International Refereed Journal of Engineering and Science (IRJES)
ISSN (Online) 2319-183X, (Print) 2319-1821
Volume 3, Issue 3(March 2014), PP.67-73

Utilization of micro silica as partial replacement of OPC & SRC in concrete

Madhusudhan T
(Research scholar JJT University, Rajasthan, India)

Abstract:- This paper presents the Mix designs of C35 grade concrete prepared with two different type of cements (OPC&SRC) with micro silica and without micro silica and cubes were tested for compressive strength at 7 days, 14 days, 28days and water absorption at 28 days . Various tests were conducted on coarse aggregate and fine aggregate to determine specific gravity, bulk density, and fineness modulus of aggregate, The Water cement ratio is kept 0.44. The compressive strength and water absorption of concrete shall compare for the Mixes with and without Micro silica.

Keywords:- OPC, SRC, Micro silica

I. INTRODUCTION

1.1. Micro silica

The term micro silica is the one normally used to describe the very fine powder which is extracted from exhaust gasses of silicon and ferrosilicon smelting furnaces and utilized in Concrete to improve the properties of the concrete. Other terms for the same product are silica fume, condensed silica fume (CSF) and silica flour.

The main purpose of incorporating the material in concrete is to make use of the very fine and reactive particles to produce a denser cement matrix. The Micro silica particles have a pozzolanic reaction with calcium hydroxide from the hydration of the cement, thereby increasing the total product of hydration and reducing the amount of calcium hydroxide. When properly used, Micro silica increases the strength and reduces the permeability of the concrete providing a more durable product. A small quantity of micro silica can be effective in a concrete mix, a typical dosage being in the range 5 to 10% by weight of the cement

The OPC cement concrete with small percentage of micro silica shall give good performance for Freeze-thaw condition, reinforcement protection, and sulphate resistance, reduced aggregate reactivity.

1.2. Sulphate Resistance Cement:

Sulfate Resisting Cement is blended cement designed to improve the performance of concrete where the risk of sulfate attack may be present. It also provides improved durability for concrete in most aggressive environments, reducing the risk of deterioration of the structure and structural failure.

Concrete designed to provide improved sulfate resistance should have greatly reduced permeability which should also provide increased resistance to the penetration of chloride ions, reducing the risk of corrosion in reinforcing steel. Provides high level of concrete performance and structural integrity in highly aggressive sulfate and acidic environments• Increased workability and pumpability significantly improved later-age concrete strengths

With the combination of the above materials we may able to prepare High performance concrete which may subject to more aggressive environmental conditions

II. OBJECTIVE

The main objective of this paper is to develop the C-35 Mix design by using OPC concrete with micro silica and SRC concrete with micro silica and evaluation of compressive strength and water absorption of the concrete cubes made with two different types of cements.

III. EXPERIMENTAL PROGRAMME

3.1. Concrete specification

Strength: Characteristic compressive strength (fck) - 35
N/mm^2 Workability: Medium
Durability: Extreme climate

3.2. Material Properties
3.2.1. Cement:
A) OPC:
Ordinary Portland cement complies with BS EN 197-1:2000 CEM-1class-42.5N& it also conforms to specification of ASTM C 150-99a type 1
B) SRC:
Sulphate resisting cement in accordance with ASTM C 150-99a Type V& it also conforms to the specification of BS 4027:1996 Class 42.5N(LA)

