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Effect of Silica Fume on Mechanical Properties of Recycled Aggregate Concrete

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ABSTRACT

The objective of this study was to investigate sustainable aggregate replacements in concrete. Recycled aggregate were added as a coarse-aggregate replacement by 50% and silica fume were added as replacement of cement in 5%, 10% and 15%.This has the potential to reduce material cost while having a beneficial impact on the environment The study involves 108 concrete specimens with various combinations of these materials, which were prepared, cured, and tested. The mechanical properties, including compressive strength, tensile strength, and flexural strength of concrete were investigated and compared to those of ordinary concrete. The results indicated that recycles aggregate replacement with a natural aggregate resulted in decreased concrete strength, while remaining useful up to 10% replacement. The silica fume improved the mechanical properties of concrete and can potentially replace up to 50% of natural coarse aggregate. A combination of recycled aggregate along with silica fume can be used to allow replacement of coarse aggregate in concrete by 50% increase in concrete strength.

1. INTRODUCTION

Protection of environment, conservation of natural resources, and sustainable constructions are the three important essences of any modern. Today, sustainable development has been supported throughout the world. Construction industry is a massive consumer of natural resources and a vast construction and demolition (C&D) waste producer as well generally; C&D waste coming from construction industry consists mostly of inert and non-biodegradable material. Furthermore, concrete rubble has been found to be a large portion consisting around 40% present in C&D waste. The C&D waste normally discards on the roadside, causes problems to traffic and environment. Moreover, it is an additional workload to the local administration. On the other hand, the resources of natural coarse aggregates are scarce and depleting very fast as the construction activities are increasing day by day. Therefore, these two important issues have to be sorted out very urgently. Both problems can be mitigated by utilizing the concrete rubble obtained from C&D waste as recycled aggregate (RA) in concrete and implemented all over the world.

Now-a-days, sustainable constructions, environmental problems and protection of natural aggregate resources are the crucial issues in the construction industry. Therefore, the present work aims to make a use of the maximum possible extent of recycled aggregate (RA) obtained from C&D waste in high-strength concrete production. The use of recycled aggregate in concrete will be an major step towards sustainable construction and the conservation of natural resources as well.

2. MATERIAL AND METHODOLOGY

2.1 Recycled Coarse Aggregates (RCA):

Recycled coarse aggregates are comprised of crushed, graded inorganic particles processed from the materials that have been used in the constructions and demolition debris. Recycled concrete aggregates mainly differ from natural aggregates in that they are composed of two different materials:

- Natural aggregate and
- Cement mortar attached.

Recycled coarse aggregate are obtained from concrete waste. Recycled aggregates contains high absorption, rough texture and angular than natural aggregates that affect the concrete mix proportion. The environmental benefits increase by using these recycled coarse aggregates in the preparation of new concrete. Hence, recycling of the concrete waste can be considered as an excellent source of coarse aggregate for the production of new concrete. improves the strength of recycled coarse aggregate by filling air voids which were occurred in recycled coarse aggregate and also by using pozzolanic material it increases the bond strength between motor and cement paste.

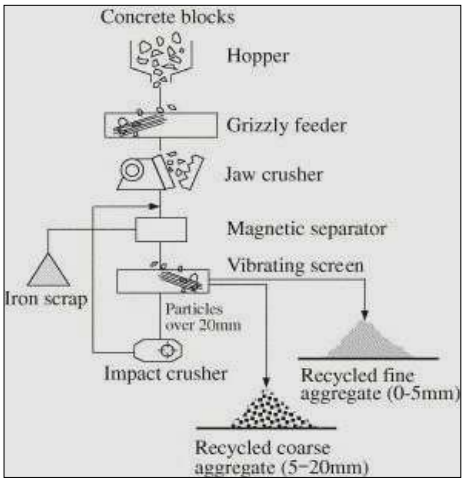

Fig.1: Recycled Aggregate Production

2.2 Silica Fume

Silica fume, also called as micro silica, is a by-product material that is used as a pozzolan. It having very fine particles, the diameter is 1 µm with an average diameter of 0.1 µm. This is 100 times smaller than cement particles. Silica fume is a very fine pozzolanic material, collected by amorphous silica produced by electric arc furnaces as a byproduct of the production of elemental silicon or ferro silicon alloys. Silica fume can be used in concrete, grouts, mortars, fibre cement products, refractory, oil/gas well cements, ceramics, elastomeric, and polymer applications.

