SILICA FUME RECYCLED AGGREGATE CONCRETE (SFRAC)

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***Abstract*—Recycled aggregates are derived from crushing demolished concrete. They comprise of crushed, graded inorganic particles processed from the materials that have been used in the construction and demolition debris. The main aim of the present experimentation is enhancing the performance of recycled aggregate concrete through the use of supplementary cementitious materials produced by replacing natural aggregates by recycled aggregates in various percentages. Silica fume supplementary cementitious material is used for experimentation. The objective of the investigation is to improve the properties of concrete produced with recycled aggregate.**

***IndexTerms*— Recycled aggregate, cementitious material, properties, replacing**

I. INTRODUCTION

The usage of natural aggregate is getting more and more intense with the advanced development in infrastructure area. In order to reduce the usage of natural aggregate, recycled aggregate can be used as the replacement materials. Recycled aggregate are comprised of crushed, graded inorganic particles processed from the materials that have been used in the constructions and demolition debris. Crushed concrete is available nowadays in large quantities, which results from the demolition of old structures and waste concrete from new structures. A report presented in 1999 to the European Commission estimated the amount of non-recycled construction waste to be 130 million tons per year.

II. MATERIALS

PORTLAND CEMENT

Cement Ordinary Portland cement, 53Grade was used for casting all the Specimens. Different types of cement have different water requirements to produce pastes of standard consistence. Different types of cement also will produce concrete have a different rates of strength development. The choice of brand and type of cement is the most important to produce a good quality of concrete. The type of cement affects the rate of hydration, so that the strengths at early ages can be considerably influenced by the particular cement used. It is also important to ensure compatibility of the chemical and mineral admixtures with cement.

COARSE AGGREGATE

Coarse aggregates are particles of gravel or crushed stone retained on the 10 mm sieve and ranging up to 150 mm. The most commonly used maximum aggregate size is 20 mm.

FINE AGGREGATE

Locally available fine aggregate are particles of natural or synthetic sand passing the 4.75 mm sieve confirming to zone-II sand is used.

RECYCLED AGGREGATE

Recycled aggregate is produced by crushing concrete obtained from demolition of buildings due to various reasons.

SILICA FUME

Silica fume is also known as micro silica it is an ultrafine powder collected as a by product of silicon and ferro silicon alloy production and consist of spherical particle. **10%** of silica fume is added with respect to cement weight. The purpose of adding silica fume is to increase the strength of concrete as recycled aggregates are used ones so its posses low strength.

WATER

Casting and curing of specimens were done with the potable water that is available in the college premises.

NEED OF RECYCLED AGGREGATE CONCRETE

Urbanization growth rate in India is very high due to industrialization. Growth rate of India is reaching 9% of GDP. Rapid infrastructure development requires a large quantity of construction materials, land requirements & the site. For large construction, concrete is preferred as it has longer life, low maintenance cost & better performance. For achieving GDP rate, smaller structures are demolished & new towers are constructed. Protection of environment is a basic factor which is directly connected with the survival of the human race. Parameters like environmental consciousness, protection of natural resources, sustainable development, play an important role in modern requirements of construction works. Due to modernization, demolished materials are dumped on land & not used for any purpose. Such situations affect the fertility of land. As per report of Hindu online of March 2007, India generates 23.75 million tons demolition waste annually. As per report of Central Pollution Control Board (CPCB) Delhi, in India, 48million tons solid waste is produced out of which 14.5 million ton waste is produced from the construction waste sector, out of which only 3% waste is used for embankment. Out of the total construction demolition waste, 40% is of concrete , 30% ceramics, 5% plastics, 10% wood, 5%metal, & 10% other mixtures. As reported by global

insight, growth in global construction sector predicts an increase in construction spending of 4800 billion US dollars in 2013. These figures indicate a tremendous growth in the construction sector, almost 1.5 times in 5 Years.

For production of concrete, 70-75% aggregates are required. Out of this 60-67% is of coarse aggregate & 33-40% is of fine aggregate. As per recent research by the Fredonia group, it is forecast that the global demand for construction aggregates may exceed 26 billion tons by 2012. Leading this demand is the maximum user China 25%, Europe 12% & USA 10%, India is also in top 10 users. From environmental point of view, for production of natural aggregates of 1 ton, emissions of 0.0046 million ton of carbon exist where as for 1 ton recycled aggregate produced only 0.0024 million ton carbon is produced. Considering the global consumption of 10 billion tons/year of aggregate for concrete production, the carbon footprint can be determined for the natural aggregate as well as for the recycled aggregate.