Table.3.2.1

PHYSICAL TEST		**OPC**			**SRC**		
REQUIREMENT		Specification		Test Results	Max	Min	Test Results
		Max	Mn				
Specific Surface Air Permeability Test (M^2/Kg)		-----	---	320	----	280	317
Setting Time	Initial (Minutes)	---	60	168	---	45	139
	Final (Minutes)	----	----	202	375		188
Soundness Le ChatelierExpansion (mm)		10.00	---	1.5			
Soundness Autoclave Expansion (%)					0.80	---	0.10
Compressive Strength: Mortar Prisms							
At 3 days N/mm^2		---	10.0	20.2	--	8.0	17.5
At 7 days N/mm^2		----	----	30.4	---	15.0	22.6
At 28 days N/mm^2		----	----	45.0	---	21.0	30.5
CHEMICAL TESTS		OPC			SRC		
Silica (SiO_2) %		---------	-------	20.75	---	---	20.87
In soluble Residue (IR %)		5	---------	0.31	0.75	---	0.29
Alumina (AI_2O_3) %		--------	---------	4.12	---	---	3.88
Ferric Oxide (Fe_2O_3) %		--------	---------	4.33	---	---	4.86
Lime (CaO)%		--------	--------	62.50	---	---	62.53
Magnesia (MgO) %		5.00	-------	2.70	6.00	---	3.01
Sulphur Trioxide (SO_3) %		3.50	-------	2.58	2.30	---	1.68
Loss on ignition (LOI) %		5.00	-------	2.00	3.00	---	1.91
Chloride (Cl) %		0.10	---------	0.01			
Alkalies (Na_2O+0.658 K_2O) %		0.60	---------	0.50	0.60	---	0.45
Tricalcium Silicate (C_3S) %		---------	---------	55.51	---	---	58.16
Dicalcium silicate (C_2S) %		---------	--------	17.61	---	---	
Tricalcium aluminate (C_3A) %		---------	--------	3.59	5.00	---	2.06
Lime saturation Factor (LSF) %		102	66	92.16			
Alumina Modulus (AM) %		-------	0.64	0.95			
Tetracalsium Aluminoferrite(C_4AF)							14.79
$2C_3A+C_4AF$					25.00	---	18.91

3.2.2. Microsil ^{R} Physical and chemical Properties

Table.3.2.2

Analysis	**EN 13263 1,2**	**ASTM C1240**	**Typical**
SiO_2 %	**Min 85**	**Min 85**	**90-97**
Free Si %	**Max 0.4**	**----------**	**0.14**
Free CaO %	**Max 1.0**	**----------**	**<0.1**
SO_3 %	**Max 2.0**	**----------**	**0.25**
Na_2O eq %	**To report**	**To report**	**0.5**
Cl %	**Max 0.3**	**----------**	**0.3**
Loss on ignition %	**Max 4.0**	**Max 6.0**	**2.0**

Specific surface (BET)(m^2/g)	**15-35**	**Min 15**	**23**
Pozzolanic Activity Index Normal curing (28 days)	**Min 100**	----------	**110**
Pozzolanic Activity Index Normal curing (7days)	----------	**Min105**	**115**
Bulk Density (Kg/m^3)			
Undensified	----------	**To report**	**350-650**
densified		**To report**	**150-170**
H_2O %	----------	**Max 3%**	**0.3**
> 45 µm %	----------	**Max 10.0**	**1.2**
p^H	----------	----------	**7.5**
Brightness			**45**

3.2.3. Aggregate Physical & Chemical Properties
3.3. Gradation of Aggregates
3.3.1Gradation of Fine Aggregate
Oven Dry Weight = 1820 gm
Washed Oven Dry Weight = 1789 gm

S,No	Property	FA	CA (10mm)	FA(20mm)
1	Specific gravity	2.68	2.81	2.81
2	Water absorption by %	1.7	0.7	0.7
3	Fineness modulus	2.68	------	----
4	Grading Zone	BS882-1992 Spec .limit	BS882-1992 Spec .limit	BS882-1992 Spec .limit
5	Soundness of aggregate Weighted percent loss	2	<1	<1
6	Chemical Analysis of aggregate			
	a) acid soluble chloride%		0.01	0.01
	b) acid soluble sulphate so_3 %		0.02	0.0
7	Organic impurities	Absent	--------	----------
8	Potential Alkali Reactivity a) Dissolved silica as Sio_2 mmol/L b) Reduction in alkalinity mmol/L	18 135	16 110	16 110
9	Clay lump & Friable particles of aggregate %	0.04	----------	----------
10	Aggregate Impact value		14%	14%
11	Losangels Abrasion value		16%	16%
12	Ten percent fines value		290 KN	290 KN
13	Flakiness index		16%	16%
14	Elongation Index		24	24

