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Experimental Investigation of Properties of Self-Compacting Concrete with Polypropylene Fibers and Metakaolin

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Abstract— *SCC is an innovative concrete that does not require any 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. SCC has favourable characteristics such as high fluidity, good segregation resistance and the distinctive self-compatibility without any need for vibration during the placing process and so noiseless construction. The control mix obtained by trial and error procedure. The mix is prepared replacing 15% to 30% of cement with Metakaolin and finding out the optimum percentage of Metakaolin. Polypropylene fibers of the range varying from 0.1 to 0.5% are added by keeping the optimum value of Metakaolin constant. The effects of Polypropylene fiber and Metakaolin inclusion on the fresh and hardened properties of self-compacting concrete are studied.*

Fresh properties of the SCC are tested comprising of slump flow, L-box height ratio and V-funnel flow time and hardened properties including compressive strength, flexural strength and splitting tensile strength are tested and compared with that of normal SCC. With the addition of Metakaolin and Polypropylene fiber the properties of SCC are enhanced.

Keywords— *Self compacting concrete, metakaolin, polypropylene fiber, fresh properties, hardened properties*.

I. INTRODUCTION

Construction of durable concrete structures requires skilled labour for placing and compacting concrete. The availability of skilled workers is decreasing all over the world. Therefore, there is a need to render the durability of the concrete structures to be independent of the quality of the construction worker. For the above, Self Compacting Concrete is an obvious answer. Making concrete structures without vibration have been done in the past. But the above concrete are generally of lower strength and difficult to obtain consistent quality. Modern application of self-compacting concrete is focused on high performance, better and more reliable and uniform quality. The utilization of self-compacting concrete started growing rapidly. European Federation of natural trade associations representing producers and applicators of specialist building products (EFNARC) has drawn up specification and guidelines for Self compacting concrete to provide a framework for design and use of high quality SCC.

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. SCC offers a very high level of homogeneity; minimize the concrete void spaces, provide uniform concrete strength and also provides the superior level of finishing and durability of structure. In recent years, the use of SCC has gained a wider acceptance.

II. MIX MATERIALS

The materials used in the project should confirm certain properties which are given below.

A. Cement

Cement is the well-known building material with adhesive and cohesive properties, which is capable of binding mineral fragment into compact mass. There are several types of cement. Ordinary Portland cement 53 Grade with physical and chemical properties as give in table has been used in this experimental study.

TABLE I. Properties of cement.

Physical Properties	Result
Specific gravity	3.15
Standard consistency	34
Initial Setting Time (min)	120

B. Fly Ash (FYA)

Fly ash, known also as pulverized- fuel ash, is a by-product obtained by electrostatic and mechanical means from flue gases of power station furnaces fired with pulverized coal. Fly ash can significantly improve the workability of concrete. Fly ash used for this study has a specific gravity of 2.1.

C. Fine Aggregates (FA)

Aggregates mainly passing through 4.75 mm IS sieve and and retained on 75 microns IS sieve is permitted for fine aggregates. Aggregates conforming to grading Zone II are used in this experimental work.

TABLE III. Properties of fine aggregate.

Properties	Result
Specific gravity	2.74
Water absorption %	1.2

D. Coarse Aggregates (CA)

Aggregate which passes through 75 mm IS sieve and retained on 4.75 mm IS sieve is used as coarse aggregate Coarse aggregates containing flat, elongated or flaky pieces should be rejected. Coarse aggregate used for the study of

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SCC is12.5mm granite broken stones. Aggregates conforming to grading Zone II are used in this experimental work.

TABLE III. Properties of coarse aggregate.

Properties	**Result**
Specific gravity	2.74
Water absorption %	1.2

E. Metakaolin (MK)

Metakaolin is refined kaolin clay that is fired under carefully controlled conditions to create an amorphous alumina silicate that is reactive in concrete. Metakaolin combines with the calcium hydroxide to produce additional cementitious compounds, the material responsible for holding concrete together. Metakaolin used in this work has a specific gravity of 2.6.

