

Effect of Polypropylene Fiber on compressive Strength of Self Compacting Concrete

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Abstract:

Self-compacting concrete has improved quality and improved performance and performance due to its high capacity and elimination of collisions. Self-compacting concrete is designed for structures with complex reinforcement and without vibration. Does a good job of covering the ground. Fiber contribution in self-compacting concrete is 1.2%, 1.8% and 2.2%. In cases where fly ash remained unchanged, comparative studies were conducted on the compressive strength of self-compacting concrete with different polypropylene fiber contents. 25% fly ash is also used instead of cement. Extensive benefits of self-compacting concrete (SCC) in full fill the mold and achieving full compaction without vibration, with good behavior after concrete cracking, raise the idea of self-compacting concrete production. The fundamental challenge in this area is the unsatisfactory performance of concrete with fibers; In other words, using fibers in concrete will reduce concrete fluidity. In this research paper polypropelenfiber is used to improve the compressive strength of self compacting concrete.

Keywords: Self Compacting Concrete, Polypropylene, Compressive Strength, Fly Ash, Fiber, Performance.

1. Introduction

Self-compacting concrete (SCC) is a specialized form of concrete that is highly flowable and can spread and compact under its own weight without the need for mechanical vibration. It is designed to flow easily into tight and congested reinforcement areas, ensuring complete filling of formwork and achieving a high-quality surface finish without the need for manual compaction. SCC is commonly used in applications where conventional concrete placement methods are impractical or difficult, such as in heavily reinforced structures, complex formwork configurations, or architectural elements requiring a high-quality surface finish. It offers benefits such as improved construction efficiency, enhanced durability, and reduced labour costs. However, proper mix design, testing, and quality control are essential to ensure the desired performance of SCC in specific applications (Wang S. et. al 2017). After pouring, it does not need vibration or stirring. Therefore, casting SCC requires less energy as compared to normal concrete. Once poured, SCC is generally similar to conventional concrete in terms of setting and curing time than traditional concrete. SCC fluid consists of different

fine aggregates such as sand (usually 50%) combined with superplasticizers (additives that enable the material flow easily) and admixtures.

In normal concrete, it is difficult to judge the extent of vibration to be provided, if it exceeds, it will lead to separation of aggregate and if it is less then it will leave voids and decrease the strength of the concrete. In an SCC, vibrations are not required, therefore this save the resources like labour, time and quality and cost of the concrete. Due to more powder contents in the SCC, it becomes more brittle than normal conventional concrete. This particular drawback of SCC could be overcome by the use of fibres in it. During the last decades, various types of fibres have been investigated in concrete to solve this problem (Das et al., Citation2020; Ahmadi et al., Citation2021; Monazami, Gupta, Citation2021; Blazy and Blazy, Citation2021; W. Wang et al., Citation2022).

SCC is a concept introduced by Professor Okamura from Kochi University in Japan in 1986. At that time, the supply of skilled workers was limited, making it difficult to apply in the related industries. The first generation of SCC used in North America is characterized by the use of high levels of binders and chemical additives, primarily super plasticizers, to improve flow and stability. SCC is often used in repair applications and construction in limited areas. Therefore, first-generation SCCs have been characterized for specific applications.

SCC can be used to cast very strong materials where compaction with vibrators is not possible. By using a SCC we can provide the best location for coarse aggregates in static structures that will not be easy to cast in the normal concrete. In the early days significant cost of the super plasticizer and adhesives used in this type of construction, prevents it from being widely used in many areas. Due to the advancement in production technology and requirement in bulk, cost of production of these the super plasticizer and adhesives has become economical, accordingly it now widely used in the precast concrete. (Raghatate Atul M. Citation 2016) The combination of powder with cementitious materials and fillers can increase the volume of the slurry, thereby increasing the flow capacity. By reducing the water content and by increasing thickness of thinner material to more than 80µm, we can reduce the super plasticizer. This reduction in free water reduces the concentration of admixture. It required to ensure stability during the casting process and until hardening begins. A fine aggregate content of approximately 50% of the total aggregate in SCC mixtures has proven to be suitable

The polypropylene fibres (PPF) addition comparatively reduces the expansion in volume of the concrete. The concrete deterioration also increases due to the presence of fiber. (Behfarnia et al. Citation2013; Lakshmi et al., Citation2022; Prakash et al., Citation2020). Addition of PPF enhances many properties of SCC however it impacts some of the good properties as workability properties such as filling, passing and flowing ability of SCC (Y. Liu et al., Citation2021; Mastali & Dalvand, Citation2017). Use of optimum fibre content in SCC reduces the cracks in the plain concrete with good workability. There are many studies on different types of SCC, including new strength, durability and microstructural properties. These include liquid flow SCC (LF-SCC) and semi-flow SCC (SF-SCC) etc. is available. SCC is generally used in road construction.

