Strength And Durability Characteristics Of Self Compacting Concrete With Micro-Silica And Steel Fibre

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Abstract:* *Japan invented self-compacting concrete (SCC) inthe late 1980s to make up for the labor shortage. Self-compactionconcrete, or SCC, is a unique kind of labor-friendly concrete thatcan flow and compact on its own. When properly designed, it canproduce better compaction than the traditional control mix, savetime, and eliminate the need for vibration.SCC has a highercement content and a higher binder content. Steel fibers wereadded to the cement to increase its ductility, and micro-silica wassubstituted for the cement in varied percentages. Furthermore,concrete has been strengthened and preserved with the use ofmicro-silica. The structure of the cement paste is changed whensilica is added to a concrete mixture. The resultant paste then hasa lower concentration of the weak and readily soluble calciumhydroxidesandahigherconcentrationofcalcium-silicatehydrates. Their smaller particle size distribution allows them toseparate and disperse among the cement particles. The currentstudy examined the fresh and hardened properties of SCC whilepreparingvariousmixratiosusingsteelfibersand micro-silica.

KeyWords:Micro-silica,Steelfibre,SCC,Waterabsorption.

I. INTRODUCTION

SinceitsdevelopmentinJapaninthe late1980s,theapplicationofSCChasexpandedsignificantly.Theviscosity-modifyingagentintheformerportionandtheadditional use of a special admixture are what set SCC apartfrom conventional control concrete. SCC is a material thatdoesn't require compaction in order to pass through crowdedreinforcing bars. According to EFNARC guidelines[2], thefreshstatepropertiesofSCChavebeenexaminedand adhered to. A higher volume of hydration products and amore uniform distribution are offered by silica particles. Theapplication of silica lessens shrinkage cracks brought on byheat of hydration, reduces thermal cracking, and eventuallyhelps to increase durability [5,6]. Concrete's ductility anddurability are enhancedby the additionof silica particlesandfibrousmaterials,respectively.Thecurrent studyexamines the properties of the SCC mix after additives likesteel fiber and micro-silica are added. Studies have also beendoneontheconcrete'shardenedproperties.

II. MATERIALTESTINGANDMIXDESIGN

Self-Compacting Concrete (SCC) was designed to flowunderits ownweight. Normal concrete was designed byusingISmethodandSelf-Compacting

Concretewas designed by using NanSu method. The mix proportionis chosen in such a way that it satisfies the performancecriteria for the concrete in both fresh and hardened state. Toobtaintherequiredworkabilityin SCC,ahigherproportionoffinermaterialsandtheincorporationofchemicaladmixturearenecessary.Table1showstheresultsofmaterial testing. Micro-silica was added to improve the CSHgel formation in concrete [7]. Table 2 shows the physicalproperties of Micro-silica. Steel fibres are added to improvetheductility property of concrete[3,4,8] and the propertiesofsteelfibreareshowninTable3.

Table1.Materialtestingresults

Physicalproperty	Values
Specificgravityofcement	3.1
Specificgravityofsand	2.61
Specificgravityofcoarseaggregate	2.66
Packingfactorofsand	1.09
Packingfactorofcoarseaggregate	1.1

Table2.PhysicalPropertiesOfMicro-Silica

Property	Micro-silica
SiO_2 content	92.8%
Loss on ignition	2.6%
Moisture	0.2%
Particle size	150 nm
Surface area	22 m^2/g

Numerous trial mixes were carried out in order to achieve the slump flow. The strength parameters were also examined and then the final mix proportions were concluded depending upon the dosage of micro-silica, steel fibres, Super Plasticizer and VMA content. Water content, Super Plasticizer and VMA content is increased to get a workable concrete in the combination mix of micro-silica and steel fibre due to their uniform distribution within the concrete mix. Mix proportion was derived based on the EFNARC guidelines and is shown in Table 4. The mix proportion was varied for obtaining various mix with 5%, 10% and 15% micro-silica and 0.5% steel fibre as a partial replacement of cement. The optimum mix was obtained by choosing the optimum micro-silica mix showing better fresh and hardened properties of concrete.

