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Hardened Properties of Concretes made with Micro Silica and Alccofine-A Performance Optimization based Comparative Study

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Abstract:- Large scale production of cement is causing environmental problem on one hand and depletion of natural resources on the other hand. This threat to ecology has lead to research to use industrial byproducts as supplementary cementitous materials in making concrete.
In the present study, an attempt has been made to investigate the hardened properties of concrete by using micro silica and alccofine in varied proportions. The main parameters investigated in this study is addition of micro silica and alccofine, by keeping maximum cement content 450kg constant and water content constant 144 kg for all mixes. The slump of concrete was practically kept around 100 ± 10mm for all the concrete mixes considered in this study. Both Micro Silica as well as Alccofine were added to concrete mixes in the following incremental proportions as addition to cement content, namely by 0.0, 3.34, 6.68, 10.02, 13.36 and 16.70% respectively. This thesis presents a detailed comparative experimental study using micro silica and alccofine, on hardened properties like compressive strength, flexural strength, splitting tensile strength and impact test.

Keywords:- Micro Silica, Alccofine, Hardened concrete properties, dosage, flexural strength, impact test.

I. INTRODUCTION

Concrete is an artificial conglomerate stone made essentially of Portland cement, water, and aggregates. While cement in one form or another has been around for centuries, the type we use was invented in 1824 in Britain. Producing one tonne of cement requires about 2 tonnes of raw materials and releases 0.95tonne (≈ 1 tonne) of CO_2. The global release of CO_2 from all sources is estimated at 23 billion tonnes a year and the Portland cement production accounts for about 7% of total CO_2 emissions.

Supplementary Cementitious Materials (SCM)

In its most basic form, concrete is a mixture of Portland cement, sand, coarse aggregate and water. The principal cementitious material in concrete is Portland cement. Today, most concrete mixtures contain supplementary cementitious materials that make up a portion of the cementitious component in concrete. These materials are generally by products from other processes or natural materials. They may or may not be further processed for use in concrete. Some of these materials are called pozzolans, which by themselves do not have any cementitious properties, but when used with Portland cement, react to form cementitious compounds. Other materials, such as slag, do exhibit cementitious properties. For use in concrete, supplementary cementitious materials, sometimes referred to as mineral admixtures, need to meet requirements of established standards. They may be used individually or in combination in concrete. They may be added to the concrete mixture as blended cement or as a separately batched ingredient at the ready mixed concrete plant.
Some examples of these materials are listed below.

- Fly Ash
- GGBS(Ground Granulated Blast Furnace Slag)
- Metakoline
- Micro Silica
- Alccofine

Unlike other mineral admixtures, micro silica and alccofine are byproducts from the industries, where their engineering values are well controlled. Therefore using micro silica and alccofine in concrete should promise advantage compared to other supplementary cementitious materials.

II. EXPERIMENTAL PROGRAM

The aim of the experimental program is to compare the properties of concrete made with microsilica and alccofine, used as supplementary cementing materials. The various tests performed on concrete samples are discussed in this chapter, followed by a brief description about mixture proportion design and curing procedure adopted. Following mechanical properties of concrete have been discussed: mechanical properties such as hardening properties compressive strength, flexural strength, splitting tensile strength, impact resistance.

Cubes of 150mm size was used for compressive test, beam 700mmx150mm was used foe flexural strength, cylinders of 150mm diameter and 300mm length for split tensile test and 150mm diameter and 64mm length for impact resistance test were casted. All the specimens were water cured for 28 days at room temperature and were tested in surface dry condition. Each value of the results presented in this paper is the average of three test samples.

Table 1: Casted Specimens Details

Variations of Parameters in terms of Percentage	Number of specimens casted			
	Cubes	Beams	Cylinders	Cylinders
Dosage variation of Micro Silica And Alccofine(%)				
a. 0.0	**12**	**3**	**3**	**3**
b. 3.34	**12**	**3**	**3**	**3**
c. 6.68	**12**	**3**	**3**	**3**
d. 10.02	**12**	**3**	**3**	**3**
e. 13.36	**12**	**3**	**3**	**3**
f. 16.70	**12**	**3**	**3**	**3**

III. MATERIALS

This section will present the chemical and physical properties of the ingredients. Bureau of Indian Standards (IS) and American Society (ASTM) procedures were followed for determining the properties of the ingredients in this investigation.