Sieve Analysis

BS Sieve Size In (mm)	Wt. Retained In (gm)	Cumulative Wt. Retained	Cumulative % Retained	Cumulative % passing	BS 882 -1992. Spc limit	
					Lower	Upper
10	0	0	0	100	100	
5	13	13	0.72	99.28	100	
2.36	391	404	22.2	77.8	60	100
1.18	338	742	40.8	59.2	30	90
0.600	400	1142	62.74	37.26	15	54

0.300	252	1394	76.6	23.4	5	40
0.150	249	1643	90.3	9.7	0	10
0.075	117	1760	96.7	3.3	0	4

Table 3.3.1

3.3.2 Gradation of Coarse Aggregate (20mm)

Oven Dry Weight =3991

Washed Oven Dry Weight = 3980

Sieve Analysis

BS Sieve Size In (mm)	**Wt. Retained In (gm)**	**Cumulative Wt. Retained**	**Cumulative % Retained**	**Cumulative % passing**	**BS 882 -1992. Spc limit**	
					Lower	Upper
37.5	0	0	0	100	100	
20	40	40	1	99	85	100
14	1666	1706	42.75	57.25	0	70
10	1684	3390	84.941	15.1	0	25
5	590	3980	99.72	0.3	0	5
2.36		3980	99.72	0.3		
1.18		3980	99.72	0.3		
0.600		3980	99.72	0.3		
0.300		3980	99.72	0.3		
0.150		3980	99.72	0.3		
0.075		3980	99.72	0.3		

Table 3.3.2

3.3.3. Gradation of Coarse Aggregate (10mm)

Oven Dry Weight =2365gm

Washed Oven Dry Weight = 2360gm

Sieve Analysis

BS Sieve Size In (mm)	**Wt. Retained In (gm)**	**Cumulative Wt. Retained In (gm)**	**Cumulative % Retained**	**Cumulative % passing**	**BS 882 -1992. Spc limit**	
					Lower	Upper
14	0	0	0	100	100	
10	19	19	0.80	99.2	85	100
5	2011	2030	85.83	14.2	0	25
2.36	330	2360	99.8	0.2	0	5
1.18		2360	99.8	0.2		
0.600		2360	99.8	0.2		
0.300		2360	99.8	0.2		
0.150		2360	99.8	0.2		
0.075		2360	99.8	0.2		

Table 3.3.3

3.3.4 .Combined Grading & Blending

BS Sieve Size	**20mm aggregate**		**10mm aggregate**		**Sand**		**Combined grading**	**BS 882:1992 spc limit**	
mm	**% pass**	**% blend**	**% pass**	**%blend**	**% pass**	**%blend**		**Lower**	**Upper**
		40.94		**15.75**		**43.31**	**100.00**		
37.5	100	**41**	100	**15.8**	100	**43.3**	**100.00**	**100**	
20	99	**40.6**	100	**15.8**	100	**43.3**	**99.7**	**95**	**100**
14	57.25	**23.5**	100	**15.8**	100	**43.3**	**82.6**		
10	15.1	**6.2**	99.2	**15.7**	100	**43.3**	**65.2**		
5	0.3	**0.1**	14.2	**2.2**	99.28	**43**	**45.3**	**35**	**55**
2.36	0.3	**0.1**	0.2	**0.0**	77.8	**33.7**	**33.8**		

1.18	0.3	**0.1**	0.2	**0.0**	59.2	**25.7**	**25.8**		
0.600	0.3	**0.1**	0.2	**0.0**	37.26	**16.1**	**16.2**	**10**	**35**
0.300	0.3	**0.1**	0.2	**0.0**	23.4	**10.1**	**10.2**		
0.150	0.3	**0.1**	0.2	**0.0**	9.7	**4.2**	**4.3**	**0**	**8**
0.075	0.3	**0.1**	0.2	**0.0**	3.3	**1.4**	**1.5**		

