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A Study on Understanding the Effects of Admixtures on the Properties of Self Compacting Concrete

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ABSTRACT- Self-Compacting Concrete (SCC) is a flowing concrete mixture that, even in the presence of crowded reinforcement, can consolidate and entirely fill up formwork under its own weight without vibrating while it is being poured.SCC was initially described by Japanese researchers in the late 1980s.The main aim of this dissertation is to discuss the effects of various admixtures on the properties of self-compacting concrete. An experimental analysis on self-compacting concrete (SCC) with a water cement content of 0.42 was conducted in this study. Various types of mixes were used, the first included different percentages of silica fumes (SF) mixed with concrete. The second mix includes super plasticizer SP-430 for a notable variation in its strength. Various batches of concrete mix were also used for testing by combining super plasticizer with different chemical admixtures. Since self-compacting concrete is the subject of the research, slump cone and V-funnel tests are performed on fresh SCC, and the compressive strengths, split tensile strengths and flexural strengths of the concrete are measured on hardened blocks as properties.

For 7 and 28 days cured specimens, it was discovered that adding 10% silica fumes and 1% SP-430 and various combinations of chemical admixtures with SP-430 respectively to the concrete were found to give noticeable compressive, flexural and split tensile strength also good workability characteristics.

KEYWORDS- Admixtures, Self Compacting Concrete, Silica Fumes, Super Plasticizer.

I. INTRODUCTION

A. General

The unique form of concrete known as self-compacting concrete (SCC) was created in Japan. If dumped from a specific height, SCC has sufficient mobility without aggregate segregation and doesn't require human compaction. It possesses the fluidity and filling capacity needed to pass through crowded reinforcement details without settling. It is highly helpful in lowering the cost of putting concrete, improving working conditions, and preventing health risks brought on by vibrations because it does not require vibration to compact. The aggregates must be completely submerged in the concrete matrix and the reinforcing must be completely coated. The following three varieties of self-compacting concretes are available to suit performance requirements: powder type, viscosity agent type, and combination type.

In its fresh condition it has properties like Filling Ability (excellent deform-ability), Passing Ability (ability to pass reinforcement without blocking) and High Resistance to Segregation. In its hardened state it shows the properties equivalent to those of conventional concrete. Various mineral admixtures are:

- Fly ash
- Ground granulated blast furnace slag (GGBFS)
- Silica fume
- Metakaoline
- Rice husk ash
- Various chemical admixtures are : Air-entraining agents Retarders
- Accelerators
- Viscosity modifying agents
- Superplasticizers
- Air – entraining admixture
- Water proofing compound
- Shrinkage Reducing Agents

II. LITERATURE REVIEW

Poloju, Kiran. (2022) An admixture is a substance that is added to cement either before or during the mixing process to enhance its qualities. The two types of admixtures are chemical admixture and mineral admixture. The admixture is crucial to the strengthening qualities of concrete and can increase or decrease the setting time. An admixture is a substance that is added to cement either before or during the mixing process to enhance its qualities. Most developing nations employ at least one additive in their concrete for best results.The two types of admixtures are chemical admixture and mineral admixture. The admixture is crucial to the strengthening qualities of concrete and can increase or decrease the setting time.

Ahmad, Saeed & Elahi, (2012) The impact of mineral admixtures on the characteristics of high-strength SSC is the subject of the experimental research presented in this study. Ordinary Portland cement, ground granulated blast furnace slag, and silica fume were used as cementitious materials to create a total of six mixtures. Up to 60% GGBS was utilised as a substitute, while up to 7.5% silica fume was added. In addition, a superplasticizer with a high-water reduction range and a viscosity modifier admixture were utilised. Concrete mix specimens were tested on a compression test machine at 3, 7, and 28 and 91 days to determine the fresh qualities, like slump, flowability, and passing ability, and the hardened properties, like compressive strength. At 28 days old, tensile strength was evaluated. The findings for fresh characteristics indicated that Mix with 5% silica fume performed the best. Both the compressive and tensile strengths were maximised in the same mixture.