A. Cement: Ordinary Portland cement 53 grade of ACC brand was used corresponding to IS standards. The specific gravity of cement was 3.15

B. Fine Aggregate: The sand used for this study was natural river sand. The sand passing through 4.75mm sieve was used. The sand conforms to grading Zone II as per IS: 383-1970(Reaffirmed 2011).

C. Coarse Aggregate: Crushed granite stones of size 20mm and 12.5mm with equal proportions were used as coarse aggregate.

Table 2: Characteristics of Fine Aggregate

1.	**Specific gravity**			**2.61**
2.	**Water absorption**			1.96
3.	**Sieve Analysis**			
IS Sieve Designation	**Qty. retained**	**Cumulative %**		**Requirement as per IS:383-1970(Reaffirmed 2011)**
		Retained	**Passing**	**Zone II**
4.75mm	0.050	5.0	95.0	90-100
2.36mm	0.095	14.5	85.5	75-100
1.18mm	0.252	39.7	60.3	55-900
600 micron	0.193	59.0	41.0	35-59
300micron	0.278	86.8	13.2	8-30
150 micron	0.119	98.7	1.3	0-10

Table 3: Combined Sieve Analysis of 20mm and 12.5mm Coarse Aggregate

1.	**Shape**			Angular
2.	**Specific gravity**			2.69
3.	**Water absorption**			0.2
4.	**Sieve analysis:**			
Cumulative sieve size(mm)	**Cumulative % passing 20mm**	**Cumulative % passing 12.5mm**	**Cumulative % passing when 20mm and 12.5mm are mixed in the ratio 50:50**	**Requirements of cumulative % passing for 20 mm graded aggregates as per IS:383-1970(RA 2011)**
40 mm	100.0	100.0	100.0	100
20 mm	90.90	100.0	95.5	95-100
12.5 mm	2.30	90.6	46.5	-
10 mm	0.0	57.0	28.5	25-55
4.75 mm	0.0	0.0	0.0	0-10

D. Micro Silica: Micro silica also called as silica fume, is another material that is used as an artificial pozzolanic admixture. It is a product resulting from reduction of high purity quartz with coal in an electric arc furnace in the manufacture of silicon or ferrosilicon alloy. Silica fume rises as an oxidised vapour. It cools, condenses and is collected in cloth bags.

Table 4: Laboratory test results on Silica fume(Micro Silica) Physical and Chemical properties.

Chemical Test			**Physical Test**		
Parameters tested	**Test conducted (% by mass)**	**Requirements As per IS 15388:2003**	**Parameters tested**	**Test conducted**	**Requirements As per IS 15388:2003**
SiO_2 content	**93.80**	**85 min.**	**Specific gravity**	**2.11**	**Not Specified**
CaO content	**1.52**	**Not specified**	**Fineness as surface area, m^2/kg**	**21000**	**15000 min**
Moisture content	**0.68**	**3.0 max.**	**Compressive strength at 7 days as % over control sample**	**106**	**85 min.**
Loss of Ignation	**1.02**	**4.0 max**	**Over size percent retained on 45nmicron IS sieve**	**0.2**	**10 max**
Total Alkalis(as Na_2O Equivalent)	**1.02**	**1.5 max**			
Alumina	**1.17**	**Not specified**	**Lime Pozzalanic test**	**16.5**	**ASTM C 593**
Iron Oxide	**0.84**	**Not specified**			

E. Alccofine: Alccofine is obtained by quenching molten iron slag (a byproduct of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder.

Table 5: Laboratory test results on Alccofine Physical and Chemical properties.