F. Polypropylene Fiber (PF)

Polypropylene (PP), also known as polypropene, is a thermoplastic polymer, when added prevents shrinkage cracks developed during curing making the structure inherently stronger. It improves the load-carrying capacity of structural member beyond cracking.

G. Super plasticizer (SP)

Master Glenium SKY 8233 was used as super plasticizer for the study. It is an admixture based on modified polycarboxylic ether. The product has been primarily developed for applications in high performance concrete where the highest durability and performance is required. It is free of chloride and low alkali. It is compatible with all types of cements.

H. Water

Water used for mixing and curing shall be clean and free from oils, acids, alkalis, salts etc. Water used for the study was free of acids, organic matter, suspended solids, alkalis and impurities when present may have adverse effect on the strength of concrete. Potable water with Ph value 7 conforming to IS: 456-2000 Is used for casting as well as curing.

III. MIX PROPORTION

There is no standard or all-encapsulating method for determining mixture proportions, currently exists for SCC. However, many academic institutions, ready-mixed, precast and contracting companies have developed their own mix proportioning methods. In this study, SCC control mix (M30) is prepared by trial and error procedure using EFNARC guidelines. Design mix is obtained by replacing cement with 15%, 20%, 25% and 30% of Metakaolin. Further design mixes are made by adding 0.1%, 0.3% and 0.5% of polypropylene fibers by maintaining the optimum value of Metakaolin constant.

Mix proportion of normal SCC is given below:

Cement = 360 kg/m^3
Flyash = 210 kg/m^3
Water = 230 kg/m^3
Fine aggregate = 758 kg/m^3
Coarse aggregate = 758 kg/m^3
Super plasticizers = 0.5%

TABLE IV. Mix Proportions (MK).

Materials	**Different Mix Proportions (Quantity per 1 m^3 of concrete)**				
	SCC	**SCC MK 15**	**SCC MK 20**	**SCC MK25**	**SCC MK 30**
Cement (kg)	360	306	288	270	252
FYA (kg)	210	210	210	210	210
MK (kg)	-	54	72	90	108
CA (kg)	758	756	755	754	753
FA (kg)	758	756	755	754	753
Water (kg)	230	230	230	230	230
SP (%)	0.5	0.3	0.3	0.25	0.2

TABLE V. Mix Proportions (PF).

Materials	**Different Mix Proportions (Quantity per 1 m^3 of concrete)**			
	SCC	**SCC MK 25 PF0.1**	**SCC MK25 PF0.3**	**SCC MK 25 PF0.5**
Cement (kg)	360	270	270	270
FYA (kg)	210	210	210	210
MK (kg)	-	90	90	90
CA (kg)	758	754	754	754
FA (kg)	758	754	754	754
Water (kg)	230	230	230	230
PF (kg)	-	1.71	2.85	0.6
SP (%)	0.5	0.25	0.25	0.25

IV. RESULTS AND DISCUSSIONS

The fresh and hardened properties of concrete were found out and studied for all the mixes.

A. Fresh Properties

In the fresh state; slump flow, T_{500}, V-funnel and L-box tests were conducted. The slump flow and T_{500} time is a test to assess the flow ability and the flow rate of self-compacting concrete in the absence of obstructions. The V-funnel test is used to assess the viscosity and filling ability of SCC. The L-box test is used to assess the passing ability

Fig. 1. Slump Flow.

of self-compacting concrete to flow through tight openings including spaces between reinforcing bars and other obstructions without segregation or blocking. The obtained value satisfies the EFNARC [1] guidelines and is tabulated below in Table VI.

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TABLE VI. Fresh properties.

Property / Mix	Slump Flow		V Funnel (8-12sec)	L Box (0.8-1.0)
	d_f (cm)	T_{500} (sec)	t_v (sec)	PA
SCC-MK0	59	3	10	0.94
SCC-MK15	64	3	9.5	0.95
SCC-MK20	67	2.5	9	0.95
SCC-MK25	70	2.5	8.7	0.96
SCC-MK30	74	2	8.1	0.98
SCC-MK25-PF0.1	70	2.5	8.9	0.94
SCC-MK25-PF0.3	69	3	9.3	0.92
SCC-MK25-PF0.5	67	3	9.8	0.91

B. *Compressive Strength*

The compressive strength is measured using cubes on compressive testing machine. The size of the cube used were 150mm × 150mm × 150mm. Nine concrete cubes were casted for each concrete mix proportions. The compressive strength of three cubes was measured and an average was taken after 3, 7 and 28 days of curing. The optimum percentage replacement of cement with Metakaolin is 25% to get highest compressive strength. Also, the addition of 0.3% polypropylene fibers with optimum percentage of Metakaolin yields the highest compressive strength.