Table 4. Mix Proportion For Control Concrete

Mix	Cement (kg/m^3)	Water (kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)	Micro silica (kg/m^3)	Steel fibre (kg/m^3)	S.P (%)	VMA (%)
C	450	200	1000	750	---	---	1.2	0.12

III. EXPERIMENTAL INVESTIGATION

In the present study, tests were conducted on fresh and hardened concrete. Fresh SCC mixes were conducted for tests like Slump flow and J-ring. The J-ring test was conducted by placing the slump cone inside the J-ring and the concrete was filled in the slump cone without compacting. Then slump cone was removed and the concrete flow through the J-ring was measured in terms of horizontal flow spread as shown in Fig.1. The slump flow was tested basically to satisfy the flowing ability criteria and is shown in Fig.2. [2]. The J-ring flow and slump flow are related to each other by the term Passing Ability Index (PAI). Passing Ability Index is the ratio of the J-ring slump flow and slump flow whose value should be less than or equal to1.

$$PAI = 1 - \frac{(d_{sf} - d_{jf})}{d_{sf}} = \frac{d_{jf}}{d_{sf}}$$

where

$$d_{sf} = Diameter\ of\ slump\ flow$$

djf = $Diameter of J - ring slump flow$ The acceptance range of values for different workability tests were shown in Table 5. From the successful mixes, final mix proportion after the cubes were cast and tested after 7 days and 28 days of curing were chosen. The compressive strength is carried out as per IS 516-1999 standard, conducted on concrete specimen of size 150mm x 150mm x 150mm. Cylinder of 100 mm diameter and 200 mm height was used for split tensile strength and prism of size 100mm x 100mm x 500mm was used for flexural strength and tested as per IS 516-1959.

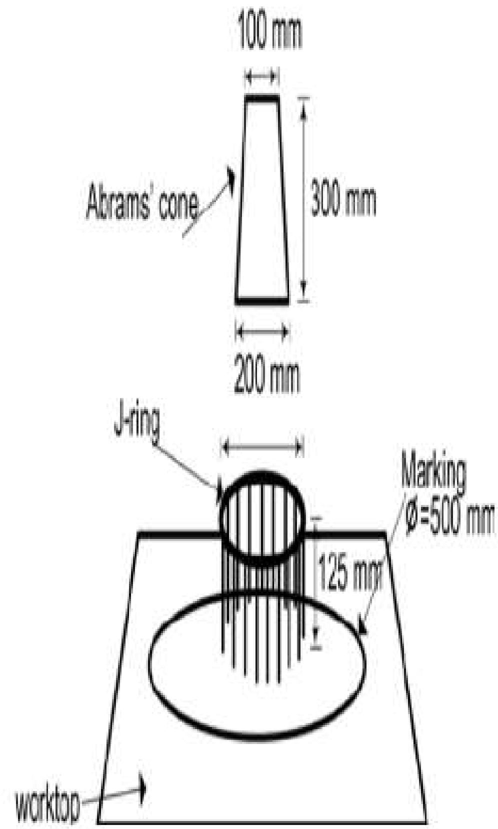

Figure 1. J-Ring Test

Table 5. Acceptance Criteria for Flow Test

Results of Scc

S.No.	Method	Unit	Typical range
1	Slump Flow	mm	650-880
2	J-Ring	mm	600-820

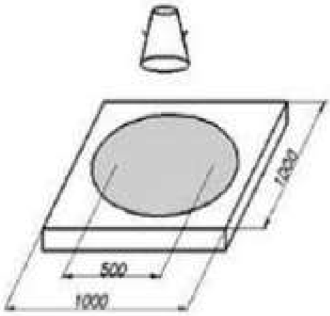

Figure 2. Slump Flow Test

IV. RESULTS AND DISCUSSION

The different types of concrete mixes were carried out in the laboratory as per the mix proportions mentioned. The fresh concrete properties were tested. The slump flow was measured and the average values of diameters at right angles were noted. The slump flow obtained for SCC control, control with 0.5% steel fibres, 10% micro-silica mix and combination mix of 10% micro-silica and 0.5% steel fibre showed slump flow of 660 mm, 658 mm, 675 mm and 657 mm respectively. From Fig.3., as the percentage of microsilica increases, the PAI value gets increased. Linear regression was carried out and the result was better with a result of R2 = 0.9986. Figure 4. and Figure 5. shows the J-Ring slump spread and Slump flow spread respectively.