Chemical Test			**Physical Test**		
Parameters tested	**Test conducted**	**Requirements As per**	**Parameters tested**	**Test conducted**	**Requirement s As per**
SiO_2 content (% by mass)	**31.34**	**85 min. IS 4032:1985**	**Specific gravity**	**2.86**	**IS 1727:1967**
CaO content(% by mass)	**31.97**	**Not specified**	**Fineness as surface area, m^2/kg**	**13000**	**Not specified**
Moisture content(% by mass)	**0.12**	**1.0 BS 6699:1992**	**Compressive strength at 7 days as % over control sample**	**105**	**85 IS 15388:2003**
Glass Content	**94.0**	**67 min**			

		BS 6699:1992	Over size percent retained on 45nmicron IS sieve	1	ASTM C 1240
Total Alkalis(as Na_2O Equivalent) (% by mass)	0.65	1.5 max IS 4032:1985			
Chloride(% by mass)	0.014	0.10max BS 6699:1992	Lime pozzalainc test	15.5	ASTM C 593
Iron Oxide(% by mass)	1.40	Not specified			

F. Water: potable water is used for mixing and curing of the concrete mixes. The properties of water are tabulated below;

Table 6: Water Properties

Sl. No.	Particulars	Constituents determined	Stipulations of IS:456-2000 (Reaffirmed in 2011)
1.	Qty. of 0.02 N NaOH required to neutralize 100 ml. water using phenolphthalein as an indicator.	0.5 ml	Shall not be more than 5 ml.
2.	Qty. of 0.02 H_2 SO_4 required to neutralize 100 ml. of water sample using mixed indicator.	22.0 ml	Shall not be more than 25 ml.
3.	Inorganic Solids	340.88 mg/l	3000 max.
4.	Sulphates as SO_4	24.0 mg/l	500 max.
5.	Chlorides as Cl	48.6 mg/l	500 max. for RCC 2000 max. for PCC
6.	Suspended Solids	48.0 mg/l	2000 max.
7.	Organic Solids	197.0 mg/l	200 max.
8.	pH Value	7.80	Shall not be less than 6

E. Chemical Admixture: Super plasticizer of normal type high range water reducer of BASF Glenium B233, was used to increase the workability. The optimum dosage of super plasticizer was around 0.4-1.5% per bag of cement which has been determined by using marsh cone test and physical test on admixtures.

Table 7: Physical Requirements as per IS 9103: 1999

Sl. No.	Requirement	Test Results obtained	Stipulation as per IS:9103-1999Table-1a for super plasticizing admixture of Normal type
1.	Slump (deviation from control sample)	5 mm above that of control sample	Not more than 15 mm below that of the control mix concrete.
2.	Time of setting: deviation from control sample (hrs) a) Initial b) Final	0 hrs 58 min 0 hrs 44 min	±1.5 hours maximum ±1.5 hours maximum
3.	Bleeding : percent increase over control sample	0.4	5 max.
4.	Air content : percent increase over control sample	0.8	1.5 max
5.	Water content, percent of control sample	80.0	80.0 max
6.	Compressive Strength, Percent of control sample a) 1day b) 3 day c) 7 day d) 28 day	156 136 150 138	140 min. 125 min. 125 min. 115 min.

7.	**Flexural Strength, Percent of control sample** e) 3 day f) 7 day g) 28 day	 125 125 115	 110 min. 100 min. 100 min.
8.	**Length change, percent increase over control sample (28 days)**	0.000	0.010 max.

IV MIX PROPORTIONS (IS 10262:2009)

Note: Mass of cement 450 kg/m^3 and mass of water 144 kg/m^3 were kept as constant for all the mixes. All the mixes are designed in order to achieve a slump of 100 mm ± 10 mm.

Table 8: Design mix with addition of different % of Alccofine.

