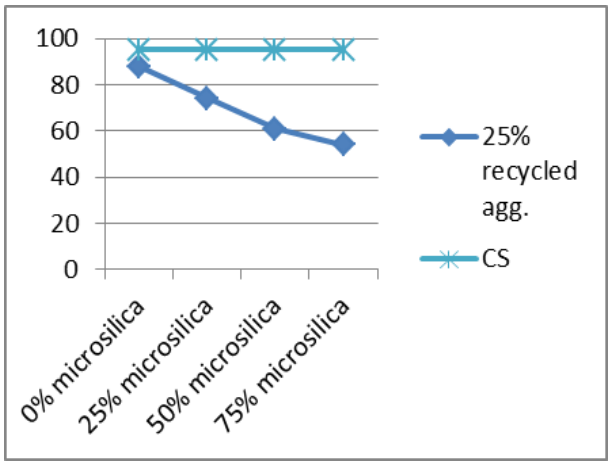
1) Determination of saturated surface dry (ssd) density of natural fine aggregate, natural coarse aggregate and recycled coarse aggregate;
2) Comparison of water absorption in each of the aggregate;
3) Adjustment of concrete mix design with the results obtained in (a) above;
4) Concrete batching;
5) Fresh concrete testing (slump test), (compaction factor test);
6) Filling of steel moulds (cube, cylinder and beam) and compaction using tamping rod and vibrating table;
7) Covering fresh concrete filled moulds with polyethylene bag to prevent loss of moisture due to evaporation;
8) De-moulding of concrete sample after 24 hours;
9) Storage of hardened concrete sample in the curing tank about 20°Cfor maximum 28 days;
10) Testing of hardened concrete at 28 days curing age.

IV. 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 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.

A. 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 5%, 10% and 15% are 22.10%, 35.78% and 43.15% respectively for addition of 15% microsilica.



Graph 1: slum value experimental results

RCA (%)	0% M	0% M	5% M	10% M	15% M
0	95	-	-	-	-
25	-	88	74	61	54

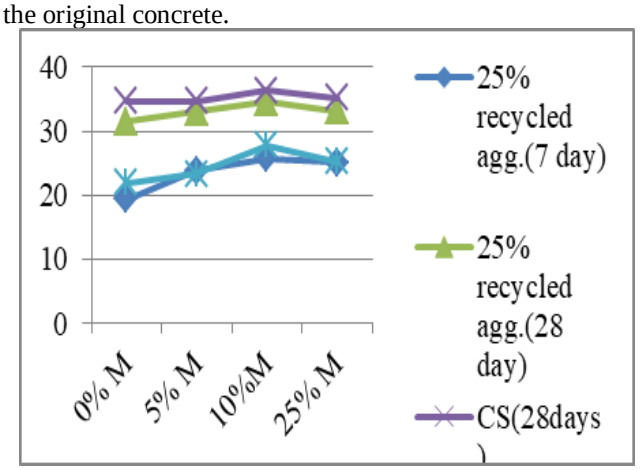
Table 1: Result of slump test for concrete mix

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.

B. 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 2: compressive strength experimental results

RCA (%)	0% M	5%M	10%M	15%M
0	21.88	23.30	27.80	25.20
25	19.38	23.80	25.80	25.10

50	17.16	-	-	-
75	15.03	-	-	-

Table 5.3: Result of compressive strength (Mpa) test for 7 days test

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

RCA (%)	0% M	5% M	10% M	15%M
0	34.7	34.69	36.34	35.40
25	31.5	32.98	34.50	33.18
50	28.2	-	-	-
75	23.5	-	-	-

Table 5.3: Result of compressive strength (Mpa) test for 28 days test

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.

V. FLEXURE TEST

The experimental setup is based on the four-points bending test on Universal testing machine. The load was applied by using a hydraulic jack via a load cell. The load was transferred from the jack to the main specimen by using a loading beamTwo roller supports carried the reactions; therefore, the loading states were four incremental bending points' loads. The deflection at the centre of web is measured by using dial gauge.

The summary of results for flexure test on beams is provided in below table. From these loads the ultimate strength and percentage increase as comparison of control beam was calculated.

Specimen designation	Ultimate load P (kN)	Ultimate strength	Percentage increase/decrease
CB	81 KN	14.40	-
RCA 25%	63 KN	10.36	28.06 decrease
RCA 25%-M10	78 KN	13.52	06.11 decrease

VI. 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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