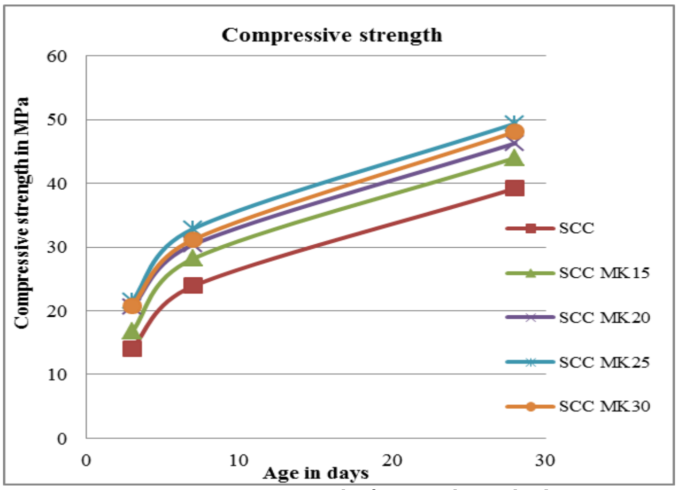

Fig. 2. Compressive strength of SCC with Metakaolin.

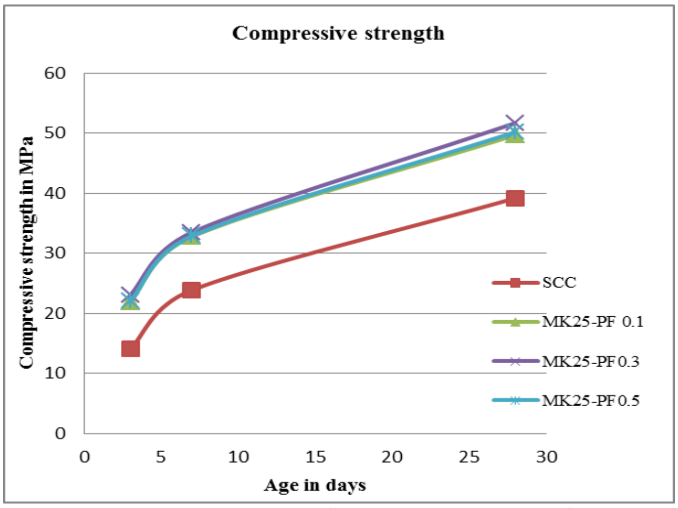

Fig.3. Compressive strength of SCC with Metakaolin and fiber.

C. *Flexural Strength*

The flexural strength of concrete is conducted on beam of size 100 mm × 100 mm × 500 mm. Six concrete beams were casted for each concrete mix proportions for 7and 28 days. The flexural strength of three beams each is measured after 7 and 28 days of curing. When 25% cement is replaced with Metakaolin, a significant rise in flexural strength to 8.52 MPa is witnessed, whereas a further increase or decrease in percentage leads to reduced flexural strength. Also, the maximum flexural strength is gained when the addition is of polypropylene fiber is 0.3%