Mix ingredients		Concrete making material for 1CU.M concrete					
% increase of Alccofine		0.0	3.34%	6.68%	10.02%	13.36%	16.7%
Mass of cement (Kgs)		450	450	450	450	450	450
Mass of water (Kgs)		144	144	144	144	144	144
Mass of Alccofine (Kgs)		0.0	15	30	45.1	60.12	75.15
Mass of coarse aggregate (Kgs)	20mm	535.90	534.88	530.66	526.23	522.84	519.25
	12.5mm	535.90	534.88	530.66	526.23	522.84	519.25
Mass of fine aggregate (Kgs)		753.10	751.6	745.6	739.40	734.8	729.60
Mass of admixture (Kgs)		3.00	3.10	3.15	3.22	3.37	3.75

Table 9: Design mix with addition of different % of Micro Silica.

Mix ingredients		Concrete making material for 1CU.M concrete					
% increase of Micro Silica		0.0	3.34%	6.68%	10.02%	13.36%	16.7%
Mass of cement (Kgs)		450	450	450	450	450	450
Mass of water (Kgs)		144	144	144	144	144	144
Mass of Micro Silica (Kgs)		0.0	15	30	45.1	60.12	75.15
Mass of coarse aggregate (Kgs)	20mm	535.90	532.52	526.44	520.51	511.44	507.9
	12.5mm	535.90	532.52	526.44	520.51	511.44	507.9
Mass of fine aggregate (Kgs)		753.10	748.20	739.8	731.4	718.60	713.8
Mass of admixture (Kgs)		3.00	3.58	4.63	5.45	5.61	6.64

V. DISCUSSION ON RESULTS

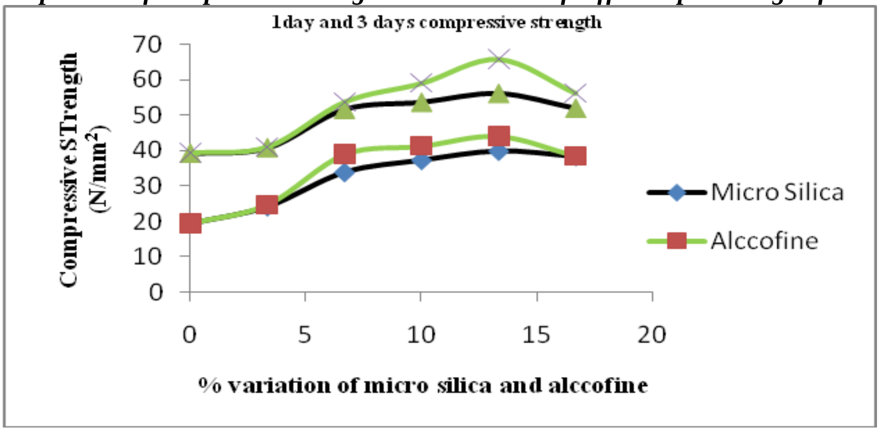
The test on hardened concrete was carried out according to the relevant standards wherever applicable. Experimental resultsobtained are tabulated and are used for discussion.

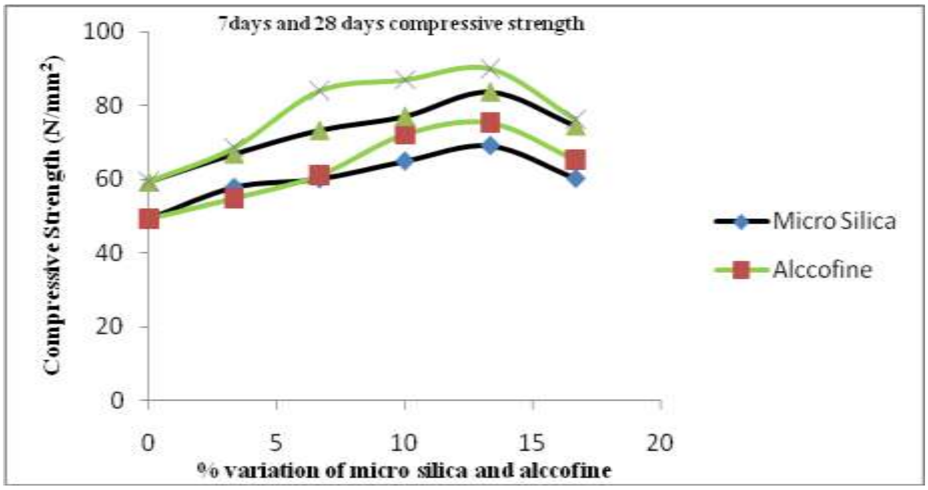
1. Test for Compressive Strength, Technical Reference: IS: 516 – 1959 (Reaffirmed 2013)