Silica fume is produced in conformity with the ASTM C 1240 specifications. The quality is controlled and monitored in every part of production process to ensure that it meets or exceeds specification requirements. According to the Florida Department of Transportation (2004), the quantity of cementation materials. Silica fume contained the fine particles with specific surface about six times of cement because its particles are very finer than cement particles. Hence, it has been found that when silica fume mixes with concrete the micro pore spaces decreases. Silica fume is pozzolanic, because it is reactive, like volcanic ash. Its effects are interconnected between the strength, modulus, ductility, sound absorption, vibration damping capacity, abrasion resistance, air void content, bonding strength with reinforcing steel, shrinkage, permeability, chemical attack resistance, alkali-silica reactivity reduction, creep rate, corrosion resistance of embedded steel reinforcement, freeze-thaw durability, coefficient of thermal expansion (CTE), specific heat, defect dynamics, thermal conductivity, dielectric on.

Table 1- Properties of Silica Fume (Adopted From Silica Fume -Technical Data Sheet Prepared By Norchem)

PROPERTIES	
State Amorphous	Sub-micron powder
Color	Gray to medium gray powder
Specific Gravity	2.10 to 2.40
Solubility	Insoluble
Bulk Density	Densified 674 to 770 kg/m^3
Bulk Density	Undensified “as produced” 192 to 320 kg/m3

Table 2:- Specifications of Silica Fume (Adopted From Silica Fume -Technical Data Sheet Prepared By Norchem)

SPECIFICATIONS		
Chemical Requirements	**ASTM**	**Typical**
Silicon Dioxide (SiO2) %	85.0 % Minimum	93.47 %
Moisture Content %	3.0 % Maximum	0.27 %
Loss on Ignition (LOI) %	6.0 % Maximum	3.82 %
Physical Requirements	**ASTM**	**Typical**
Oversize percent retained on 45-µm (325 sieve)	10.0 % Maximum	2.54 %
Accelerated Pozzolanic Strength Activity Index with Portland cement (7 day)	105.0 % Minimum	126.07 %
Specific Surface	15 m^2/g Minimum	22.28 m^2/g

3. OBJECTIVES

The present study is carried out with the objective, to utilize maximum possible quantity of recycled aggregate obtained from construction and demolition (C&D) waste for producing high-strength concrete and to decide the process/method of RAC making to achieve the aim.

- To produce concrete utilizing recycled aggregate obtained from construction and demolition (C&D) waste and silica fume.
- To decide the maximum possible replacement level of Silica fume in concrete.
- To solve the problems of environmental pollution, achieve sustainable construction, and conservation of natural resources of aggregates.

3.1 Scope

- Recycled aggregates were obtained by processing waste of demolished building element.
- The use of recycled aggregate restricted to coarse aggregates.
- Mix proportion of RAC was carried out by direct weight replacement method.
- Mechanical properties of hardened concrete were limited to compressive strength, split tensile strength and flexural strength by means of standard concrete cube 150, cylinders with 150 mm diameter and 300 mm high. Beam having cross section 100mm X 100mm and 500 mm in length
- Total 3 numbers of beam specimens, 3 cylinders and 3 beams were tested. The replacement ratio was 0%,5%,10% and 15% of silica fume and 50% of recycled aggregate

4. METHODOLOGY

The main purpose of the work is to utilize more quantity of recycled aggregate and silica fume for the production of concrete. To achieve the main aim, first of all, the existing problems associated with recycled aggregate (RA) and recycled aggregate concrete (RAC) and silica fume (SF) were studied thoroughly to understand the basic scenario of both RA and RAC.

