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STUDY ON STRENGTH PROPERTIES OF SELF-COMPACTING CONCRETE WITH MICRO SILICA

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Abstract: Self-compacting concrete (SCC) is a flowing concrete mixture that is able to consolidate under its own weight. The highly fluid nature of SCC makes it suitable for placing in difficult conditions and in sections with congested reinforcement. Use of SCC can also help minimize hearing-related damages on the worksite that are induced by vibration of concrete. Another advantage of SCC is that the time required to place the concrete in large sections is considerably reduced. In this paper the performance of SCC by varying the range of micro silica as partial replacement of cement is studied. When used as an admixture micro silica can improve the property of concrete in both fresh and hardened state .The trial mixes are formed based on the EFNARC specifications. Cement is replaced with various percentage of micro silica (5%, 10%). The workability properties of mix are evaluated by workability tests such as slump flow test, V-funnel. L-Box tests. In this study the performance of concrete mix with micro silica, super plasticizer and VMA is evaluated. It was found that te compressive strength of cubes at 5% replacement is 28% higher than that of 10% replacement.

Keywords*:* Self-Compacting Concrete, micro silica, workability, compressive strength.

I. INTRODUCTION

These days, apart from steel, concrete is the most common and widely used as structural material in construction field. Concrete defined as a composite material made up of composed granular material (the aggregate or filler) embedded in a hard matrix of material (cement or binder) and water. They are many types of concrete with different material used in mix design. The Self Compacting Concrete is a concrete which flows and settles due to its own weight without segregation and bleeding. SCC has several advantages over normal conventional concrete. It can flow easily in congested reinforced areas such as in beam column joints. The terms "High performance concrete" and "High strength concrete" are often taken to mean the same thing. However, as indicated, "High performance" strictly relates to a concrete that has been designed to have good specific characteristics, such as high resistance to chloride ingress or high abrasion resistance, as a result it may also have a high strength.

High-strength concrete is specified where reduced weight is important or where architectural considerations call for small support elements. By carrying loads more efficiently than normal-strength concrete, high-strength concrete also reduces the total amount of material placed and lower the overall cost of the structure. The most common use of high-strength concrete is for construction of high-rise buildings.

A. SELF COMPACTING CONCRETE

Development of Self-Compacting Concrete (SCC) is a desirable achievement in the construction industry in order to overcome problems associated with cast-in-situ concrete. SCC is not affected by skills of labours, the shape and amount of reinforcement or the arrangement of a structure and due to its high fluidity and resistance to segregation it can be pumped longer distances. The concept of SCC was proposed in 1986 by Professor Hajime Okaruma, but the prototype was first developed in 1988 in Japan, by Professor Ozawa (1989) at the University of Tokyo. SCC was developed at the time to improve the durability of concrete structures. Since then, various investigations have been carried out and SCC has been used in practical structures in Japan, mainly by large construction companies. Investigations for establishing a rational-mix design method and Self-Compacting testing methods have been carried out from the viewpoint of making it a standard concrete.

Self-Compacting Concrete is cast so that no additional inner or outer vibration is necessary for the compaction. It flows like "honey" and has a very smooth surface level after placing. With regard to its composition, Self-Compacting Concrete consists of the same components as conventionally vibrated concrete, which are cement, aggregates and water, with the addition of chemical and mineral admixtures in different proportions. Usually, the chemical admixtures used are High-Range Water Reducers (super plasticizers) and Viscosity Modifying Agents, which change the rheological properties of concrete. Mineral admixtures are uses as an extra fine material, besides cement, and in some cases, they partially replace cement. In this study, the cement content was partially replaced with mineral admixtures, micro silica that improves the flowing and strengthening characteristics of the concrete.

The main reasons for the employment of SCC can be summarized as follows:

- To shorten the construction period.
- To assure compaction in the structure- especially in confined zones where compaction is difficult.
- To eliminate noise due to vibration.

B. HIGH STRENGTH CONCRETE

High-strength concrete has a compressive strength greater than 40 Mpa. High-strength concrete is made by lowering the water-cement (W/C) ratio less than 0.35. Often micro silica is added to prevent the formation of free calcium hydroxide crystals in the cement matrix, which might reduce the strength at the cement-aggregate bond. Low W/C ratios and the use of micro silica make concrete mixes significantly less workable, which is particularly likely to be a problem in high-strength concrete applications where dense rebar cages are likely to be used. To compensate for the reduced workability, super plasticizers are commonly added to high-strength mixtures. Aggregate must be selected carefully for high-strength mixes, as weaker aggregates may not be strong enough to resist the loads imposed on the concrete and cause failure to start in the aggregate rather than in the matrix or at a void, as normally occurs in regular concrete. In some applications of high-strength concrete the design criterion is the elastic modulus rather than the ultimate compressive strength.

