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An Experimental Study on Self Compacting Concrete

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***Abstract*: Concrete is the most widely used construction material because of its mould ability into any required structural form and shape due to its fluid behaviour at early ages. Thorough compaction, using vibration, is normally essential for achieving workability, the required strength and durability of concrete. Inadequate compaction of concrete results in large number of voids, affecting strength and long term durability of structures. Self- Compacting Concrete (SCC) provides a solution to these problems. As the name signifies, it is able to compact itself without any additional vibration. This study presents the performance of M40 grade SCC by using Ordinary Portland cement, fine aggregate, Coarse aggregate, mineral admixtures named Fly ash, and chemical admixture named Poly Carboxylate ether used as a super plasticiser. In order to prepare suitable mix proportion for M40 grade for fly ash based SCC, investigations were undertaken replacing cement with 0%, 10%, 20% and 30% of fly ash and with adjusted dosage of super plasticizer (Poly Carboxylate ether). As per IS 10262: 2019, various workability tests have been carried out on fresh properties of SCC. The Compressive strength, Split Tensile strength and Flexural strength of the specimens have been analysed for 7 days, 14 days and 28 days curing and 20 to 25 % replacement of fly ash can be regarded as a suitable replacement.**

***Keywords*: Self compacting concrete, Fly ash, Poly carboxylate ether, Fresh properties, Hardened properties**

1. Introduction

Self-compacting concrete (SCC) 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. The hardened concrete is dense, homogeneous and has the same engineering properties and durability as traditional vibrated concrete. SCC was conceptualized in 1986 by Prof. Okamura at Kochi University, Japan, at a time when skilled labour was in limited supply, causing difficulties in concrete-related industries. By the early 1990s Japan has developed and used SCC. As of the year 2000, SCC is used as prefabricated products (precast members) and ready mix concrete (cast- in-situ) in Japan, USA, and later on India etc. Present day SCC can be classified as an advanced construction material. Self-compacting concrete offers a rapid rate of concrete placement, with faster construction times and ease of flow around congested reinforcement. The fluidity and segregation resistance of SCC ensures a high level of homogeneity, minimal concrete voids and uniform concrete strength, providing the potential for a superior level of finish and durability to the structure. The elimination of vibrating equipment improves the environment on and near construction and precast sites where concrete is being placed, reducing the exposure of workers to noise and vibration. The improved construction practice and performance, combined with the health and safety benefits, make SCC a very attractive for civil engineering construction.

2. Materials of SCC

1) Cement

Ordinary Portland cement confirming to IS 12269-1987 was used throughout the project.

Table 1
Properties of Cement

S. No	Property	Value
1.	Specific gravity	3.12
2.	Normal consistency	33%
3.	Fineness of cement	6%
4.	Setting times (minutes) Initial Final	 50 240

2) Fine Aggregate

Locally available river sand confirming to Zone II as per IS 383-1987 was used as fine aggregate in this project.

Table 2
Properties of Fine Aggregate

S.No	Property	Value
1.	Specific Gravity	2.64
2.	Fineness modulus	2.78
3.	Water Absorption	0.82%

3) Coarse Aggregate

Aggregates of size 10mm to 12.5 mm are used for SCC throughout the project.

Table 3
Properties of Coarse Aggregate

S. No	Property	Value
1.	Specific Gravity	2.73
2.	Fineness modulus	6.2
3.	Water Absorption	0.4%

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4) Mineral Admixture

Mineral admixtures are used to improve specific concrete properties such as workability and strength. The mineral admixture used in this work was Fly ash.

Table 4
Chemical composition of Fly ash

S.No	Compound	Percentage
1.	Silica (SiO2)	59.00
2.	Alumina (Al2O3)	21.00
3.	Iron Oxide (Fe2O3)	3.70
4.	Lime (CaO)	6.90
5.	Magnesia (MgO)	1.40
6.	Sulphur Trioxide (SO3)	1.00
7.	Potassium Oxide (K2O)	0.90
8.	Loss on Ignition	4.62

5) Chemical Admixture

The use of chemical admixtures is necessary in order to improve the fundamental characteristics of fresh and hardened concrete. In the present work, a super plasticizer named Poly Carboxylate ether is used to increase the workability of concrete.