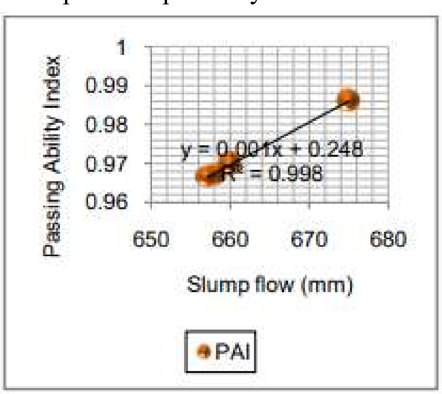

Figure 3. Variation Of Pai

Figure 4. J-Ring Slump Spread

From Fig. 6., it can be seen that the control concrete with 0.5% steel fibre and micro-silica mix with 0.5% steel fibre exhibited a higher percentage increase in compressive strength compared to control concrete, meanwhile the mix with micro-silica showed 4.48% increase in compressive strength

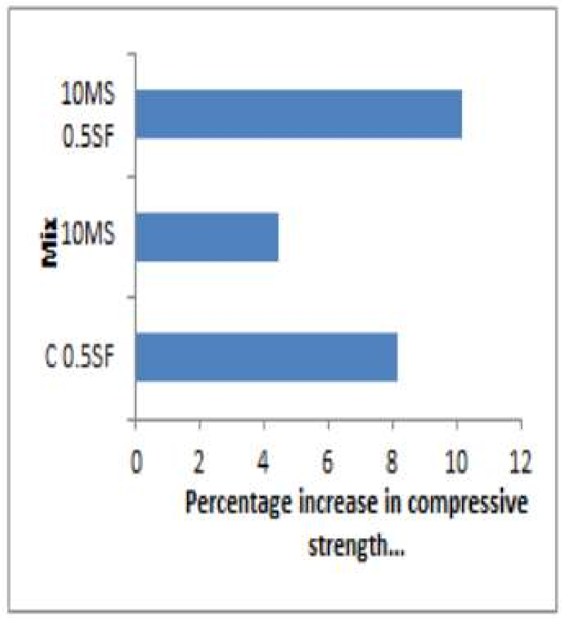

Figure 6. Percentage Variation Of Compressive Strength

From Fig.7. and Fig.8., it can be noted that as the steel fibres are added to the concrete, there is a considerable increase in both Split tensile strength and Flexural strength. Meanwhile, when micro-silica is added to concrete, both Split tensile strength and Flexural strength increases by 22.9% and 24.5% respectively compared to control concrete

Figure 5. Slump Flow Spread

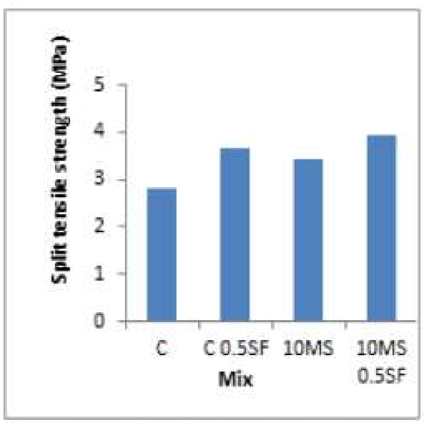

Figure 7. Variation Of 28 Days Split Tensile Strength

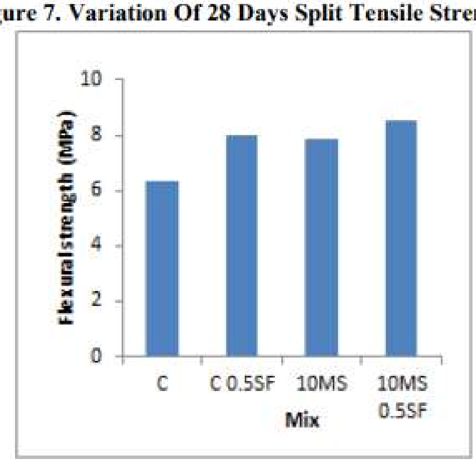

Figure 8. Variation Of 28 Days Flexural Strength

From Fig.9., it was noted that there is a reduction in absorption of water by the specimen containing micro-silica. This is due to the pore filling effect of micro-silica, leading to the formation of less porous structure. The percentage of water absorption is more for mix containing steel fibre due to the irregular positioning of steel fibres in concrete.