III. BENEFITS OF SILICA FUME RECYCLED AGGREGATE CONCRETE:

- Using recycled concrete can conserve natural resources.
- Keeping concrete debris out of landfills.
- Ecofriendly to nature.
- Admixture silica fume is used, possesses high strength.
- While being crushed large amount of CO2 is absorbed.

IV. APPLICATIONS RECYCLED AGGREGATE IN CONCRETE:

- Can be used for construction, gutters, pavements etc.
- Large pieces used in building revetments.
- Sidewalks
- Residential roads and driveways
- Parking lots
- Noise barriers
- Slope stabilization
- Hydraulic structures
- Swimming pool decks

V. OBJECTIVES OF RECYCLED AGGREGATE CONCRETE

- The main aim of the present experimentation is enhancing the performance of recycled aggregate concrete through the use of supplementary cementitious materials produced by replacing natural aggregates by recycled aggregates in various percentages.
- Silica fume supplementary cementitious material is used for experimentation.
- The objective of the investigation is to improve the properties of concrete produced with recycled aggregate.

VI. RECYCLED AGGREGATE CONCRETE PROPERTIES

Properties of recycled aggregate Concrete

FRESH CONCRETE	HARDENED PROPERTIES
➢ Workability ➢ Setting ➢ Segregation ➢ W/C ratio	➢ Density ➢ Compressive strength ➢ Durability

VII. METHODOLOGY FOR RECYCLED AGGREGATE CONCRETE

- Collection and study of literature pertaining to the dissertation work.
- IS Mix design is conducted and concrete cubes are casted into moulds and tested.
- Determine the engineering properties of recycled aggregate concrete and compare them with conventional concrete.
- Cast various trial mixes with varying percentages of recycled aggregate and compare for the compressive strength.

VIII. LIST OF TESTS ON MATERIALS

TEST ON CEMENT

- Specific gravity
- Normal consistency
- Fineness of cement
- Initial setting time
- Final setting time
- Compressive strength of cement

TEST ON FINE AGGREGATE

- Specific gravity

- Sieve analysis
- Water absorption
- Bulking of fine aggregate

TEST ON COARSE AGGREGATE

- Specific Gravity
- Water absorption

TEST ON RECYCLED AGGREGATE

- Water absorption
- Specific gravity

TEST ON FRESH CONCRETE

- Slump cone
- Compaction factor

TEST ON HARDENED CONCRETE

- Compressive strength
- Water absorption test

IX. MIX DESIGN AS PER IS 10262-1982

Design stipulations :

i) Characteristic compressive strength at 28 days = 20 N/mm^2
ii) Maximum size of aggregate = 20mm
iii) Type of aggregate = crushed rock (granite)
iv) Degree of workability = 0.8
v) Degree of quality control = good
vi) Type of exposure = Severe

Data obtained from tests in laboratory:

i) Cement – Ordinary Portland cement
   a. Specific gravity of cement = 3.15
ii) Aggregates
   a. Specific gravity
      Coarse aggregate = 2.68
      Fine aggregate = 2.55
      Recycled aggregate = 2.35
   b. Water absorption
      Coarse aggregate = 1%
      Fine aggregate = 1%
   c. Free surface moisture
      Coarse aggregate = 0
      Fine aggregate = 0

Target mean strength of concrete

Fck = fck + t*s
= 20+1.65x4 = 26.6N/mm2

Where, S = standard Deviation
T = a statistical value depending on the expected proportion
For, Fck = 26.6 Mpa
As the type of exposure is severe, Water Cement Ratio = 0.5
The result of sieve analysis of sand shows the given in the zone –II and the normal size of coarse aggregate = 20mm
For 20mm maximum size of aggregate, sand confirming to Zone = II,
Water content per m^3 concrete = 186 lts.
Sand content = 35% of total aggregate by absolute volume.

