Impact of Composite Mixes on the Flow and Strength Properties of Self-Compacting Concrete

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ABSTRACT
Concrete used to be made from cement, aggregate, water, and admixtures; nowadays, it is an engineering substance with a variety of extra components. Even under the most extreme exposure situations, modern concrete can satisfy any exact standards. A variety of performance criteria must be met by contemporary concrete. Because of this, concrete must have characteristics like a high degree of fluidity, the ability to self-compress, a high level of strength, a high level of durability, a better capacity for function, and a long service life. To meet these objectives, self-compacting concrete (SCC) was developed. Self-compacting concrete may be forced into every nook and cranny of the formwork with the aid of its own weight and without the need of vibrating compaction. Thanks to its great flow capacity, coarse aggregate is not segregated.
Keywords: Self-compacting concrete; additives; Nanoparticles; Nano-silica; physical properties; mechanical properties.

INTRODUCTION

These days, concrete building performance estimates are in great demand. Thus, high fluidity, self-compactness, strength, durability, higher service life, and longer service life should all be features of concrete. To meet these needs, self-compacting concrete (SCC) was developed in Japan in the 1980s [1]. Self-compacting concrete is a mix that compacts at each corner of the formwork on its own, without the help of compaction. Despite having a large flow capacity, the coarse material is not separated. SCC eliminates the need for internal or external vibration for concrete compression while maintaining the technical properties of the concrete. Concrete used to merely include cement, gravel, water, and composites, but today's concrete is a designed substance with a variety of additional components. Today concrete can meet any specific requirements in a variety of exposure conditions [3]. EFNARC has published explanations and guidelines for self-compacting concrete (EFNARC 2002) [4]. Self-compacting concrete can be defined as the concrete that flows through the interior of the formwork, passing through the reinforcement, filling in a natural manner, consolidating in the action of its own weight. Filling efficiency, passing efficiency and consistency are considered to be the main features of the latest SCC. To make durable concrete structures, adequate compression is required by skilled workers. However, the gradual decline in the number of skilled workers in the Japanese construction industry led to a similar decline in the quality of construction work. One solution to achieving durable concrete is the employment of self-compacting concrete [5].

Self-compacting concrete as the name implies must be able to compact on its own without any additional vibrations or compression. Self-compacting concrete must

REVIEW OF LITERATURE

This chapter takes a chronological look at the research that has been done in the field of self-compacting concrete. The current research's objectives are determined based on the literature review.

Hajime Okamura in his paper entitled *"Self Compacting High-Performance Concrete"* has talked about self-compacting concrete as a mix that can be compacted into every corner of a formwork by its own weight alone, without the use of vibrating compaction. The coarse aggregate is not separated, despite its excellent flow ability.

To see how successfully self-compacting concrete flows around barriers, a model formwork was employed. The right-hand tower is filled with concrete, which flows through the barriers and rises in the left-hand tower. The barriers were selected to represent the limited zones of a real structure. The self-compacting concrete on the left can virtually reach the same height as the self-compacting concrete on the right. It is realized that the development of self compacting concrete would be necessary to guarantee durable concrete structures in the future. The coarse aggregate's relative placement changes when concrete flows between reinforcing bars. In addition to compressive stress, relative displacement creates shear stress in the paste between the coarse aggregates. The amount of shear force needed for relative displacement is mostly determined by the water cement ratio. Increased water cement ratio improves cement paste flow ability while lowering viscosity. As a result, super plasticizer is required. Fine aggregate content is limited to 40% of mortar volume and coarse aggregate content is limited to 50% of solid volume. The U type test is the best way to determine self compact ability [2].

Kamal H. Khayat in his paper entitled "*Workability, Testing and Performance of Self-Consolidating Concrete"* has looked at the advantages of employing self-consolidating concrete to make casting densely reinforced sections easier and increase productivity and working conditions on the job. To ensure self-consolidation, a condition for workability Also presented are the principles involved in proportioning such extremely flow able concrete. The deformability, filling capacity, and stability of self-consolidating concrete are all evaluated using field testing.