Menezes de Almeida (2008) A discussion is had on the binding strength to reinforcing bars and prestressing strands, along with the top-bar effect for a number of various types of SCC mixes. The top-bar effect is mitigated by the utilisation of chemical admixtures, such as viscosity-modifying admixtures (VMAs), as is the subject of this discussion. In this article, we take a look at how the bond strength characteristics of SCC are influenced when supplementary cementitious materials (SCMs) and fillers are used. This article reviews the bond strength between consecutive lifts of SCC in multi layered casting, emphasizing on the effect of elapsed time for the castings of different layers as well as the thixotropy of the lower lift on bond strength in multi-layer casting. In conclusion, we will discuss about the bond strength characteristics that are present between SCC mixes used in repair and the existing hardened concrete.

III. SELECTION OF MATERIALS

Cement: Development of SSc will require the utilization of standard Portland cement of grade 53. Aggregates: Coarse aggregates with a maximum sieve size of 12.5 mm to 10 mm and that adhere to IS standards. Fine aggregates will have particles that are larger than 0.125 mm but smaller than 4 mm. Powdered particles having an average diameter about less than 0.125 millimetres are used to lower the possibility of segregation in the concrete.

Admixtures: various mineral and chemkical admixtures employed are silica fumes, SP-430, viscosity modifying agent, air enteraining agent, water proofing component, reatarder and accelerator.

IV. TEST METHODS

- Tests on Aggregates like Sieve analysis, Specific gravity, Water absorption, Shape analysis: A 10 mm sieve may pass and keep material with a maximum aggregate size of 12.5 mm, demonstrating continuous gradation. The following table lists the physical properties of the materials and details the gradation and other tests that were carried out according to ASTM standards, each requiring 5 trials
- The T500 test and slump flow test: The slump test, evaluates both flow rate and flow time. This statistic assesses the void-filling capacity of self-compacting concrete. The T500 time can be used as a substitute for the viscosity of the self-compacting concrete. Fill the cone without any agitation or Roding, level position. Remove any extra concrete from the base plate after
- 30 seconds, and make sure the entire base is damp. Set aside the filled cone to dry. The time taken for the concrete to reach the 500 mm circle at any point ought to be recorded to the nearest 0.1 seconds in order to obtain the required T500 time. A stopwatch must be started as soon as the cone loses contact with the base plate. You should record the largest diameter you can measure and then measure the diameter of the flow spread perpendicular to it to within 10 mm. Check the concrete spread to make sure it hasn't been contaminated if you think the test will fail due to segregation.
- V-Funnel Analysis: It is led to survey the filling limit and thickness . Fresh concrete is transfered into a V-shaped funnel, and the time taken by the concrete to flow out is measured to get the V-funnel flow time. Custom-made v-shaped funnel with a quick-release, leak-proof gate at the bottom. The metal used to build the V-funnel must be smooth and impervious to attack from cement paste or corrosion. But in order to preserve the test specimen, you'll need a container with a volume bigger than the volume of the funnel and not less than 12 times the Length.
- Compressive Strength Test: Test specimens in the size 150*150*150mm were prepared in standard cast iron moulds for the testing of compressive strength. The mixes of percentages of admixtures as the partial replacement of cement were casted into cubes and tested after 7 and 28 days of curing. No cushioning material was placed between plates and specimen. Axial application of load was done till the specimen was crushed.
- Split Tensile Test: Test specimens (cylinders) of size 100*200mm size were casted according to IS 5816 1999 for testing the split tensile strength of concrete. The concrete mixes with various proportions of admixtures as partial replacement of cement were cast into cylinders for the testing. The specimens thereby cast were tested for 7 and 28 days of curing starting from addition of water to dry mix. No cushion was placed in between the specimen and the machine plates. 2KN of load was applied till the specimen crushed.
- Flexural Strength Test: The flexural strength test was conducted by taking IS 516-1959 as reference using three prismatic specimens of size 150*150*600mm. The four point bending test was conducted with the beams. Load was applied in small installments by a hydraulic jack. Using load cell load was measured. The behaviour was observed in terms of crack development, the failure mode and the ultimate load. The deflection was recorded using LVDTs.