Standard table for selection of water content and % of sand
Approximate sand and water content / m3 of concrete W/C = 0.60, Workability = 0.80 C.F. (Slump 30mm approximate, applicable for concrete upto grade M35)

SL. NO	Max size of aggregate (mm)	Water content including surface water / m3 of concrete (kg)	Sand as percent of total aggregate by absolute volume
1	10	200	40
2	20	186	35
3	30	165	30

Adjustment of values in water content and sand percentage for other conditions

Change	% Adjustment Required	
	Water content	Sand
Increase or decrease in the value of compaction factor by 0.1	0	0
Decrease in W/C ratio	0	-2
For sand confirmed zone -2	0	0

Therefore, required sand content as % of total aggregate by
Absolute volume = 35-2=33% and
Required water content = 186 kg/m^3

Determination of cement content

Water / cement ratio = 0.5
Water = 186 kg/ m3
Cement = 186/0.5= 372 kg/m^3

Estimation of air content

For 20mm nominal maximum size aggregate 2% air content is obtained from the table 3 of IS : 10262 – 1982 (1)
Therefore Net Volume of concrete = gross volume of Concrete – air content = 1 – 0.02 = 0.98 m^3

Determination of coarse and fine aggregate

Where, V = Absolute volume of concrete m^3
W = Mass of water kg/m^3 of concrete
P = Ratio of fine aggregate to total aggregate by absolute volume
fa = Total mass of fine aggregate kg/m^3 of concrete
Sfa = Specific gravity of fine aggregate
Sc = Specific gravity of cement
C = mass of cement kg/ m^3 of concrete
V = [W+(C/Sc)+(Fa/P)(1/2.55)]*(1/1000)
Therefore , 0.98 = [186 + (372/3.15) + (fa/0.33)(1/2.55)] x (1/1000)
Fa = 568.77 kg/ m^3

Ca = $(\frac{1-P}{P})$ * f a * $(\frac{Sca}{Sfa})$

Where, Ca = Total mass of coarse aggregate kg/ m3 of concrete
P = Ratio of fine aggregate to total aggregate by absolute volume
fa = Total mass of fine aggregate kg/m^3 of concrete
Sca = Specific gravity of coarse aggregate
Sfa = Specific gravity of fine aggregate
Therefore, Ca = [(1-0.33)/ 0.33] x 568.77 x (2.68/ 2.55)
Ca = 1213.65 kg/m^3

MIX PROPOTION

WATER	CEMENT	FINE AGGREGATE	COARSE AGGREGATE
186	372	568.77	1213.65
0.5	1	1.52	3.26

MIX PROPORTION AFTER CORRECTIONS

WATER	CEMENT	FINE AGGREGATE	COARSE AGGREGATE
203.81	372	563.09	1201.52
0.54	1	1.51	3.22

IX. RESULTS

SLUMP CONE TEST

S. NO	% of RCA	H=[H1-H2] (mm)
1	0	65
2	20	55
3	40	45
4	60	35
5	80	25
6	100	20

COMPACTION FACTOR TEST

S. NO	% of RCA	C.F=[W1/W2]
1	0	0.95
2	20	0.93
3	40	0.92
4	60	0.91
5	80	0.90
6	100	0.89

COMPRESSIVE STRENGTH For 7 days

S. NO	% of RCA	Compressive strength N/mm^2
1	0	13.56
2	20	16.29
3	40	18.66
4	60	18.81
5	80	17.77

6	100	17.73

COMPRESSIVE STRENGTH For 28 days

S. NO	% of RCA	Compressive strength N/mm^2
1	0	20.44
2	20	27.55
3	40	28.29
4	60	28.73
5	80	27.84
6	100	27.25

X. DISADVANTAGES OF RECYCLED AGGREGATE CONCRETE

- Process of cleaning of recycled aggregate is complicated.
- Water absorption of these concrete is generally higher compared with natural concrete.
- Reduces workability of concrete.
- Lack of specifications and guidelines.

XI. CONCLUSION

Based on the above results and discussion it is justified the efforts to use supplementary cementitious material (silica fume) in recycled aggregate concrete which can contribute to the preservation of the environment and can achieve the same final performance with probably less cost than ordinary concretes. However, the suitability of recycled aggregate concrete derived from different sources will have to be assessed individually. Moreover, it is important to recognize that there is a need to introduce new standards for recycled aggregates, and demonstrate that these materials can be used successfully in practice, under the range of exposure conditions.

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INDIAN STANDARD CODES

1) I.S. 12269-1989 is used for Specifications for 53 grade ordinary Portland cement
2) I.S. 383-1970 is used for Specification for Coarse and Fine Aggregate Natural sources for concrete.
3) I.S. 456-2000 is used for Indian Standard Plain Reinforced Concrete code practice.
4) I.S.10262-1982 is used for Recommended Concrete Mix Design.
5) IS: 516-1959, Indian Standard Code of Practice- Methods of Test for Strength of Concrete, Bureau of Indian Standards (BIS), New Delhi, India.