The performance of concrete mixes proportioned according to two major methodologies is evaluated in order to ensure high deformability, minimal risk of obstruction during flow, and proper stability. Concrete with a moderate water-to-cementations material ratio (w/cm) of 0.41 and a viscosity-enhancing admixture to promote stability, as well as mixes without viscosity-enhancing admixtures but with lower w/cm of 0.35 to 0.38 to minimize free water contents and give stability. Mixtures with moderate and high ternary cementations concentration were tested. Each concrete's performance was compared to that of a flow able concrete with a slump of 250 mm.

The conclusions drawn from the study are:

An SCC with a slump flow of 650 mm and 300 to 330 kg/m3 of 20-mm maximum size aggregate, 555 kg/m3 of cementations materials, and 0.60 to 0.66 sand/paste volumes may be better for casting highly congested structural sections than a mix with 375 to 400 kg/m3 of coarse aggregate, 425 kg/m3 of cementations materials, and 0.70 to 0.85 sand/paste volumes. To lower the cement amount, heat of hydration, and shrinkage in self-compacting concrete, binary or ternary binders containing high volumes of pozzolanic or non pozzolanic fillers, such as limestone powder, can be employed.

Lowering the w/cm to maintain enough cohesive friction between the mortar and coarse aggregate and ensure uniform flow of SCC in restricted portions is one way to improve viscosity. Another way is to incorporate a low to moderate dosage of a VEA without lowering the w/cm. This can enable the reduction of coarse aggregate volume and reduce the risk of blockage, which is especially useful in the mixtures containing moderate content of cementations materials and fine fillers **[25]**.

Kwan, A.K.H.in his paper entitled **"***Use of Condensed Silica Fume for Making High Strength ,Self Compacting Concrete"* The goal of this project was to develop high-strength, self-consolidating concrete. By lowering the water/binder ratio and increasing the super plasticizer dosage, high strength and workability concrete can be obtained.

However, these methods alone cannot generate a high-performance concrete with both high strength and high workability because lowering the water/binder ratio reduces workability, and there is a limit to how much workability can be increased by adding super plasticizer. Concrete strength must be enhanced without increasing the water/binder ratio in order to achieve high strength, high workability concrete. This can be accomplished by incorporating silica fume.

A design chart for the mix proportioning of high strength, high workability concrete is created based on the testing data .This chart is applicable to concrete mixes made of the materials used in this study. Similar charts for concrete mixes can be made for other materials by using the same methodology. This study also helps to explain qualitatively the role of CSF super plasticizer concrete**[26]**.

Subramanian,S. and Chattopadhyay, Din their paper entitled *"Experiments for Mix Proportioning of Self-Compacting Concrete"* I've looked into several areas of SCC. They discussed the process of developing SCC mix proportions as well as the strategy for selecting the right mixture of viscosity modifying agent, super plasticizer, and ultra-fine particles. The following findings have been reached:

Trial proportions by Okamura and Ozawa appear to be suitable for rounded gravel aggregate. When using crushed angular aggregate, the proportions are to be adjusted, incorporating more fines.

A viscosity modifying agent (VMA) is required for sensitivity to changes in mixture proportions. Welan gum, out of four VMAs tested, was shown to perform better due to its rheological qualities.

After evaluating the bleeding tendency, setting time, and compatibility with the super plasticizer employed, the ideal dosage of Welan gum should be determined.

Taking micro silica at the right dose will help you cut down on the amount of Welan gum you take. This may shorten the time it takes for the final setting and boost the compressive strength. The suitability of the self-compacting concrete mixture percentage was tested in a difficult mould and in a field trial. The findings are promising [11].