V. RESULTS

A. *Tests on Aggregates*

Table 1: Results of the tests on aggregates

S. no	Test	Method of test	Average Result	Permissible value
1	Sieve analysis	IS:2720-Pt-4	Fineness modulus = 2.90	2.3 to 3.1
2	Specific gravity	IS:2386-Pt-3	Bulk specific gravity = 2.60	2.5 to 3.2
			Apparent specific gravity = 2.5	
3	Water absorption	IS:2386-Pt-3	0.5	<2%
4	ggregate shape test Flakiness index	IS:2386-Pt-1	12%	Max 30%
	Elongation index		14%	

B. *T500 , Slump Flow Test and V funnel test*

Table 2: showing the T500, Slump flow and v-funnel test results

Method	Obtained value		Typical range values	
	SCC + Silica	SCC +SP 430	Minimum	Maximum
Slump Flow (Abram cone) in mm	650	750	660	810
T50Cm slump flow in sec	6	5	3	6
V funnel in sec	8	10	7	13

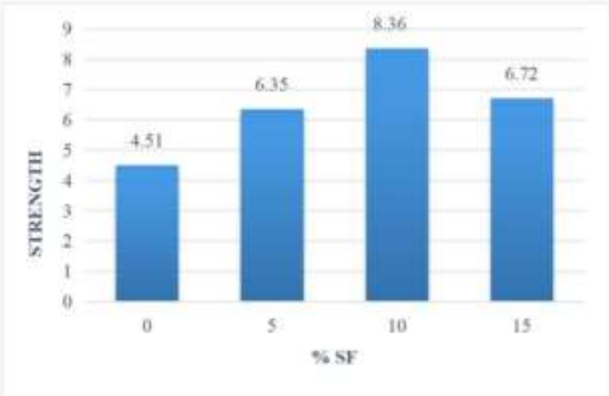

Figure 2: Bar chart showing the compressive strength results of mix having SF after 28 days of curing

C. *Compressive Strength Test*

- **Silica Fumes As Partial Replacement**

Figure 1 and Figure 2 respectively show the compressive strength test results for 7 and 28 days of curing for varying percentages (0%,5%,10,15%) of silica fumes as partial replacement of cement, in the form of bar chart representation.

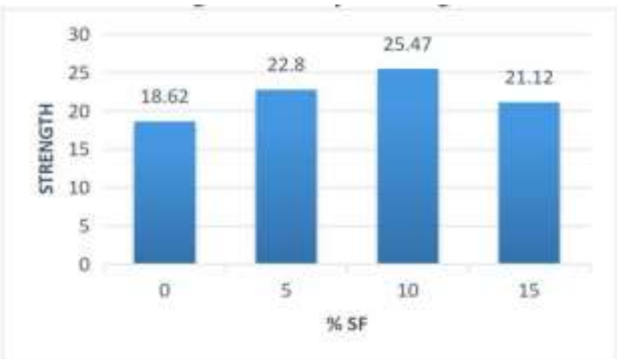

Figure 1: Compressive strength results of mix having SF after 7 days of curing

- **Sp-430 as Partial Replacement**

Figure 3 and figure 4 respectively show the compressive strength results for 7 and 28 days of curing for various percentages (0%,0.5,1%,1.5%) of SP-430 as partial replacement of cement.

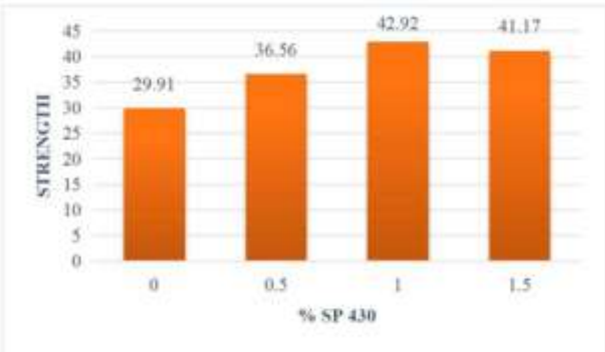

Figure 3: Compressive strength results of mix having SP 430 after 7 days of curing

