© 2017 IJSRST | Volume 3 | Issue 6 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Science and Technology

Strength Properties of Self Compacting Concrete With Partial Replacement of Cement by Mineral Admixtures Using Polypropylene

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ABSTRACT

Self Compacting Concrete has an ability to flow on its own weight hence it can be used where dense reinforcements are present. Self Compacting Concrete can be produced by adding necessary superplasticizers as per the requirement. One of the main reasons of adding mineral admixtures to concrete is to reduce cost. This paper mainly focus on determining the strength characteristics like compressive strength, split tensile strength and flexural strength of SCC where cement is partially replaced by mineral admixtures like GGBS, Fly Ash and Alccofine along with polypropylene. Polypropylene was added to increase the strength slightly and by adding Polypropylene shrinkage values can be reduced considerably and also Microstructure of the concrete samples were also investigated.

Keywords: Self Compacting Concrete, Strength, Mineral Admixtures, Superplasticizers, Microstructure

I. INTRODUCTION

Self-compacting concrete was initially introduced by japan in 1990's due to lack of skilled workmen. Self-compacting concrete doesn't need any vibration or compaction as it has the capacity of flowing on its own weight. Self-compacting concrete gives better strength than conventional concrete for the same grade. One of main difference between conventional concrete and SCC is use of superplasticizers and in SCC cement and fine aggregate quantity will be more when compared to normal concrete. Polypropylene fibers were added to concrete in order to increase the strength characteristics like compressive strength, split tensile strength and flexural strength slightly. Mineral admixtures like Ground granulated blast furnace slag (GGBS), Fly Ash and Alccofine are added so that concrete can be economical

II. OBJECTIVE OF THE STUDY

The main objective of this resarch work is to find the strength charecterstics such as Compressive strength, split tensile strength and flexural strength of self compacting concrete with and without polypropylene fibers separately for different mixes where cement is partially replaced by various mineral admixtures

III. MATERIALS USED

In this section details regarding materials used for the project work is mentioned below

Cement: OPC 53 Grade
Fine Aggregates: River sand
Coarse Aggregates: 12.5 mm size
Mineral Admixtures: GGBS, Class F Fly Ash and Alccofine
Superplasticizer: MasterGlenium SKY 8233

IV. TEST METHODS OF CONCRETE

a) FRESH CONCRETE PROPERTIES

Fresh concrete properties includes Slump flow test, V Funnel test, U box Test and L Box test are mentioned below

Table 1 - Without Polypropylene

Property	Mix 1	Mix 2	Mix 3	Mix 4	EFNARC
Slump	723	686	708	694	650 - 800

V funnel	8	11	9	10	6 – 12
U Box	15	11	13	12	0 -30
L Box	0.83	0.95	0.85	0.92	0.8 – 1

Table 2 - With Polypropylene

Property	Mix 5	Mix 6	Mix 7	Mix 8	EFNARC
Slump	684	664	672	655	650 - 800
V funnel	10	13	11	12	6 – 12
U Box	19	14	17	16	0 -30
L Box	0.91	0.98	0.92	0.95	0.8 – 1

b) HARDENED CONCRETE PROPERTIES

Hardened properties of concrete include Compressive strength, split tensile strength and Flexural strength.

Table 3 – Mould Size

Moulds	Mould Size
Cubes	150mm×150mm×150mm
Cylinder	150mm×300mm
Prism	100mm×100mm×500mm

V. EXPERIMENTAL PROGRAM

In this research work mix design was carried according to Nan Su method. M40 grade of concrete was opted for this study. Here cement is partially replaced by mineral admixtures such as GGBS, Fly Ash and Alccofine 48 cubes, 48 cylinders and 48 prisms were casted to determine compressive strength, split tensile strength and flexural strength respectively