II. LITERATURE REVIEW

W.Zhu , This paper reports a study carried out to assess the impact of the use of Self-Compacting Concrete(SCC) on bond and interfacial properties around steel reinforcement in practical concrete element. The results showed that the maximum bond strength decreased when the diameter of the steel bar increased from 12 to 20 mm. For both diameters of the reinforcement bars , the actual bond strength of mixes were higher than those of refrence mixes.**Vikas Srivastava,** This paper reports that the addition of pozzolanic materials like silica fume increases the various properties of concrete. In this paper he concludes that the addition of silica fume decreases the workability and increases compressive strength as well as the bond strength of concrete.**A.A. Maghsoudi ,** In this investigation, by trial and error procedure, different mix design of Self Compacting Light Weight Concrete (SCLWC) were caste and tested to reach a so called standard self compacting concrete in fresh matrix phase such as; values of slump flow, L-box, V-funnel and in hardened phase, the 28 day compressive strength. Based on the results obtained, for two best so-called standard mix design of SCLWC the stress-strain diagrams are drawn and discussed. The Author concluded that by use of Light Expand Clay Aggregate (LECA) as light weight aggregate it is possible to produce a self compacting light concrete. **Bertil Perrson,** study included eight mix proportions of sealed or air-cured specimens with water ±binder ratio (w/b) varying between 0.24 and 0.80. Half of the mixes studied were based on NC. The age at loading of the concretes in the creep studies varied between 2 and 90 days. Four different stress to strength levels were studied. Parallel studies were performed on strength (fc) and relative humidity (RH). The results show that elastic modulus, creep and shrinkage of SCC did not differ significantly from the corresponding properties of NC.

III. MATERIAL PROPERTIES

Cement: Ordinary Portland Cement of 53 grade (Zuari Cement) is used.

Fine & Coarse Aggregate: Locally available river sand conforming to grading zone II of IS 383-1970 was used. The Specific gravity of fine aggregate was 2.53.The maximum size of coarse aggregate was restricted to avoid the blocking

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effect in Self-Compacting Concrete. Coarse aggregate of nominal size 12.5 mm was used. The Specific gravity of coarse aggregate was 2.35.

Micro silica: Micro silica also referred to as silica fume or condensed micro silica, is a by product material that is used as a pozzolan. The micro silica having the specific gravity 2.2 was used in the present investigation.

Super Plasticizer: Conplast SP 337 was used in this investigation. Their properties are listed in table 1.

Table 1 Physical properties of SP Conplast 337

Appearance	Brown liquid
Specific Gravity	1.18±0.01 kg/l at 20º C
Chloride content	Zero percentage
Alkali content	< 72 gr.Na_2O equiv./l

Viscosity Modifying Agent: Glenium Stream 2 was used in this investigation in table 2.

Table 2 Physical properties of Glenium Stream 2

Appearance	Colourless free flowing liquid
Relative Density	0.01 at 25 º C
pH	≥6
Chloride ion content	<0.2%

IV. MIX DESIGN WITH DATA

The trial mixes taken for development of Self-compacting concrete with various percentages of micro silica are summarized in the table 3.

Table 3 Mix Design for SCC

Trial	Cement kg/m^3	Micro silica kg/m^3	Fine aggregate kg/m^3	Coarse aggregate kg/m^3	Water kg/m^3	Super Plasticizer (%)	Viscosity Modifying Agent (%)
S_1	503.50	26.50	890	740	195	2	1
S_2	477	53	890	740	195	2	1
S_3	570	30	890	740	195	2	1
S_4	540	60	890	740	195	2	1
S_5	250	250	890	740	195	2	0.5
S_6	522.50	27.50	890	740	195	2	0.5
S_7	495	55	890	740	200	2	0.5

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V. WORKABILITY TEST

Tests on fresh concrete were performed to study the workability of SCC. The tests conducted are listed below:

i Slump flow test
ii V- funnel flow test
iii L-box test

The acceptance criteria for the fresh properties of SCC are listed in Table 4.

Table 4 Acceptance criteria for SCC as per EFNARC

S. No.	Method	Unit	Typical range of values	
			Minimum	Maximum
1	Slump-flow	mm	650	800
2	V-funnel	Sec	8	12
3	L-Box	h_2/h_1	0.8	1.0


(a)


(b)


(c)

Fig.1, Workability Tests (a) Slump-flow test (b) V-funnel test (c) L-Box test

VI. RESULTS AND DISSCUSSION

The results of various workability test are evaluated. The values should be in acceptance criteria as per EFNARC. The trials are also satisfied in table 5.