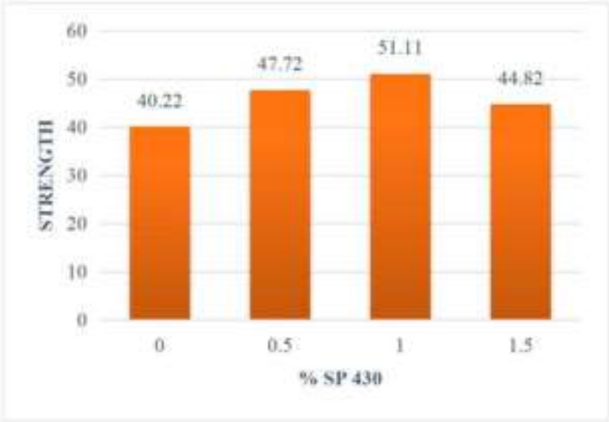

Figure 4: Bar chart showing the compressive strengthSp-430 as partial replacement results of mix having SP430 after 28 days of curing

D. Split Tensile Strength Test

- **Silica fumes as partial replacement:**

Figure 5 and Figure 6 respectively show the tensile strength test results for 7 and 28 days of curing for varying percentages (0%,5%,10,15%) of silica fumes.

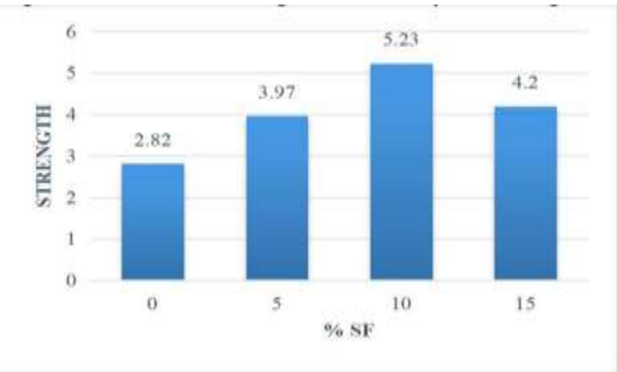

Figure 5: Bar chart showing the split tensile strength results of mix having SF after 7 days of curing

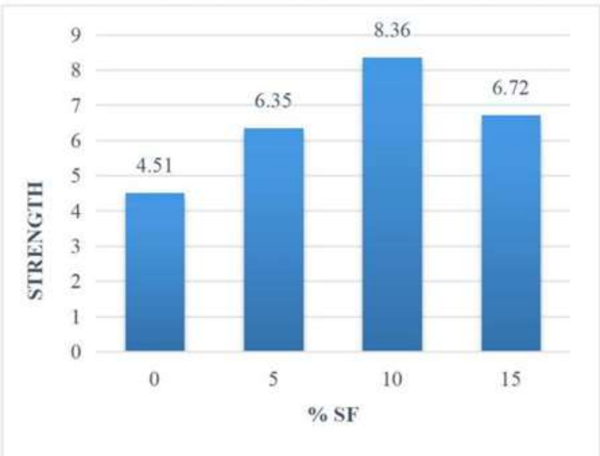

Figure 6: Bar chart showing the tensile strength results of mix having SF after 28 days of curing

- **Sp-430 as partial replacement**

Figure 7 and figure 8 respectively depict the split tensile strength results for 7 and 28 days of curing for various percentages(0%,0.5,1%,1.5%) of SP-430.

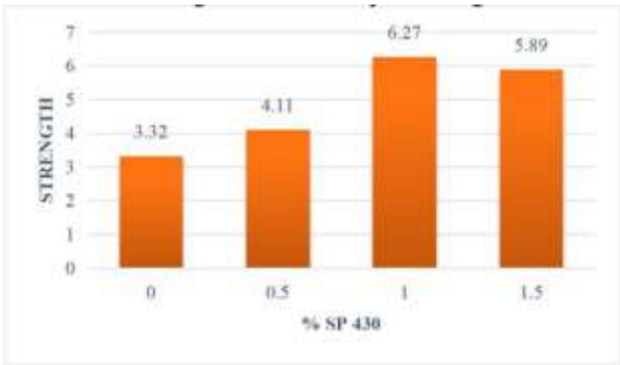

Figure 7: Bar chart showing the split tensile strength results of mix having SP430 after 7 days of curing