Table 5
Details of Super Plasticizer

S.No	Property	Result
1.	Colour	Light to Pale yellow
2.	Form	Liquid
3.	Odour	Odourless
4.	Solids	39-41%
5.	Specific Gravity	1.10 to 1.12 at 20^0C
6.	PH Value	5-7
7.	Chloride Content	Nil

6) Water

Potable water shall be used for the production of SCC. The content of water mixed in the SCC is proportionate to the total binders such as cement, fly ash etc.

3. Mix Design for SCC

The mix design for M40 grade SCC is derived as per IS 10262: 2019.

1) Mix proportions

Cement = 332 kg/m^3 Fly ash = 143 kg/m^3
Water (net mixing) = 190 kg/m3 Fine aggregate (SSD) = 937.5 kg/m3
Coarse aggregate (SSD) = 740 kg/m^3 Chemical admixture = 2.85 kg/m^3 Free water-cement ratio = 0.40 Powder content = 550 kg/m^3
Water powder ratio by volume = 0.95

4. Experimental Procedure

1) Tests on Fresh concrete

Table 6
Acceptance criteria for SCC

S.No	Method	Units	Range	
			Min	Max
1.	Slump flow test	mm	650	800
2.	T50 Slump flow	Sec	2	5
3.	L-Box test	h2/h1	0.8	1.0
4.	V-Funnel test	Sec	6	12
5.	V-Funnel at T5 minutes	Sec	6	15
6.	Sieve Segregation resistance	%	0	15

2) Tests on hardened concrete:

a) Compressive strength: In this investigation, the cube specimens of size 150 mm x 150 mm x 150 mm are tested in accordance with IS: 516 – 1969. A uniform rate of loading 140 kg/cm2/min was maintained.

b) *Split Tensile strength:* The test was carried

- *Slump flow test and T50 test*: This test is used to find out the filling ability of concrete. The higher the value of slump, the greater will be the ability to flow.
- L-Box test: This test is carried out to find the passing ability of concrete in its fresh state. Passing ability of concrete depends upon the passing ratio (h2/h1)
- *V-Funnel test:* This test is used to find the filling ability of concrete.
- *V-Funnel at T5 minutes:* This test is used to find the segregation resistance of fresh concrete.
- *Sieve segregation resistance*: This test is used to find the Segregation resistance. Out by placing a cylindrical specimen horizontally between the loading faces of a compression testing machine and the load was applied until failure of the cylinder, along the vertical diameter. A concrete cylinder of size 150mm diameter and 300mm height was subjected to the action of a compressive force along two opposite edges.
- *Flexural strength*: Standard beam test (Modulus of rupture) was carried out on the beams of size 100 mm x 100 mm x 500 mm as per IS: 516. The rate of loading is 1.8 kN/minute for 100 mm specimens.

5. Results and Discussion

1) Fresh properties of SCC

B. Slump flow test

Table 7
Slump flow value at different proportions of fly ash content

Mix number	Fly ash content (%)	Slump flow (mm)
1.	0	650
2.	10	664
3.	20	686
4.	30	716

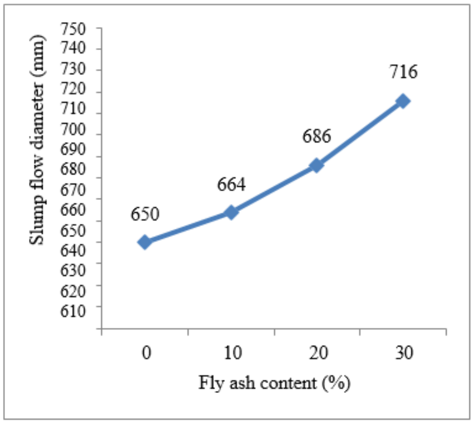

Fig. 1. Graph showing slump flow value at different proportions of fly ash

1) *T50 slump test*

Table 8

T50 slump value at different proportions of fly ash content

Mix number	Fly ash content (%)	T50 slump (sec)
1.	0	5
2.	10	4
3.	20	4
4.	30	3

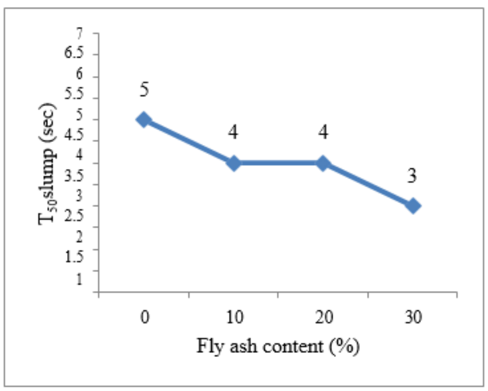

Fig. 2. Graph showing T50 slump value at different proportions of fly ash

2) *L-Box test*

Table 9

Passing ratio (h2/h1) at different proportions of fly ash content

Mix number	Fly ash content (%)	Passing ratio (h2/h1)
1.	0	1
2.	10	0.93
3.	20	0.95
4.	30	1