2. Experimental Work

2.1 Procedure for making of Self Compacting Concrete

In this particular procedure, the content of course aggregate was kept to 37% of volume of concrete and fine aggregate to 47.5 % of volume of mortar. Starting from trial mix TR1 to TR3, Japanese design mix was adopted by keeping all ingredients constant in the mix, except super plasticizer. Three trial mixes were experimented, using three different percentages of super plasticizer in the dosage of 1.2%, 1.3% and 1.8% of the binding material. Design mix were carried out after carrying design mix test like slump flow and L-box were also carried out so the properties of SSC could be determined and selection of mix could be possible. Also in the other mix design 75 to 88% cement and 12 to 25% fly ash was used. Water and powder ratio varied from 0.29 to 0.40 and super plasticizer dosage from 1 to 1.3%. Content of fine and course aggregate was kept constant to 750 kg/m³ and 790 kg/m³. These test were carried out from trial mixes TR4 and TR8. After selection of SSC the following mixes were prepared with the addition of polypropylene fiber in the different quantity like 1.2%, 1.8% and 2.2%. The cubes of size 150mm*150mm*150mm were casted. After curing for 7 days, 14 days and 21 days, these cubes were tested and compressive strength of concrete was determined.

Table.1- design mix

Sr. No.	Mix	Cement (kg/m ³)	Fly Ash (kg/m ³)	Course aggregates (kg/m ³)	Sand (kg/m ³)	Water (kg/m ³)	SP (kg/m ³)	Fiber %
1	SSC-F1	450	150	750	790	216	7.2	1.2
2	SSC-F2	450	150	750	790	216	7.2	1.8
3	SSC-F3	450	150	750	790	216	7.2	2.2
4	SSC-F4	450	150	750	790	216	7.2	2.2

2.1.1 Different tests taken for making of Self Compacting Concrete.

1. Slump flow test
2. V- Funnel test
3. L- box test
1. Slump Flow Test



Fig.1- Slump Flow Test

Slump flow testing is used to measure the workability and flow of self-compacting concrete (SCC). It provides valuable information about the ability of SCC to flow and collect complex samples without obstruction or clogging. This testing helps ensure that SCC meets new concrete product requirements for successful placement and bonding. The slump flow test provides valuable information about the workability and flowability of self-compacting concrete. The measured slump flow value helps evaluate the ability of SCC to flow and fill complex formwork without blocking. Optimization of the workability and fluidity of self-compacting concrete can be made based on the effects of slumping, along with adjustments to mix distribution, along with water-containing material or admixture dosage. Maximum Slump Flow for SCC shall be as follows ;

- a) ASTM C1611 is a standardized test method that specifies methods for measuring the slow flow rate of self-cured concrete. Maximum flow reduction is 750 mm (30 inches)
- b) EN 12350-8 pertains to the testing of fresh concrete and specifically focuses on Self-Compacting Concrete through the Slump-flow Test: Maximum Slump Flow: 800 mm
- c) ACI 237R-07 (Self compacting Concrete): Maximum slump flow is 650 mm.
- d) CSA A23.1/A23.2 specifies standards for concrete materials, concrete production methods, and methods and standard practices for concrete testing: Maximum slow flow: 800 mm .

2. V- Funnel Test

This test measures the ease of creep of concrete, a shorter creep time indicates greater creep ability. A flow time of 10 seconds is considered suitable for SCC. The inverted cone shape restricts flow, and extended flow times may indicate a compound's susceptibility to clogging. After 5 minutes of settling, the concrete segregation will show a less continuous flow with increasing flow time. The funnel is filled with about 12 liters of concrete and the time it takes for it to flow through the device is measured. The funnel can then be refilled with concrete and allowed to settle for 5 minutes. If the concrete exhibits segregation, then the flow time will be significantly increased.



Fig.2- V-Funnel test

3. L- Box Test

The L-Box test, which evaluates the permeability and flow characteristics of self-compacting concrete (SCC), uses a standardized method. It provides valuable information on the ability of SCC to flow through confined spaces and fill complex formwork without the need for external consolidation. Time measurement is part of the test. taken for concrete creep and concrete spreading

in the horizontal part of the L-Box device. The use of the L-Box test ensures the suitability of concrete for specific applications, guides the optimization of mix design and broadly evaluates the workability and performance of SCC in construction projects. Widely recognized and standardized, the L-Box test evaluates the fluidity and permeability of self-consolidating concrete (SCC).

SCC is a highly fluid and workable concrete mix that can flow and fill complex forms without the need for mechanical reinforcement. The L-Box test helps assess the robustness and filling capacity of SCC and ensures its suitability for various construction applications. The formula for calculating the passing ability index is as follows:

$$PAI = (H2 / H1) \times 100 \dots \dots \dots (1)$$

Where,

H1 is the height of the vertical section of the L-Box apparatus (measured in centimeters).