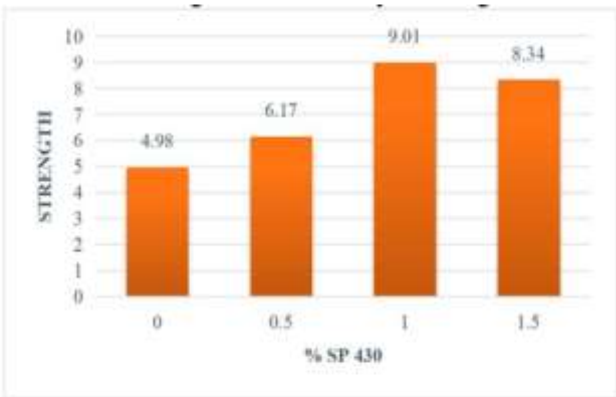

Figure 8: Bar chart showing the split tensile strength results of mix having SP430 after 28 days of curing

E. Flexural Strength Test

- **Silica fumes as Partial Replacement**

Figure 9 and Figure 10 respectively show the flexural strength test results for 7 and 28 days of curing for varying percentages (0%,5%,10,15%) of silica fumes respectively.

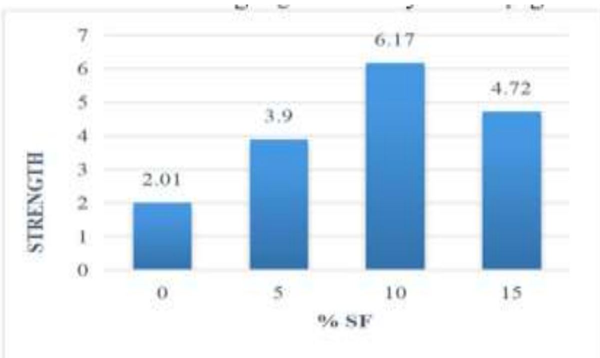

Figure 9: Bar chart showing the flexural strength results of mix having SF after 7 days of curing

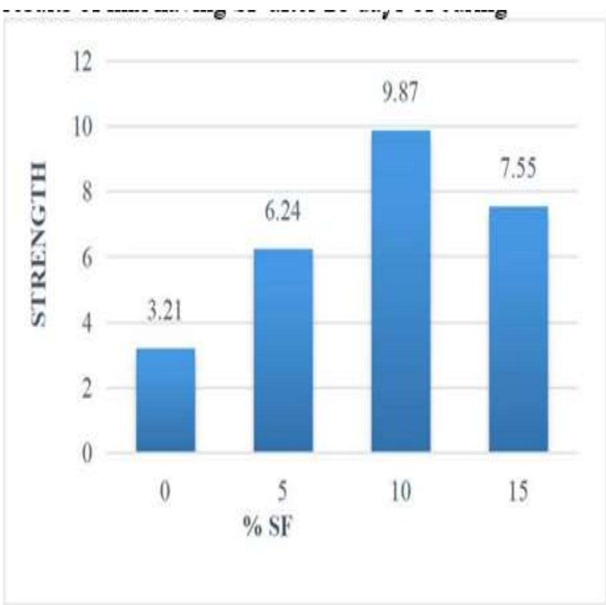

Figure 10: Bar chart showing the flexural strength results of mix having SF after 28 days of curing

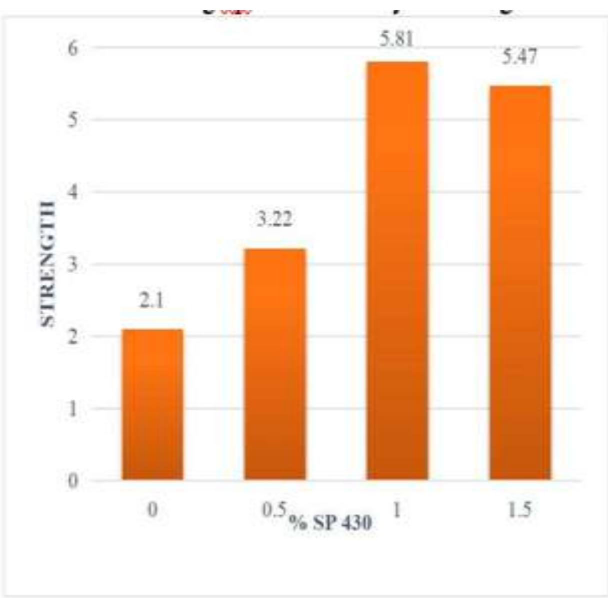

Figure 11: Bar chart showing the flexural strength results of mix having Sp 430 after 7 days of curing

- **Sp-430 as partial replacement**

Figure 11 and figure 12 respectively depict the split tensile strength results for 7 and 28 days of curing for various percentages(0%,0.5,1%,1.5%) of SP-430.