Table10:Variation of compressive strength with addition of different percentage of micro silica

% Variation of cementitious materials	Compressive Strength (N/ mm^2)							
	Micro Silica (No of days)				Alccofine (No of days)			
	1 day	3 days	7 days	28 days	1 days	3 days	7 days	28 days
0.0	19.5	39.3	49.2	59.2	19.5	39.3	49.2	59.2
3.34	24.3	40.9	57.8	66.8	24.8	41.0	54.8	68.5
6.68	34.0	51.8	60.1	73.3	39.0	53.7	61.1	84.1
10.02	37.4	53.8	64.9	77.1	41.3	59.0	72.2	87.1
13.36	40.0	56.3	69.1	83.8	44.1	65.8	75.3	90.1
16.7	38.5	52.1	60.2	74.5	38.5	56.2	65.2	76.2

Fig I : Comparison of compressive strength with addition of different percentage of micro silica.





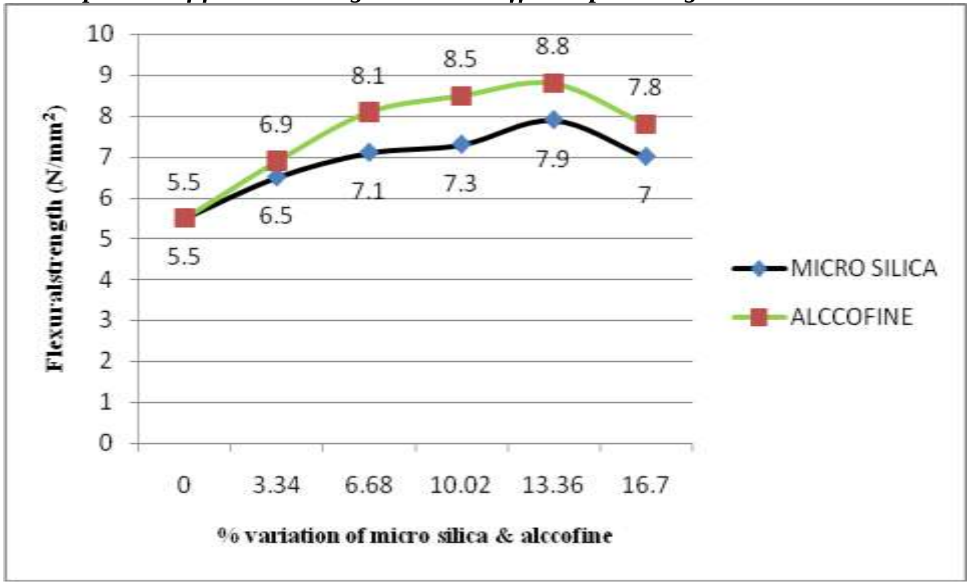
2. Flexural Strength, Technical Reference: IS: 516 – 1959 (Reaffirmed 2013)

Table10:Comparison of flexural strength between different percentage Micro Silica and Alccofine.

Sl.no	% increase of cementitious materials	Flexural Strength(N/mm^2)	
		Micro Silica	Alccofine
1.	0.0	5.5	5.5
2.	3.34	6.5	6.9
3.	6.68	7.1	8.1
4.	10.02	7.3	8.5

5.	13.36	7.9	8.8
6.	16.7	7.0	7.8

Fig II: Comparison of flexural strength between different percentage Micro Silica and Alccofine.