OBJECTIVES OF THE WORK

In the last decade, concrete technology has advanced dramatically. In the field of material science, new technology is rapidly developing. In the last two or three decades, a great deal of research has been done around the world to improve the performance of concrete in terms of strength and durability. We can now prepare any sort of concrete to fit the conditions on the job site. Concrete is now a designed material with numerous constituents, rather than a material made up of cement, sand, aggregates, and admixtures. All proper concrete processes must be followed in order to obtain good concrete. Proportioning, mixing, placing, compacting, and curing must all be done with extreme caution. Negligence in any one operation may damage the concrete severely. Consolidation, often known as compaction, is one of the most significant concrete activities. It is believed that 5% of the entrapped air can reduce the compressive strength of concrete by anywhere from 25% to 30%. As a result, consolidation or compaction is crucial in the creation of high-quality concrete. However, achieving 100% compaction on a budget is quite challenging. Thus, concrete technologists aspired to create a concrete that does not require compaction and fills every hollow due to its flow characteristics. When Ok amara invented self-compacting concrete in Japan in 1988, concrete technologists' dreams came true. Ozawa and Melawi of Japan contributed to the research on self-compacting concrete.

t. In concrete, many properties influence the strength parameters, among that most important parameter is proper compaction. Complete compaction is not possible using conventional concrete with hand compaction or machine vibration in structural element like long column and beam column joints. In these cases, self-compacting concrete (SCC) plays a vital role. It gives full compaction without any external effort. This type of concrete compacts by its own weight, another important advantage with SCC is the absence of segregation. Hence SCC usage has increased enormously in the last few decades. Having lot of merits SCC also has few demerits. One important demerit is that, to prepare SCC lot of cement content is needed compare to conventional concrete; this may increase the CO2 emission also it leads to higher heat of hydration this may cause shrinkage cracks if adequate curing is not provided. This study is an attempt to review the influence of different types of mineral admixtures and chemical admixtures used in self compacting concrete along with a brief knowledge about the change in mechanical behavior with respect to the influence of these admixtures.

Self-compacting concrete (SCC) can be placed and compacted due to its self-weight with little or no vibration effort & at the same time cohesive enough which can be handled without segregation or bleeding of fresh concrete. SCC contain super plasticizer, high content of fines viscosity modifying additive, While the use of super plasticizer gives fluidity, the finer content provides stability to the mix resulting in resistance against bleeding and segregation of the mix. Use of silica & fly ash in SCC reduces the dosage of super plasticizer needed to obtain similar slump flow compared to concrete mixes made with only Portland cement. It is found that SCC may result in up to 40% faster construction & gives good workability than using normal concrete with ordinary Portland cement, elastic modulus & shrinkage of SCC will remain as same as of the corresponding properties of normal concrete while the compressive, splitting, and flexural strength of self-compacting concrete shows that the water cured specimens for 28 days will give the highest results of concrete with respect to engineering properties than the specimens cured in air by about 10% to 11%respectively. When concrete flows between reinforcement, the relative location of coarse aggregate will be changed & results in relative displacement which develops shear & compressive stress in the concrete mix. For concrete to flow through such obstacles smoothly, shear stress should be small enough to allow the relative displacement of the aggregate which can be done by moderate increase in viscosity of the paste is necessary. The shear force required for relative displacement largely depends on the water-to-cementitious materials ratio (W/C) of the paste while increase of the water-to-cementitious materials ratio will increase the flowability of the mix.
Self-Compacting Concrete is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. One of the disadvantages of self-compacting concrete is its cost, associated with the use of high volumes of Portland cement and use of chemical admixtures. One alternative to reduce the cost of self-compacting concrete is the use ofmineral admixtures such as silica fume, ground granulated blast furnace slag and fly ash, which is finely, divided materials added to concrete during mixture procedure. When these mineral admixtures replace a part of the Portland cement, the cost of self-compacting concrete will be reduced especially if the mineral admixtures are waste or industrial by-product. Moreover, the use of mineral admixtures in the production of self-compacting concrete not only provides economical benefits but also reduces heat of hydration. The incorporation of mineral admixtures also eliminates the need for viscosity-enhancing chemical admixtures. The lower water content of the concrete leads to higher durability, in addition to better mechanical integrity of the structure