Table 3.3.4

4. MIX DESIGN

Mix Specifications

1. 28 days characteristics compressive strength – 35 N/mm^2
2. Nominal Max. Size of aggregate – 20mm

Type of cement: OPC

Min Cement Content Used -380Kg/M^3 (Without micro silica) Max W/C ratio – 0.44

Slump after 90 minutes – 100$\pm$ 25 mm

Water – Potable Water

Mix proportions per cubic meter

4.1. OPC Concrete without Micro silica

Materials	**Unit**	**Qty**	**Specific gravity**	**Abs vol-Cumt**
20mm Aggregate	Kg	780	2.81	0.278
10mm Aggregate	Kg	300	2.80	0.107
Washed Sand	Kg	825	2.73	0.302
Cement	Kg	380	3.15	0.112
Water	Lt	168	1.00	0.168
Admixture-Rheobuild 857	Lt	6	1.23	0.006
Air voids assumed	%	1.5	-------	0.015
Density in Kg/m^3 =	**2460**		**Total Volume = 1.000**	

Table 4.1(A)

Aggregate cement Ratio by weight	**5.01 : 1**
Aggregate Proportion by Mass in %	
20 mm Aggregate	40.94
10mm Aggregate	15.75
Washed sand	43.31

Table 4.1(B)

4.2. OPC concrete with Micro silica

Materials	**Unit**	**Qty**	**Specific gravity**	**Abs vol-Cumt**
20mm Aggregate	Kg	780	2.81	0.278
10mm Aggregate	Kg	300	2.80	0.107
Washed Sand	Kg	825	2.73	0.302
Cement (93 % of min cement content used)	Kg	353	3.15	0.112
Densified Micro silica (7%on minimum cement content)	Kg	27	2.20	0.012
Water	Lt	168	1.00	0.168
Admixture-Rheobuild 857	Lt	6	1.23	0.006
Air voids assumed	%	1.5	-------	0.015
Density in Kg/m^3 =	2460		**Total Volume = 1.000**	

Table 4.2(A)

Aggregate cement (c+ms) Ratio by weight	5.01 : 1
Aggregate Proportion by Mass in %	
20 mm Aggregate	40.94
10mm Aggregate	15.75
Washed sand	43.31

Table 4.2(B)

4.3. SRC Concrete without Micro silica

Materials	Unit	Qty	Specific gravity	Abs vol-Cumt
20mm Aggregate	Kg	780	2.81	0.278
10mm Aggregate	Kg	300	2.80	0.107
Washed Sand	Kg	825	2.73	0.302
Cement	Kg	380	3.15	0.112
Water	Lt	168	1.00	0.168
Admixture-Rheobuild 857	Lt	6	1.23	0.006
Air voids assumed	%	1.5	-------	0.015
Density in Kg/m^3 = 2460			**Total Volume = 1.000**	

Table 4.3(A)

Aggregate cement Ratio by weight	5.01 : 1
Aggregate Proportion by Mass in %	
20 mm Aggregate	40.94
10mm Aggregate	15.75
Washed sand	43.31

Table 4.3(B)

4.4. SRC Concrete with Micro silica

Table 4.4(A)

Aggregate cement (c+ms) Ratio by weight	5.01 : 1
Aggregate Proportion by Mass in %	
20 mm Aggregate	40.94
10mm Aggregate	15.75
Washed sand	43.31

Table 4.4(B)

Materials	Unit	Qty	Specific gravity	Abs vol-Cumt
20mm Aggregate	Kg	780	2.81	0.278
10mm Aggregate	Kg	300	2.80	0.107
Washed Sand	Kg	825	2.73	0.302
Cement (93 % of min cement content used)	Kg	353	3.15	0.112
Densified Micro silica (7%on minimum cement content)	Kg	27	2.20	0.012
Water	Lt	168	1.00	0.168
Admixture-Rheobuild 857	Lt	6	1.23	0.006
Air voids assumed	%	1.5	-------	0.015
Density in Kg/m^3 = 2460			**Total Volume = 1.000**	