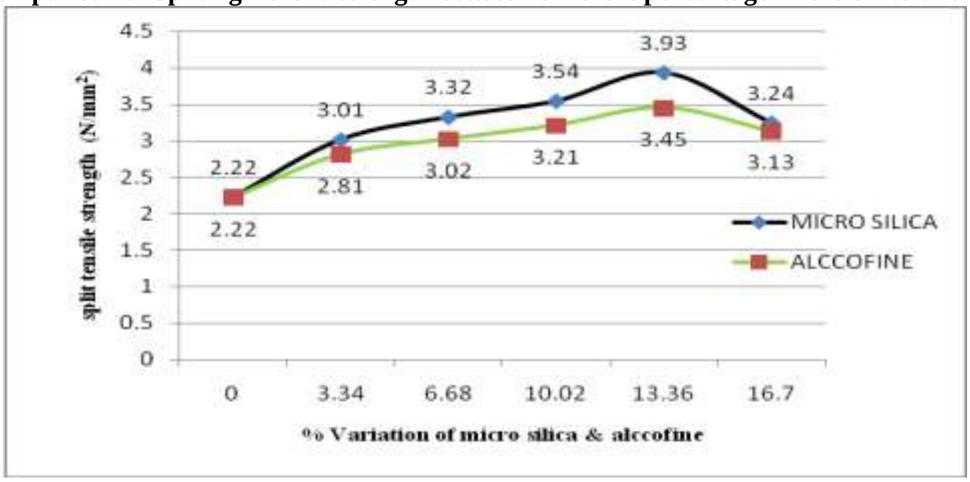


3. ***Splitting Tensile Strength of Concrete, Technical Reference IS 5816: 1999(Reaffirmed2103)***

Table 11: Comparison of splitting strength between different percentage Micro Silica and Alccofine.

Sl.no	**% increase of cementitious materials**	**Splitting Tensile Strength (N/mm^2)**	
		Micro Silica	**Alccofine**
1.	0.0	2.22	2.22
2.	3.34	3.01	2.81
3.	6.68	3.32	3.02
4.	10.02	3.54	3.21
5.	13.36	3.93	3.45
6.	16.7	3.24	3.13

Fig III: Comparison of Spliting Tensile strength between different percentage Micro Silica and Alccofine.

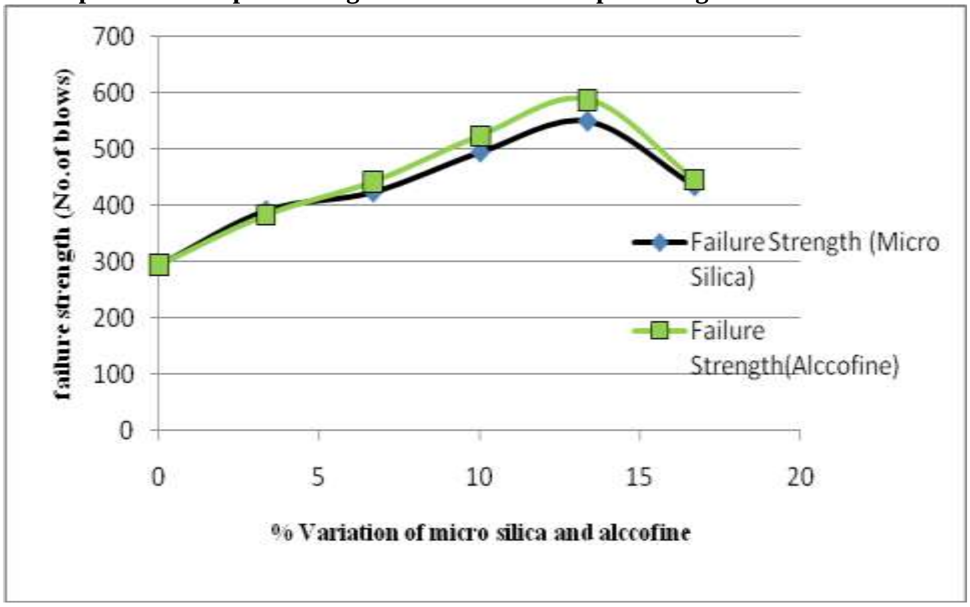


4. Impact Test (drop-weight test), FRC under Fatigue and Impact Loading, Laboratory Development Method
The number of blows that causes first crack is recorded as first crack strength; the number of blows that causes disc to fail is recorded as failure strength at 28 days.