4 .MATERIALS AND METHODOLOGY

This chapter deals with the description of different materials used in the experimentation. Also, a brief explanation is given about the procedure of experimentations as per IS codes .Mix design details are also discussed. The cement used in the experiment is 43 grade ordinary Portland cement (OPC), which meets the requirements of the IS: 8112-1989 specifications [66]. The physical properties of the tested cement are given in Table

4.1**Table4.1Physicalproperties of Ordinary Portland Cement(IS:8112-1989)**

Oxides	**Percentages**
SiO_2	50
Al_2O_3	28
FeO_3	09
CaO	03
MgO	01
SO_3	01
Others	08

Properties	**Results**	**Permissiblelimitasper IS:8112-1989**
Fineness	286 m^2/kg	Should not beless than 225 m^2/kg
Normalconsistency	31%	-
Specific gravity	3.15	-
SettingTime a. Initial b. Final	 175 min 286 min	 Should not be less than 30 minutesShouldnotbemorethan600mi nutes
Soundnesstest a. Le-chatelierexpansion b. Autoclave%	 1.00 mm0. 09	 10mm maximum0.8% maximum
Compressivestrengthof mortarcubesfor a.3days b.7days c.28days	 26.20MPa 37.80MPa 48.20MPa	 Should not be less than 23 MPaShouldnotbelessthan33MP a Shouldnot beless than 43 MPa

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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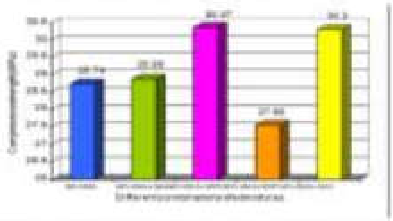

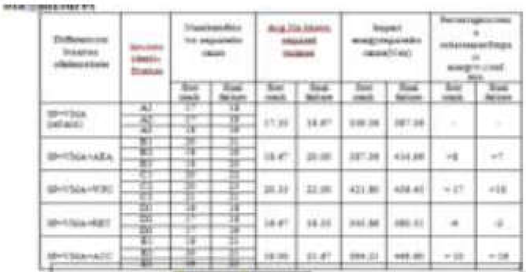

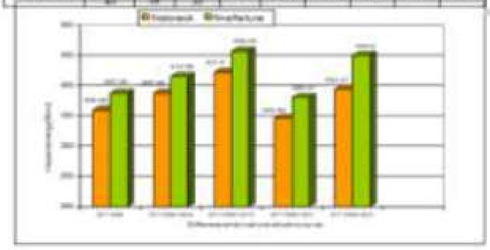

5. RESULTS

The percentage decrease of compressive strength w.r.t. reference mix is found to be22%,22%,22%and21%respectively.Thus, on an average percentage decrease of compressive strength is 22%. Similar observation serenade w.r.t. tensile strength, flexural strength and impact strength. The percentage decrease of flexural strength is found to be less as compared to compressive strength,, tensile strength and impact strength. (SP+VMA+AEA+ACC), (SP+VMA+AEA+RET), (SP+VMA+AEA+WPC) and (SP+VMA+AEA+ SRA) when subjected to acidic attack is more as compared to Coproduced with the combination of admixtures (SP+VMA).This may be due to the fact that the addition of accelerator or retarder or water proofing compound or shrinkage reducing agent in above combination of admixtures have made the concrete denser leaving less chance for the acid to penetrate inside.

Among all the combination of admixtures tried, it is found that the performance of SCC containing the combination of admixtures (SP+VMA+AEA+WPA) is more satisfactory w.r.t. acidic attack. The residual strengths of SCC produced with the combination of admixture (SP+VMA+AEA+WPA) is more promising in acidic media as compared toothier combination of admixtures. This may be due to the fact that the WPC added may form a layer which can resist the entry of acidic media into the concrete mass thus limiting the damage.