Table 5 SCC Workability Properties

Trials	Slump flow mm	V- Funnel sec	L-Box mm
S_1	790	8	1
S_2	750	10	0.9
S_3	760	11	1
S_4	650	10	0.9
S_5	590	13	-
S_6	700	12	0.8
S_7	750	9	1

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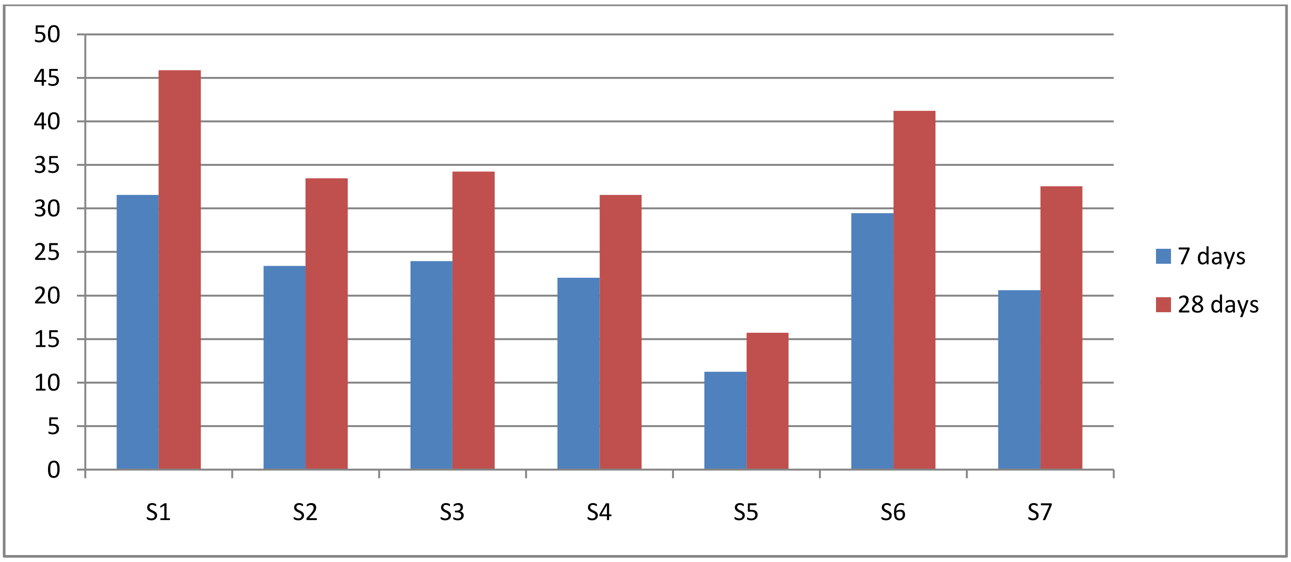
As per EFNARC specification, S_1 satisfies the workability properties.S_2 at 10% replacement of micro silica the workability property slightly decreases compared to S_1. By varying the powder content at 5% replacement of micro silica ,S_3 gives good flow ability and satisfies the workability properties. For the same powder content at 10% replacement of micro silica, S_4 also satisfies the workability criteria. At 50% replacement of micro silica and also decreases the percentage of VMA to 0.5%, the workability of mix, S_5 greatly affected.

By varying the powder content to 550 kg/m^3 at 5% replacement of micro silica, the S_6 shows good workability even though the VMA is kept as 0.5%.For the same powder content at 10% replacement of micro silica, the workability values are within the permissible limits.

Table 6 Compressive Strength Results

Trials	Compressive strength(N/mm^2)	
	7 days	28 days
S_1	31.56	45.87
S_2	23.42	33.45
S_3	23.96	34.23
S_4	22.04	31.57
S_5	11.23	15.74
S_6	29.45	41.21
S_7	20.6	32.54

Fig.2 Compressive Strength Results



In fig.2.,The compressive strength at 5% replacement of micro silica is high compared to 10% replacement at varying powder contents (530kg/m^{3,} 600kg/m^3 , 500kg/m^3 ,550kg/m^3).By using equal amount of silica and cement the compressive strength of the mix decreased.

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VII. CONCLUSION

In this study several trials of SCC were designed at varying powder contents ranging between 500kg/m^3 to 600kg/m^3 as per EFNARC Specifications and its fresh state properties are evaluated. From the workability test results, it was seen that the workability decreases with increase in percentage of micro silica. It was concluded that at 5% replacement (powder content of 530kg/m^3) of micro silica the mix shows good workability and compressive strength. With further increase in replacement percentage the compressive strength decreases gradually. It can be concluded that the SCC with micro silica can be used in the construction sector.

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