F. Effect of admixtures on the flow and strength characteristics of SSC

Various tests were conducted to check the characteristics of SSC with the addition of chemical admixtures like VMA, AEA, WPC, RET, ACC along with SP 430. The results thereby obtained are provided below in the form of tables and charts

Table 3: Results of SCC Flow tests for various Admixture Combinations

Different combination of admixtures	SlumpSlump flow with J-ring (mm)	flow (mm)	Orimet test flow time (sec)	V-funnel test flow time (sec)	L-Box test results			U Box test results of filling height (H1-H2) (mm)
					Blocking ratio H2/H1	T20 (sec)	T40 (sec)	
SP+VMA(Ref.mix)	466	591	24	33	0.1	21	31	550
SP+VMA+AEA	498	621	15	14	0.24	10	15	326
SP+VMA++WPC	486	611	16	16	0.28	14	18	410
SP+ VMA+RET	479	593	19	21	0.31	16	20	480
SP+ VMA+ACC	449	570	39	51	0.19	29	No flow	620

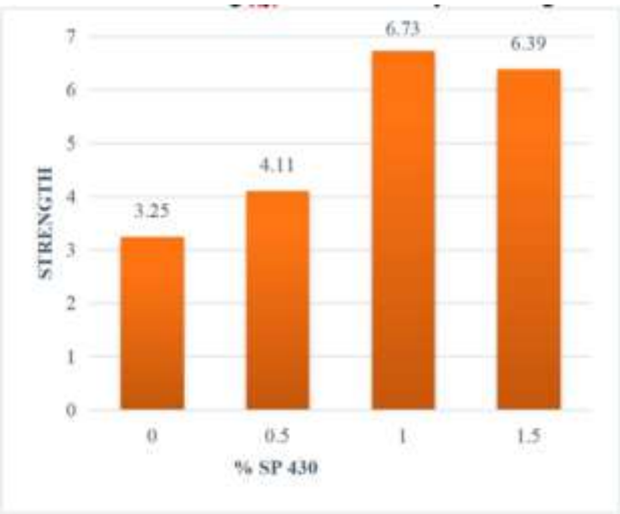

Figure 12: Bar chart showing the flexural strength results of mix having Sp 430 after 28 days of curing

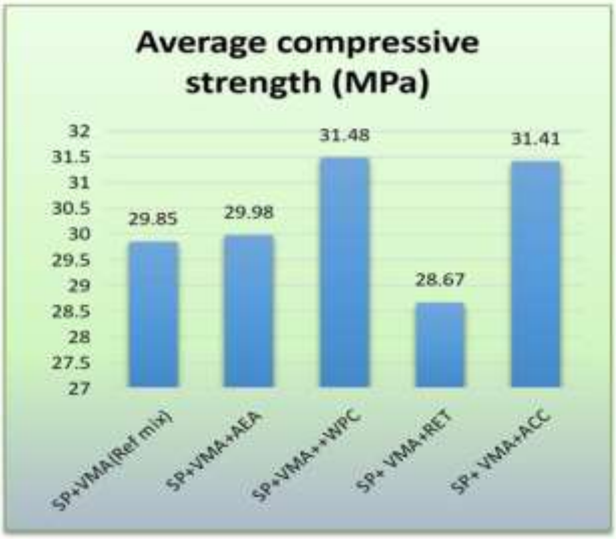

Figure 13: Variation in SCC compressive strength for various admixture combinations