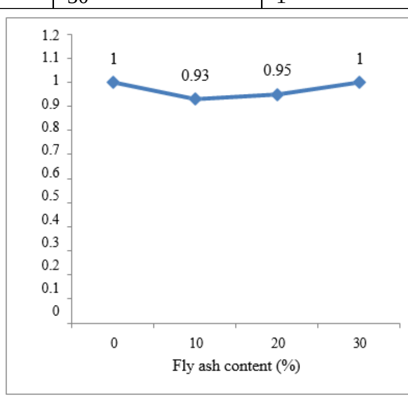

Fig. 3. Graph showing L-Box value at different proportions of fly ash

3) *Funnel test*

Table 10

Flow time of V-Funnel test at different proportions of fly ash content

Mix number	Fly ash content (%)	Flow time (sec)
1.	0	9
2.	10	8
3.	20	7
4.	30	6

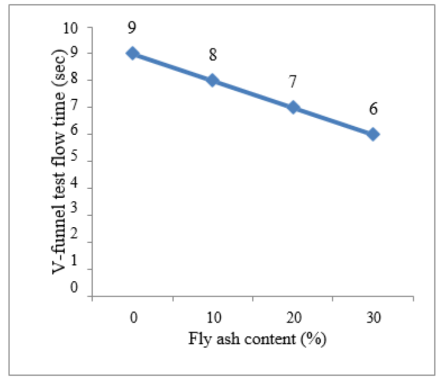

Fig. 4. Graph showing V-Funnel test value at different proportions of fly ash

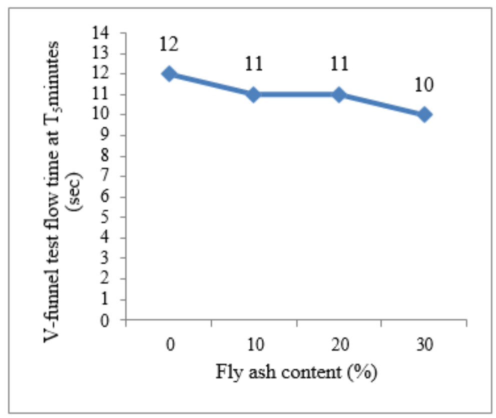

Fig. 5. Graph showing V-Funnel test value at T5 minutes at different proportions of fly ash

4) *V-Funnel at T5 minutes*

Table 11

Flow time of V-Funnel test at T5 minutes different proportions of fly ash

Mix number	Fly ash content (%)	Flow time (sec)
1.	0	12
2.	10	11
3.	20	11
4.	30	10

5) *Sieve segregation resistance*

Table 12

Segregation resistance at different proportions of fly ash content

Mix number	Fly ash content (%)	Segregation resistance (%)
1.	0	15.23
2.	10	15.06
3.	20	14.56
		14.11

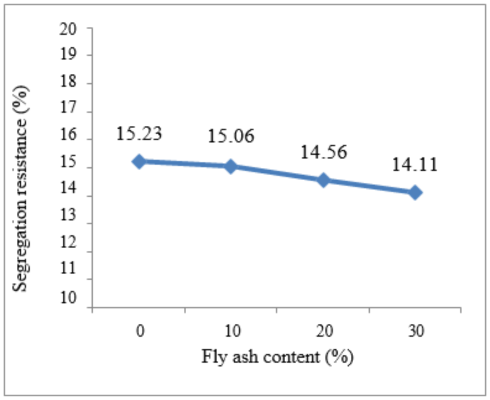

Fig. 6. Graph showing Segregation resistance at different proportions of fly ash

C. *Mechanical properties of SCC*

1) *Compressive strength*

Table 13
Compressive strength values of SCC

Mix number	Fly ash content (%)	Compressive strength (N/mm²)		
		7 days	14 days	28 days
1.	0	26.56	34.78	46.40
2.	10	27.99	35.32	46.65
3.	20	31.48	38.91	50.82
4.	30	24.82	33.06	44.73