In this study, the experimental work has been carried out. The mix proportion of M30 grade has adopted. However, each time, a new mix has been prepared by replacing virgin coarse aggregates with recycled aggregates (both processed and un- processed) and replacing cement with silica fume. The percentage replacement of Natural coarse aggregate (NCA) with recycled aggregate (RA) is 50% and percentage of replacing cement with silica fume is 5%, 10% and 15%

5. MIX DESIGN OF CONCRETE

Table 3. :- Mix Proportions Per Cubic Meter Of Concrete

Mix No.	% replacement of silica fume	Cement (Kg/M^3)	Silica fume (Kg/M^3)	Coarse Aggregate (Kg/M^3)	Recycled Coarse Aggregate (Kg/M^3)	Fine Aggregate (Kg/M^3)	Super Plasticizer (Kg/M^3)
M_0	0	400	0	1198	0	657.438	4
M_5	5	380	20	599	599	657.438	4
M_{10}	10	360	40	599	599	657.438	4
M_{15}	15	340	60	599	599	657.438	4

5.1 Expeimental Investigation

Table 4. -- Results Of Test On Coarse Aggregate As Per Is:2386(Part-I-Viii)

Sr. no.	Test Performed	Results
1	Fineness modulus	2.75
2	Silt Content	4.76%
3	Bulking of Sand	2.21%

Table 5- Results of Test On Sand As Per Is Guidelines

Sr.no.	Test performed	Natural aggregate	Recycled aggregate
1	Fineness Modulus	6.53	6.76
2	Impact test	14.54%	19.29%
3	Water Absorption	1.58%	2.01%
4	Specific Gravity	2.705	2.68

Table 6 -Results Of Tests On Fresh Concrete

Mix .No.	Tests conducted	
	Slump Cone	Compaction Factor
M0	102	0.94
M5	105	0.957
M10	98	0.917
M15	95	0.904

- *Testing of Hardened Concrete as per IS guidelines-*

1) Compressive Strength Test of Concrete Cubes- For cube test 15cm X 15cm X 15cm size of moulds are used. These specimens are tested by compression testing machine after 7 days curing or 28 days curing. Load should be applied gradually at the rate of 140 Kg/cm2 per minute till the Specimens fails.

Table 7. - Results of Compressive Test On Hardened Concrete

Mix No.	Compressive Strength (N/mm^2)		
	7 Days	28 Days	56 Days
M0	18	30.2	32.7
M5	21.03	33.6	35.89
M10	19.03	32.72	34.88
M15	18.23	31.67	34.2

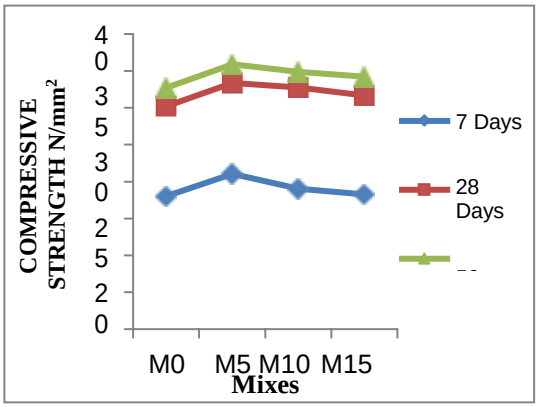

Fig. 2. - Outcome Of Compressive Strength.

2) Splitting Tensile Test as per IS guidelines-

Table 8.-Results of Splitting Tensile Test On Hardened Concrete

Mix No.	Splitting tensile Strength (N/mm^2)		
	7 Days	28 Days	56 Days
M0	1.59	2.47	2.60
M5	1.76	2.79	2.91
M10	1.67	2.65	2.76
M15	1.61	2.6	2.71

3) Flexural Strength : Standard beam test (Modulus of rupture) was carried out on the beams of size 100 mm x 100 mm x 500 mm as per IS: 516 [Method of test for strength of concrete], the rate of loading is 1.8 KN/minute for 100 mm specimens. Flexural strength test is workout using two point load method.