V. RESULTS & DISCUSSION

5.1. Compressive Strength Test Results

Average Compressive strength N/mm^2	C-35 OPC	C-35 OPC+MS	C-35 SRC	C-35 SRC+MS	Mode of Failure
7 Days	33.94	36	32	32.9	SF
14 Days	37.03	40	35	37.2	SF
28 Days	44.32	48	43.2	44.7	SF

Table5.1

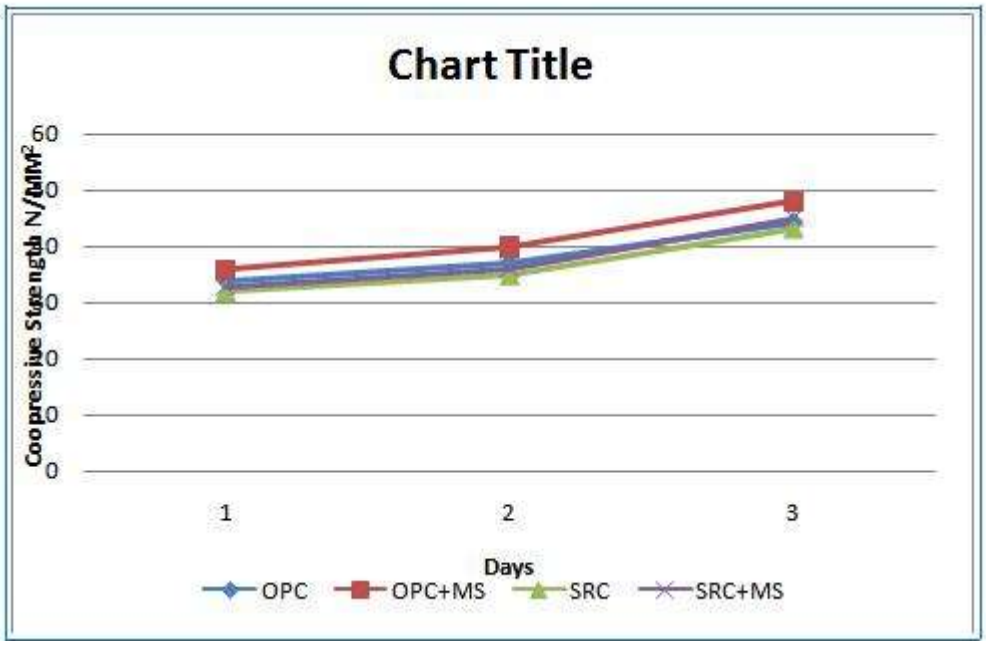

Fig .5.1

5.2 Water absorption Test Results

Water absorption in accordance with BS1881:Part 122:2011	C-35 OPC	C-35 OPC+MS	C-35 SRC	C-35 SRC+MS
28 Days (Mean %)	1.8	1.2	1.4	1

Table.5.2

Table.5.1 &Fig 5.1 shows that the compressive strength of the cubes prepared from the above mix proportions are giving more or less same strength. From the above experimental investigations proves that in concrete partial replacement of cement with 7% of micro silica will give the same cube strength when compared to the concrete prepared by Ordinary Portland cement or Sulphate Resisting Cement.

Table 5.2 shows that the % of water absorption of the OPC+MS mix is less compared to alone OPC Mix; similarly the % water absorption of SRC+MS mix cubes is less compared with alone SRC Mix. It proves that usage of micro silica in concrete with OPC or SRC improves the water resistance property of the concrete

By effective usage of this industrial waste (Micro silica) in optimum percentage in concrete may make concrete economical and environmental friendly

REFERENCE

[1]. MS shetty, Concrete Technology
[2]. BS 882 -1992. Spc limit
[3]. BS1881: Part 122:2011
[4]. **Microsil** **R** Product Information