H2 is the height of the concrete filling the horizontal section of the L-Box apparatus (measured in centimeters).

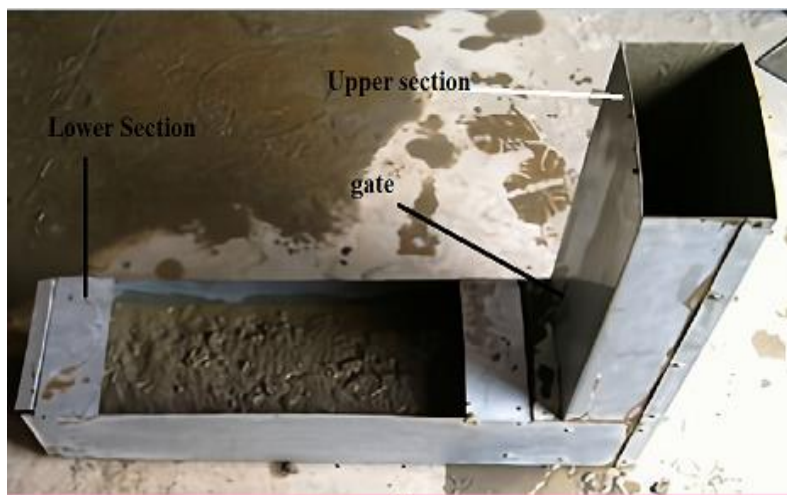


Fig.3 L- Box Test

By performing the above tests for self compacting concrete, following limits to be recommended for different properties of self compacting concrete

Table 2- Recommended limits for properties of SCC

Sr. No.	Method	Unit	Minimum typical range of values	Maximum typical range of values
1	Slump flow by Abrams cone	mm	650	800
2	T50 Slum Flow test	Sec.	2	5
3	V funnel test	Sec.	6	12
4	T5 minutes V funnel test	Sec.	0	3
5	L- box test	H ₂ /H ₁ (Ratio)	0.8	1

3 Result and Discussion

3.1 Test results for mix designs

Table 3- Test Results for mix Design

Sr. No.	Mix	Slump Flow (mm)	T50 (sec.)	V- funnel (sec.)	V- funnel T5 (Sec.)	L-Box(H ₂ /H ₁)	Compressive Strength(MPa)		
							7 Days	14 days	21 days
1	TR1	800	1	0	2	0.1	10.10	11.2	14
2	TR2	1000	1	0	3	0.1	15	17.21	19
3	TR3	950	1	0	2	0.1	13	14.23	16.23
4	TR4	500	6	1	4	0.1	16.11	18.34	20.21
5	TR5	600	4	0	4	0.2	18.34	20	20.98
6	TR6	610	2	6	5	0.2	20.12	20.90	21.23
7	TR7	601	3	7	5	0.3	21	21.67	21
8	TR8	620	2	6	6	0.3	21.23	22.11	22.78
9	SCC1	656	3	8	6	0.7	23.55	29.67	34.10
10	SCC2	690	6	10	7	0.9	29.50	37.64	43.3

1. The mix TR1,TR2 and TR3 could not satisfy the properties of self compacting concrete i.e. flow ability , passing ability
2. As the content of sand and water in the TR1,TR2 and TR3 was too large to get the results upto the mark as per standards.
3. So to obtain the proper result and to reduce bleeding , reduced the water content from 0.41 to 0.29, 0.34, 0.37 and super plasticizer reduce to 6 kg/m³
4. After doing the effective correction in the mix we got SCCF1 and SCCF2. Apart from the most corrected results received from SCCF2.
5. The Compressive strength of the mix SCCF2 was found in 7 days curing was 29.50 MPa, for 14 days curing was 37.64MPa and 21 days curing was 43.3 MPa.

3.2 Compressive Strength of Self Compacting Concrete with Polypropylene Fiber.

Table 4- Compressive strength of SCC

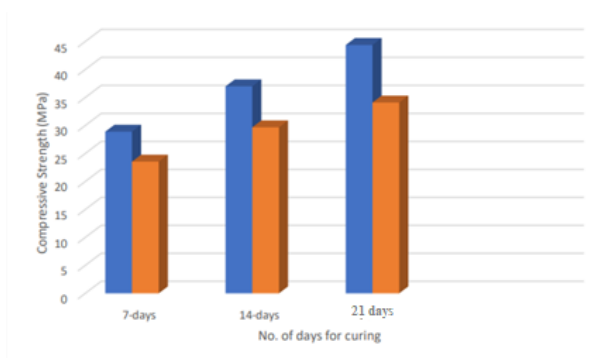
Sr. No.	Mix	Compressive Strength(MPa)		
		7 days	14 days	21 days
1	SCCF1	23.55	29.67	34.10
2	SCCF2	28.90	36.99	44.38
3	SCCF3	11.24	13.49	15.38
4	SCCF4	23.54	30.37	35.83

1. In the mix of SCCF1 contains 1.2% fiber and from the above table compressive strength of SCCF1 mix received as 23.55MPa for 7 days. Also SCCF1 received compressive strength as 29.67 MPa for 14 days and 34.10MPa for 21 days.