MIXES

MIX 1: 100% Cement MIX 2: 70% Cement + 15% GGBS + 15% Fly Ash MIX 3: 70% Cement + 20% Fly Ash + 10% Alccofine MIX 4: 70% Cement + 10% GGBS + 10% Fly Ash + 10% Alccofine MIX 5: 100% Cement+ Polypropylene MIX 6: 70% Cement + 15% GGBS + 15% Fly Ash + Polypropylene MIX 7: 70% Cement + 20% Fly Ash + 10% Alccofine + Polypropylene MIX 8: 70% Cement + 10% GGBS + 10% Fly Ash + 10% Alccofine + Polypropylene

MIX DESIGN

Step 1: Calculation of Fine aggregate & Coarse aggregate

$W_{fa} = PF \times W_{fal} \times (s/a)$

$W_{fa} = 1.10 \times 1456.78 \times 0.54$

$W_{fa} = 865.327$ kg/m^3

$W_{ca} = PF \times W_{cal} \times (1\text{-}s/a)$

$W_{ca} = 1.1 \times 1346.6 \times (1\text{-}0.54)$

$W_{ca} = 681.379$ kg/m^3

Step 2: Calculation of Cement content

C = c × (f’c/20)

C = 1.38 (40/0.14)

C = 394.28 kg/m^3

Step 3: Calculation of Mixing Water

$W_{wc} = (w/c) \times C$

$W_{wc} = 0.40 \times 394.28$

$W_{wc} = 157.71$ kg/m^3

Step 4: Calculation of filler materials

$V_{pf} = 1 - \left(\frac{C}{1000\times Gc}\right) - \left(\frac{Wfa}{1000\times Gfa}\right) - \left(\frac{Wca}{1000\times Gca}\right) - \left(\frac{Wwc}{1000\times Gwc}\right) - V_a$

$V_{pf} = 1 - \left(\frac{394.28}{1000\times 3.15}\right) - \left(\frac{865.327}{1000\times 2.63}\right) - \left(\frac{681.379}{1000\times 2.65}\right) - \left(\frac{157.71}{1000\times 1}\right) - (1/100$

$V_{pf} = 1 - 0.125 - 0.329 - 0.257 - 0.155 - 0.01$

$V_{pf} = 0.1209$

Amount of filler required

$W_f = \frac{Vpf\times 1000\times Gf}{1+(\frac{w}{p})\times Gf}$

$W_f = \frac{0.1209\times 1000\times 3.15}{1+0.4\times 3.15}$

$W_f = 168.607$ kg/m^3

Total cement content = $W_f + C$

= 168.607 + 394.28

= 562.893 kg/m^3

Step 5: Calculation of water needed for SCC

$W_w = \left(1+\frac{wf}{p}\right)\left(\frac{w}{c}\right)C + \left(\frac{w}{f}\right)Wf$

$W_w = \left(1 + \frac{168.607}{562.893}\right)(0.40)394.28 + (0.40)168.607$

$W_w = 67.962$ kg/m^3

Total water content W = $W_{wc} + W_w$

= 157.71 + 67.962

= 225.677 kg/m^3

MIX PROPORTION

Cement – 562.893 kg/m^3

Fine Aggregates – 865.327 kg/m^3

Coarse Aggregates – 681.379 kg/m^3

Water – 225.677 kg/m^3

Superplasticizer – 5.62lit/m^3

VI. RESULTS

Here the results obtained from testing the concrete specimens which are cured for 7 and 28 days are tabulated below and comparison between the mixes with polypropylene and mixes without polypropylene is shown in graph.

a) Compressive Strength

Table 4 – Compressive strength

Mixes	Without Polypropylene		With Polypropylene	
Curing	7 days	28 days	7 days	28 days
Mix 1	43.48	52.72	47.70	56.53
Mix 2	31.30	43.11	33.31	47.82
Mix 3	37.45	47.70	39.22	51.55
Mix 4	30.66	41.03	36.45	48.74