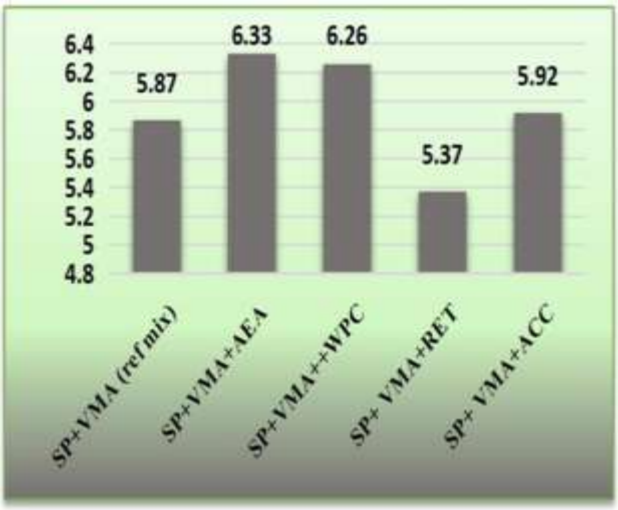

Figure 14: Tensile strength of SCC varying with various admixtures combinations

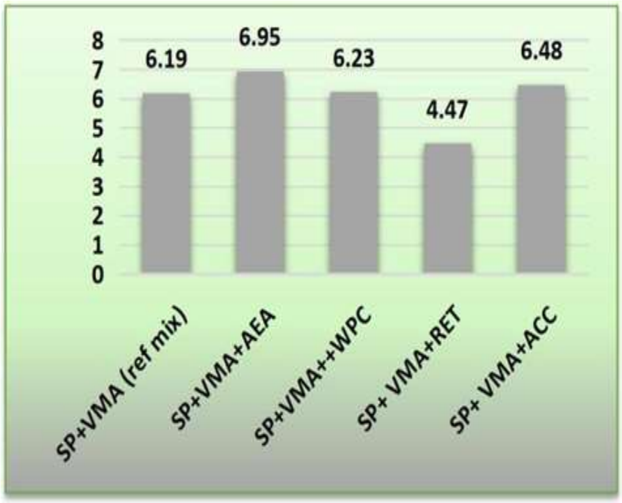

Figure 15: Flexural Strength of SSC varying with various admixtures combinations

With the addition of admixture, the compressive strength, tensile strength and flexural strength of SCC all increased significantly (SP + VMA + AEA), (SP+VMA+WPC) and (SP + VMA + ACC) are much higher as compared to SCC due to the presence of mixing (SP + VMA). However, the strength properties of SCC with the combination of admixture (SP+VMA+RET) are somewhat changed, and the resulting strength is lower than that of the reference mix. This might be because the AEA or WPC added will induce greater flow, and, the concrete will self-consolidate in a better fashion,leading to increased strength of SCC. The addition of accelerator causes the concrete to set faster, increasing the material's strength. The use of a retarder causes the setting time of SCC to be prolonged as it forms a film around each cement particle. This may have an effect on the hydration of the cement, which will result in strength reduction.

VI. CONCLUSION

Self-compacting concrete (SCC) admixtures, when carefully designed into a mix, provide concrete that is completely flowing, self-compacting, and can be laid without any vibration. Additionally, it has a lower risk of bleeding and segregation.Fluidity may be achieved either via the use of conventional superplasticizers or by the use of recently developed polycarboxylate ether co-polymers. The latter are especially useful since they produce fluid concrete that is still cohesive and has a high flow retention rate.

However, it is possible that an admixture will also be necessary to manage the rheology or segregation (VMA). This may be included into the mixture on its own or as a component of a dual-function admixture along with the superplasticizer.

According to the results of the many laboratory experiments conducted in accordance with IS requirements for porous concrete with a variety of compositions, the following conclusions have been drawn:

When it comes to testing for strength, specimens that have been cured in water tend to provide superior results than those that have been cured in air. The purpose of carrying out this analysis is to determine the optimum dose for the treatment.

The value of compressive, split tensile and flexural strength was observed to be higher for a mix of SCC that contained 10% replacement of Silica Fumes by weight of cement when compared to other replacements of Silica fumes in 450 kg/m3 cement content. This was the case for all three strengths.

With variation of SP 430 plasticizer, at 1% in concrete mix gave the highest value of concrete compressive, split tensile and flexural strength when compared to other mixes consisting of Silica Fumes in SCC.

It is possible to improve the flow properties of SCC by combining it with admixture such (SP + VMA + AEA), (SP+VMA+WPC) and (SP+VMA +RET).

The changes in the flow properties of SCC by addition of admixture (SP + VMA + ACC) are slightly affected.

The combination of admixtures such as (SP + VMA + AEA),(SP+VMA+WPC),and (SP + VMA + ACC) can be used to enhance the strength characteristics of SCC. Other combinations include (SP+VMA+ACC).

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