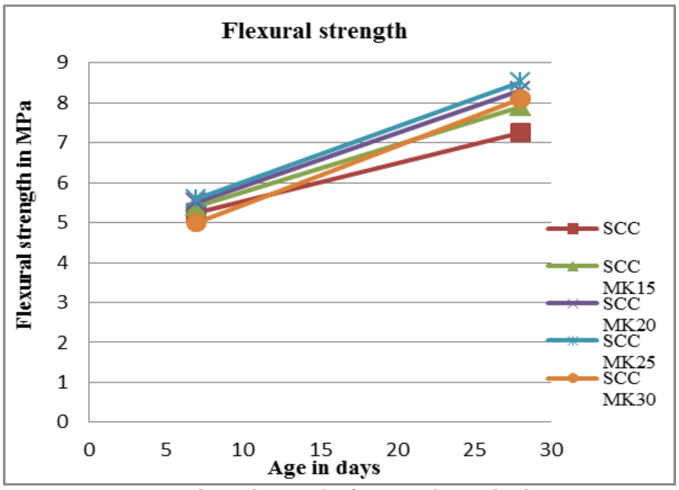

Fig. 4. Flexural strength of SCC with Metakaolin.

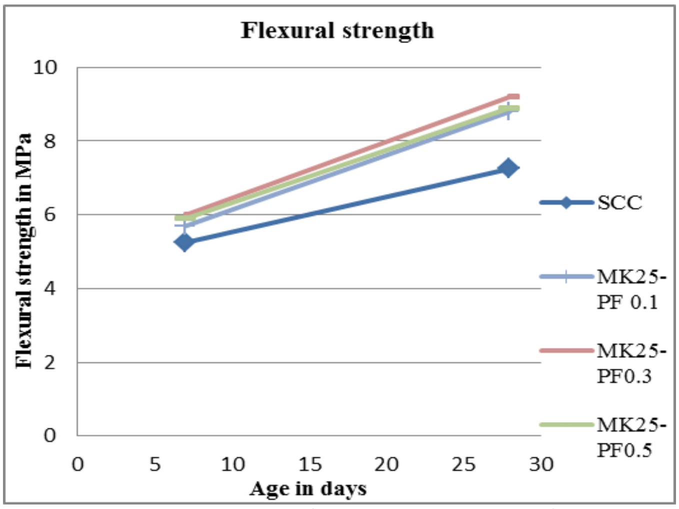

Fig. 5. Flexural strength of SCC with Metakaolin and fiber.

D. *Split Tensile Strength*

The Split tensile strength is conducted on cylinder of 300 mm × 150 mm size. Nine concrete cylinders were casted for each concrete mix proportions for 7 and 28 days. Splitting tensile strength can be calculated from the following equation using the maximum load applied on the compression testing machine. When 25% cement is replaced with Metakaolin, a significant rise in split tensile strength to 2.95MPa is witnessed, whereas a further increase or decrease in percentage lead to reduced split tensile strength. Also, the optimum of polypropylene fiber is 0.3% addition with 25% cement replaced with Metakaolin.

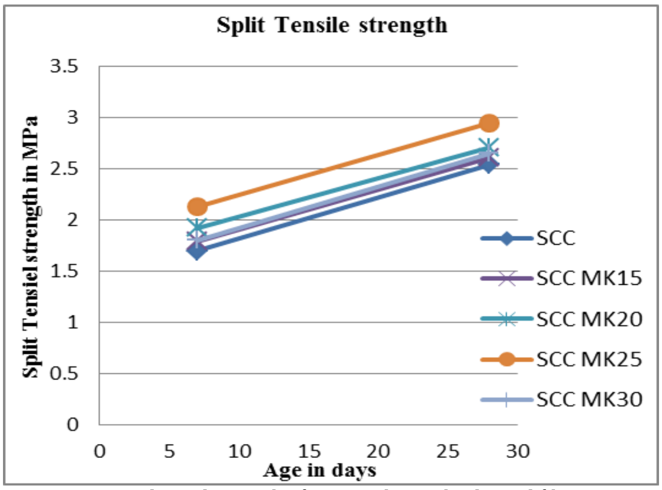

Fig. 6. Flexural strength of SCC with Metakaolin and fiber.