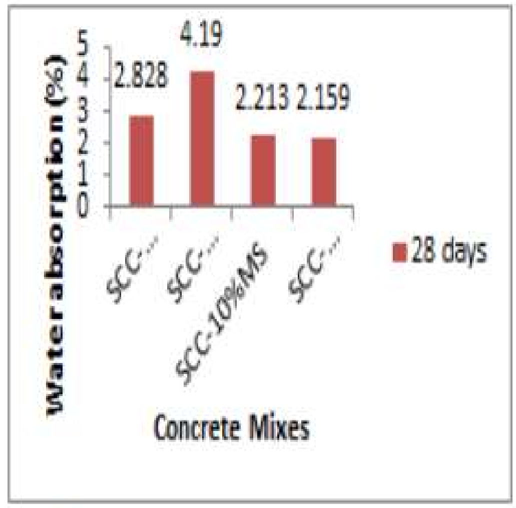

Figure 9. Variation Of Water Absorption Capacity

V. CONCLUSION

When the percentage of micro-silica gets increased, the workability of concrete gets reduced. The risk of segregation and bleeding was reduced by adding a higher percentage ofsilica particles along with the appropriate dosage particles. Workability of concrete gets reduced when micro silica was added to concrete in addition to steel fibre. The mechanical properties of concrete increases with the addition of microsilica and steel fibre. Due to more CSH gel formation in micro-silica, the absorption of water in the concrete specimen gets reduced, whereas the addition of steel fibres increases the pore size of concrete and leads to more water absorption

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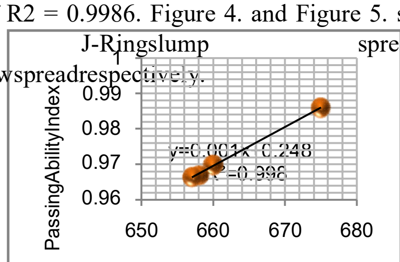

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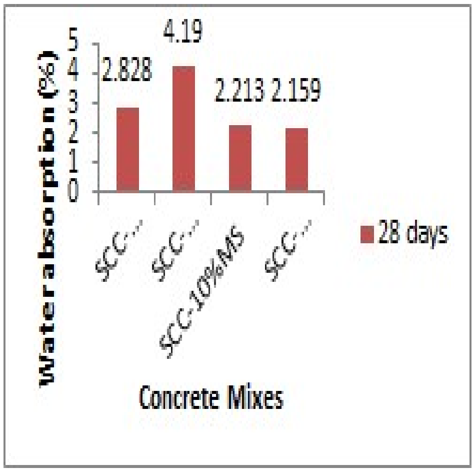

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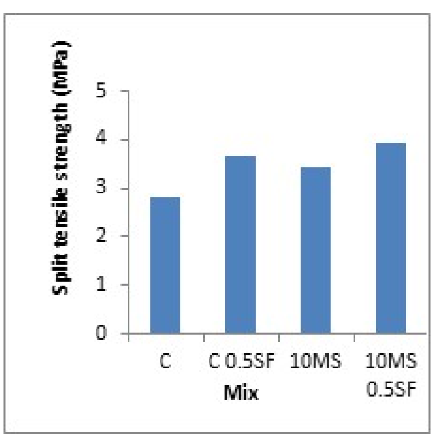
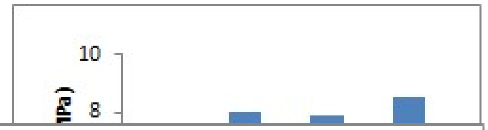
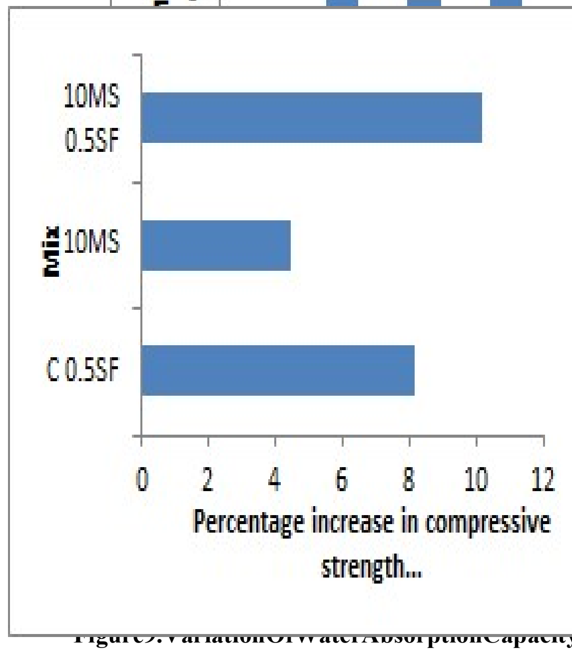


Figure7.VariationOf28DaysSplitTensileStrength





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