2. While the compressive strength of the SCC-F2 having 1.8% of the fibre content and the compressive strength of these mixes are found after 7 days to be 28.90MPa and after the curing of 14 days and 21 days are found to be 36.99MPa & 44.38 MPa respectively.
3. In the mix SCC-F3 contains 2.2% fibre with 0.36 W/P ratio, and the compressive strength obtained after 7 days of curing is 11.24MPa, while after 14 and 21 days are 13.49MPa & 15.38MPa respectively.
4. But in the SCC-F4 having the fibre 2.2% and W/P ratio as 0.42, the compressive strength after the 7 days, 14 days, and 21 days of curing is 23.54MPa, 30,37MPa, and 35.83MPa respectively.

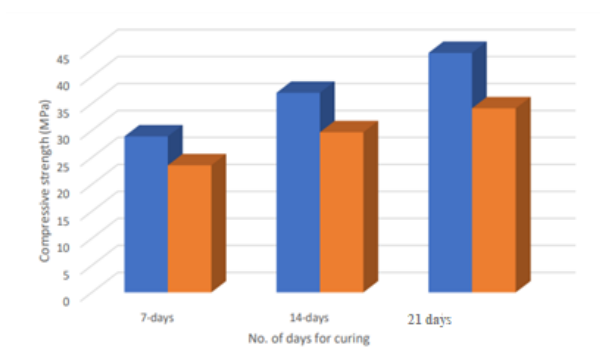
3.3 Graphical representation

Graphical Comparison of self compacting concrete and SCC-F1 ,SCC-F2, SCC-F3 and SCC-F4 shown in the below ,

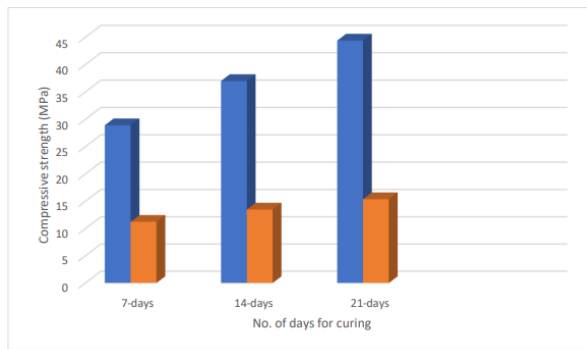


Graph 1- Comparison of compressive strength for 7- days, 14-days, and 21-days curing of SCC and SCC-F1.

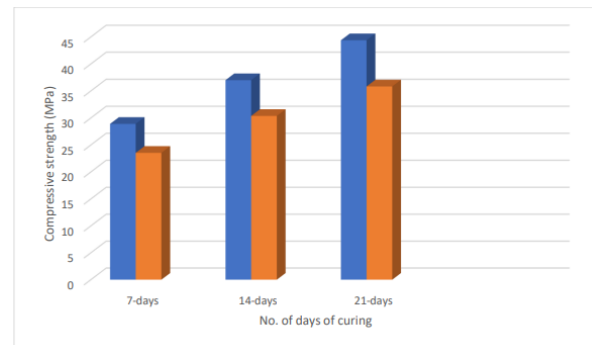
Blue bar in the graph represent the compressive strength of SCC-F1 and orange bar represent the compressive strength self compacting concrete. For 21 days of curing SCC F1 gives the maximum strength as compare to the normal SCC. Same like in the below graphs SCC-F2, SCC-F3 and SCC-F4 gives maximum compressive strength as compare to normal SCC.



Graph 2- Comparison of compressive strength for 7- days, 14-days, and 21-days curing of SCC and SCC-F2



Graph 3- Comparison of compressive strength for 7- days, 14-days, and 21-days curing of SCC and SCC-F3



Graph 4- Comparison of compressive strength for 7- days, 14-days, and 21-days curing of SCC and SCC-F4

Conclusion

Methodology develop in this work gives the effective contribution in comparative compressive strength of self compacting concrete and compressive strength of self compacting concrete with polypropylene fiber. Addition of Polypropylene fibers may slightly impact properties of SCC, they can enhance the durability and strength of self-compacting concrete. Polypropylene fibers had a better effect affected on SCC workability compared to carbon steel fibers. Present research show the addition of polypropylene fibers in concrete increased the compressive strength of concrete.

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