Table 12. Comparison of Impact strength between different percentage Micro Silica and Alccofine.

% Variation of cementitious materials	Impact Strength Test(Number of Blows)			
	Micro Silica		Alccofine	
	First Crack Strength	Failure Strength	First Crack Strength	Failure Strength
0.0	290	294	290	294
3.34	386	391	375	383
6.68	421	424	438	442
10.02	491	495	521	524
13.36	547	550	586	588
16.7	432	435	443	446

Fig IV: Comparison of Impact strength between different percentage Micro Silica and Alccofine.



VI. CONCLUSION

Following are the observations made from the study of using micro silica and alccofine in concrete.

- From the above study, it can be inferred based on
- The compressive strength, flexural strength, splitting tensile strength and impact strength test results that both micro silica and alccofine when added to concrete,exhibit maximum values of each property at around 13.36% addition level beyond which, further addition tends to reduce the performance of concrete with respect to mentioned properties.
- Compresive strengths of alccofine are better than micro silica at the same addition level of concretes.Compressive strength increases with addition of micro silica and alccofine upto 13.36% addition level/replacement level and then starts decreasing.
- Flexural strengths performance of alccofine is higher than the micro silica. The optimized content of both micro silica and alccofine was found to be at around 13.36% addition level based on the study.
- The behavior of splitting tensile strengths of concrete with micro silica is better compared to concrete with alccofine at the same addition level.
- Impact Strengths of micro silica is slightly better then alccofine.

REFERENCES

[1]. Dilip Kumar Singha Roy, Amitava Sil, “Effect of Partial Replacement of Cement by Silica Fume on Hardened Concrete”, International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, Volume 2, Issue 8, August 2012.

[2]. Nausha Asrar, Anees U. Malik, et al., “Corrosion studies on micro silica added cement in marine environment”, Research& Development Centre, Saline Water Conversion CorporationP, Kingdom of Saudi Arabia.

[3]. B. Sabet Divsholi, B. Kondraivendhan, et al., “effect of ultra fine slag replacement on durability and mechanical properties of high strength concrete”, 36th Conference on Our World in Concrete & Structures Singapore, August 14-16, 2011.

[4]. M. Shariq, J. Prasad, A.K. Ahuja, “Strength development of cement mortar and concrete incorporating GGBFS”, Asian journal of civil engineering vol.9 2008 pp.61-74.

[5]. Venu malagavelli, “ High performance concrete with ggbs and robo sand”, Department of Civil Engineering, BITS, Pilani Hyderabad ,International Journal of Engineering Science and Technology, Vol. 2(10), 2010, 5107-5113.

[6]. Mohammad Abdur Rashida, Mohammad Abul Mansurb“Considerations in producing high strength concrete”,Journal of Civil Engineering (IEB), 37(1) (2009) 53-63.

[7]. Impact Test (drop-weight test), FRC under Fatigue and Impact Loading, Laboratory Development Method (Fiber Reinforced cement composites, Perumal swamy N Balaguru and Surendra P Shah, MCGraw Hill International Editions; Civil Engineering series 1992).

[8]. M.S. Shetty, “Concrete Technology: Theory and Practice”, published by S.Chand and Co Ltd, (Reprint 2008).

[9]. Neville A.M., “Properties of concrete”, Third edition, 1981, ELBS, London.

[10]. IS 456:2000, “Plain and Reinforced concrete-code of practice”, BIS, New Delhi, India.

[11]. IS 383:1970, “Specification for coarse and fine aggregate from natural sources for concrete”, second revision, BIS, New Delhi, India.