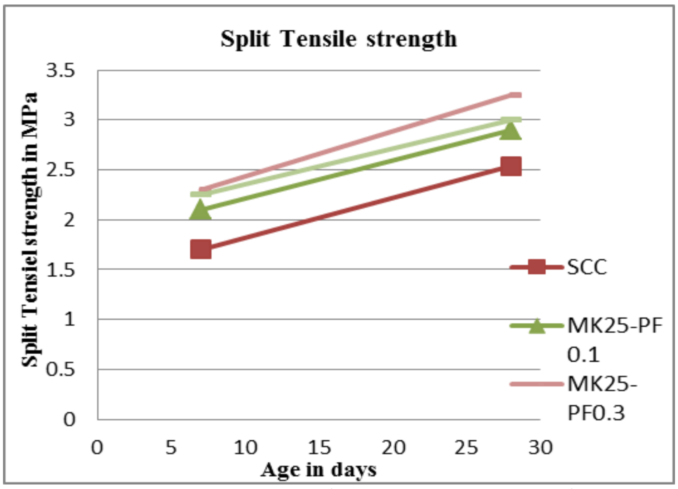

Fig. 7. Split Tensile strength of SCC with Metakaolin and fiber.

V. CONCLUSIONS

- The M30 mix of self-compacting concrete satisfying the required criteria is obtained by trial and error procedure.
- The fresh properties of self-compacting concrete prepared were satisfactory for all the mixes.
- Workability of SCC added with fibers was found to be less when compared with normal SCC, but it satisfies all the fresh state properties easily
- Fresh and hardened properties of SCC M30 mix with 15, 20, 25 and 30 percentages of cement replaced with Metakaolin are determined and compared.
- Studies are conducted with 0.1%, 0.3% and 0.5% addition of polypropylene fiber in the mix maintaining the optimum value of Metakaolin constant.
- It is found out that the hardened properties increase with an increase in Metakaolin up to 25% and then decreases.
- The result highly justifies the use of metakaolin as a replacement to cement in the production of SCC.
- Also, the optimum percentage addition of polypropylene fiber is obtained as 0.3%.
- It is observed that both cement replacement with Metakaolin and addition of polypropylene fiber lead to enhanced properties.
- Optimum percentages of metakaolin and polypropylene fibers are 25% and 0.3% respectively.

REFERENCES

[1] EFNARC (2005) Specification and Guidelines for Self Compacting Concrete, EFNARC UK.
[2] S. Asada, P. Gunawana, and M. Syarif Alaydrusb, "Fresh state behavior of self compacting concrete containing waste material fibres," *Procedia Engineering*, vol. 14, pp. 797–804, 2011.
[3] N. Su, K. Chung Hsu, and H. W. Chai, "A simple mix design method for self-compacting concrete," *Cement and Concrete Research*, vol. 31, issue 12, pp. 1799-1807, 2001.
[4] J. Ahmad, R. B. Dixit, and R. Singh, "To study the properties of self-compacting concrete using recycled aggregate and polypropylene fibre," *International Journal of Recent Research in Civil and Mechanical Engineering (IJRRCME)*, vol. 2, issue 1, pp. 173-177, 2015.
[5] T. Ponikiewski and J. Katzer, "Properties of fresh SCC mix reinforced by different types of steel and polymer fibre," *Construction and Building Materials*, vol. 62, pp. 96-101, 2014.
[6] Y.-N. Sheena, L.-J. Huanga, T.-H. Suna, and D.-H. Leb, "Engineering properties of self-compacting concrete containing stainless steel slags," *Procedia Engineering*, vol. 142, pp. 79-86, 2016.
[7] R. Madandoust, M. M. Ranjbar, and A. A. Moshiri, "The effects of steel and pet fibers on the properties of fresh and hardened self-compacting concrete," *Asian Journal of Civil Engineering (BHRC)*, vol. 15, no. 5, pp. 671-682, 2014.
[8] M. S. Shetty, *Concrete Technology Theory and Practice*, S. Chand & Company Ltd., New Delhi, 2005.
[9] IS 383-1970, Specification for Coarse and Fine Aggregates from Natural Sources for Concrete, Bureau of Indian Standards, New Delhi.
[10] IS 516-1959, Indian standard code of practice methods of test for strength of concrete, Bureau of Indian Standards, New Delhi, India.
[11] IS: 10262-1982- Recommended guidelines for Concrete Mix Design, Bureau of Indian Standards, New Delhi, 2000.