The result of flexural strength test shown in table no.-9

Table 9.:- Results Of Flexural Test On Hardened Concrete

Mix No.	Flexural Strength (N/mm^2)		
	7 Days	28 Days	56 Days
M_0	8.84	11.31	12.36
M_5	10.46	12.08	12.98
M_{10}	9.78	11.63	12.28
M_{15}	9.64	11.01	12.33

6. CONCLUSION

There is a global need to protect our environment and preserve scarce natural resources for following generations. Recycling of construction and demolition materials can help preserve our public fill capacity and landfill space. It can also help us to reduce the need for quarrying and other damage caused to the natural landscape. Recycled aggregates can be used in many applications, including concrete production.

Silica fume is the one of the most popular pozzolanas, whose addition to concrete mixtures results in lower porosity, permeability and bleeding because their oxides (SiO2) react with and consume calcium hydroxides which is produced by the hydration of ordinary Portland cement. The main results of pozzolanic reactions are: lower heat liberation and strength development; lime activity; smaller pore size distribution.

This study has presented various aspects regarding recycled aggregates and their use in concrete, which can be summarized as follows:

- In recycled aggregate concrete, workability is less than the natural aggregate concrete. The reason
- behind it is due to porous and rough surface texture of recycled coarse aggregate.
- Workability of recycled aggregate concrete is reduced rapidly when concrete prepared by using silica fume, due to finer particle size of silica fume.
- It is observed that use of recycled aggregate without any surface treatment shows lower performance level in terms of loads but addition of silica fume increased the performance of RAC.
- The rate of gaining strength in two stage mixing approach is higher in earlier days than the rate of gaining of strength in 28 days.
- Recycled aggregate concrete have lower value of compressive, tensile and flexural strength but after addition of silica fume, it enhance all mechanical properties of concrete.
- 5% Silica Fume, as a partial replacement of cement and 50% RCA gives better result among all the combinations.
- This initial study indicates that the inclusion of silica fume does improve the properties of RAC to enable use in structural applications. Due to the small sample size, the results from this investigation should not be relied upon exclusively. Further study is necessary to confirm these effects and ensure repeatability of results.

7. REFERENCES

[1] Ozgur Cakir and Omer Ozkan Sofyanli.,(2014**)** studied the “Influence of silica fume on mechanical and chemical properties of recycled aggregate concrete”, HBRC Journal (2015) 11, 157–166.

[2] P Huoth,T G. Suntharavadivel, K Duan(2014) “Effect of silica fume on recycled aggregate concrete” 23rd Australasian Conference on the Mechanics of Structures and Materials (ACMSM23) Byron Bay, Australia, 9-12 December 2014, S.T. Smith (Ed.)

[3] Animesh Awasthi, Gaurav Soni and Ram Bharosh (2018) “Study of Recycled Aggregate Concrete Containing Silica Fume as Partial Replacement for Cement” International Journal of Advance Research, Ideas and Innovations in Technology

[4] Ranjodh Singh, Sudhir Arora (2017) “Influence of Silica Fume & Recycled Concrete Aggregates on Mechanical Properties of Concrete” International Journal of Engineering Technology, Management and Applied Sciences January 2017, Volume 5, Issue 1, ISSN 2349-4476

[5] J. Kalyana Chandrasekhar Reddy, P. S. S. Anjaneya Babu (2016) “ Significance of Silica Fume on the Mechanical Properties of Recycled Aggregate Concrete” International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Index Copernicus Value (2013): 6.14 | Impact Factor (2015): 6.391,

[6] Volume 5 Issue 6, June 2016