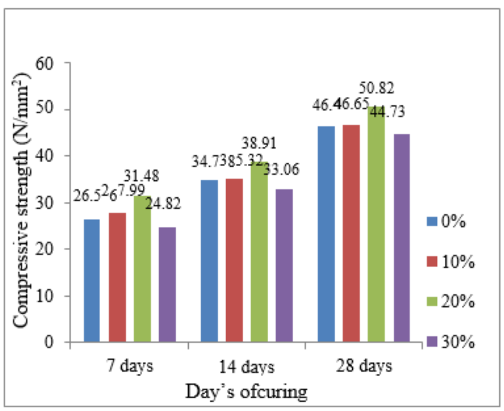

Fig. 7. Graph showing the compressive strength values at different proportions of fly ash

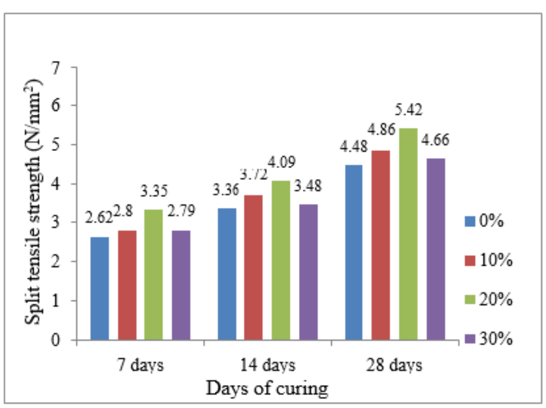

Fig. 8. Graph showing the Split tensile strength values at different proportions of fly ash

2) *Split Tensile strength*

Table 14
Split tensile strength values of SCC

Mix number	Fly ash content (%)	Split tensile strength (N/mm²)		
		7 days	14 days	28 days
1.	0	2.62	3.36	4.48
2.	10	2.80	3.72	4.86
3.	20	3.35	4.09	5.42
4.	30	2.79	3.48	4.66

3) *Flexural strength*

Table 15
Flexural strength values of SCC

Mix number	Fly ash content (%)	Flexural strength (N/mm²)		
		7 days	14 days	28 days
1.	0	4.02	5.25	6.89
2.	10	4.28	5.50	7.31
3.	20	4.76	5.90	7.87
4.	30	3.63	4.42	5.98

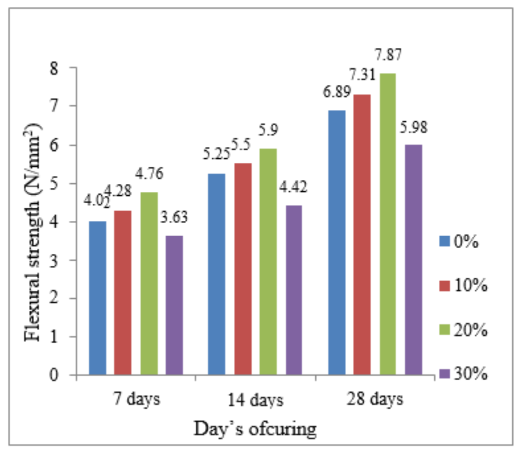

Fig. 9. Graph showing the Flexural strength values at different proportions of fly ash

6. Conclusion

This study was carried out to evaluate the fresh and hardened properties of M40 grade of Self Compacting Concrete (SCC). The following conclusions are drawn:

1. All the workability properties like slump flow, passing ratio, flow time and segregation resistance are between the range specified in IS 10262: 2019.
2. SCC containing fly ash can be produced with proper workability with the use of super plasticizer named Poly carboxylate ether.
3. Nearly 20- 25% of fly ash can be regarded as a suitable replacement and this has been recommended since it provides good workability and achieved desired strength grade.
4. Compressive strength of SCC increases up to the replacement of cement with 20% of fly ash. When the fly ash content is further increased to 30%, the

compressive strength decreases.

5. Splitting tensile strength and flexural strength followed the same pattern as compressive strength for different desired grades of SCC.
6. The powder content was chosen as indicated in guidelines of IS 10262: 2019 for producing different grades of SCC.
7. It is concluded that fly ash is the good replacement for M40 grade SCC up to a partial replacement of cement with 20- 25% of fly ash. Further increase in fly ash content is not recommended since it affects the mechanical properties of SCC.

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