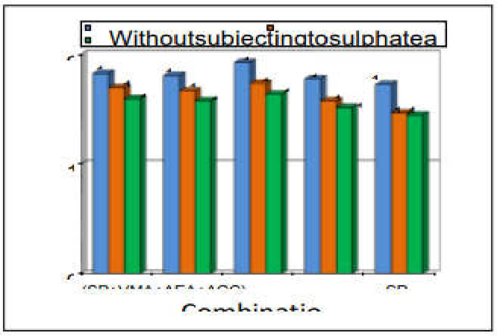

Table6.30 Impact strength test results of SCC with different combinations of admixtures when subjected to sulphate attack of 5% concentration

Description of SCC	Specimen identification	Weight of specimen before immersion (gms)	Weight of specimen after immersion (gms)	Weight loss (%)	Percentage weight loss	Avg percentage weight loss	Number of blows to cause first crack	Number of blows to cause final failure	Impact energy to cause (N-m) first crack	Impact energy to cause (N-m) final failure	Avg impact energy to cause (N-m) first crack	Avg impact energy to cause (N-m) final failure
SCC with(SP+VMA+AEA+ACC)	A1	25.90	24.10	1.80	6.95	6.92	12	14	248.97	298.47	248.97	298.47
	A2	26.10	24.20	1.90	7.28		13	17	269.72	352.71		
	A3	26.00	24.30	1.70	6.54		11	11	228.23	228.23		
SCC with(SP+VMA+AEA+RET)	B1	25.20	23.80	1.44	5.55	6.13	11	16	228.23	331.96	228.23	298.47
	B2	24.80	23.60	1.20	4.84		12	12	248.97	248.97		
	B3	24.40	22.40	2.00	8.19		10	14	207.48	298.47		
SCCwith (SP+VMA+AEA+WPC)	C1	27.30	25.30	2.00	7.32	8.25	13	16	269.72	331.96	269.72	331.96
	C2	27.10	24.80	2.30	8.49		11	15	228.23	311.22		
	C3	26.80	24.40	2.40	8.95		15	17	311.21	352.71		
SCC with(SP+VMA+AEA+SRA)	D1	25.20	23.50	1.70	6.73	7.78	11	12	228.23	248.97	228.23	248.97
	D2	25.80	24.00	1.80	6.97		11	13	228.23	269.72		
	D3	25.60	23.20	2.40	9.37		11	11	228.23	228.23		
SCC with(SP+VMA)	S1	24.40	22.00	2.40	9.84	11.38	10	11	207.48	228.23	207.48	228.23
	S2	25.20	22.20	3.00	11.90		11	11	228.23	228.23		
	S3	25.80	22.60	3.20	12.40		09	11	186.73	228.23		

CONCLUSION

Both the precast and concrete industries have been greatly influenced by the advent of SCC. Using SCC during construction might accelerate it by up to 25%. Due to its superior finishing quality, rapid building process, and energy efficiency, SCC is a well-liked material. Nearly 1900 specimens were cast and evaluated during this inquiry. The most recent research has demonstrated that admixtures may be employed to improve the flow and strength properties of SCC during production. Furthermore, it has been discovered that admixtures can improve SCC's durability while creating SCC. When early strength and early setting are required, or when delayed setting is preferable, the construction sector can profit from the use of a combination of admixtures in the production of SCC, where delayed setting is required, where water proofing is a must, or where shrinkage must be managed due to durability issues. In any of the aforementioned conditions, the combination of admixtures will aid the construction sector .Based on the research work conducted the following broad conclusions are drawn Admixtures such as (SP + VMA + AEA), (SP+VMA+WPC), (SP+VMA+RET), and (SP+VMA + ACC) can be utilized to make SCC without causing any compatibility issues. When a combination of admixture (SP + VMA + ACC) is applied, however, the flow properties of SCC are slightly changed. When the combination of admixture (SP + VMA + RET) is utilized, the strength properties of SCC are slightly reduced.

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