Chart -1: compressive strength for 7 days

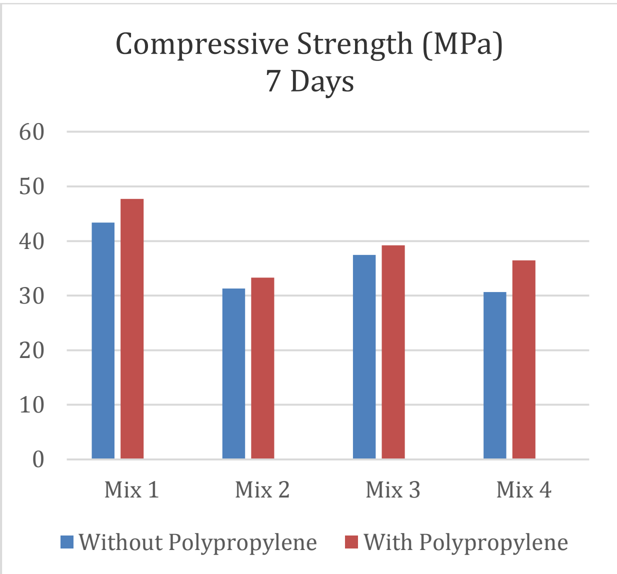
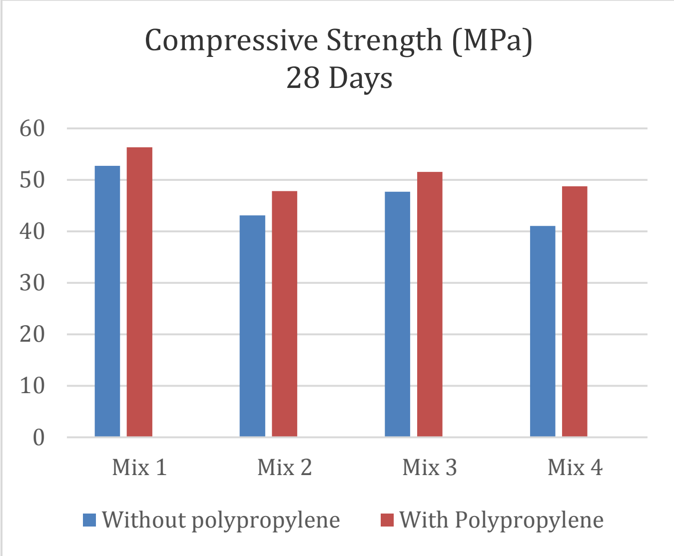


Chart -2: compressive strength for 28 days



b) Split Tensile Strength

Table 4 – Split Tensile strength

Mixes	Without Polypropylene		With Polypropylene	
Curing	7 days	28 days	7 days	28 days
Mix 1	2.77	3.28	3.02	3.50
Mix 2	2.56	3.04	2.64	3.12
Mix 3	2.27	3.68	3.39	3.72
Mix 4	2.21	3.03	2.93	3.11

Chart -3: Tensile strength for 7 days

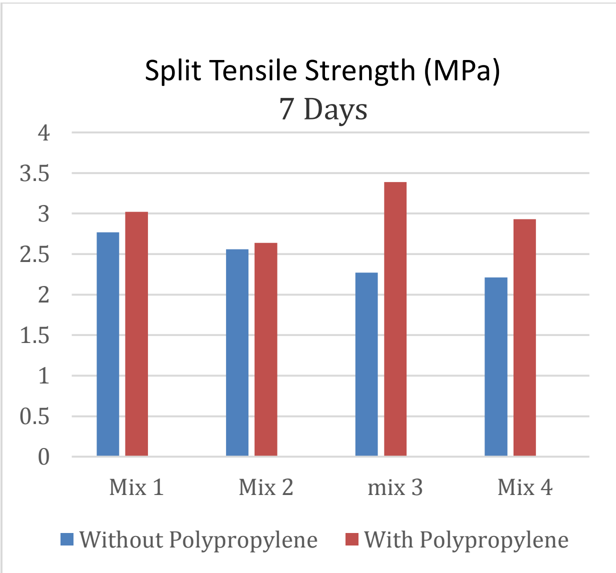
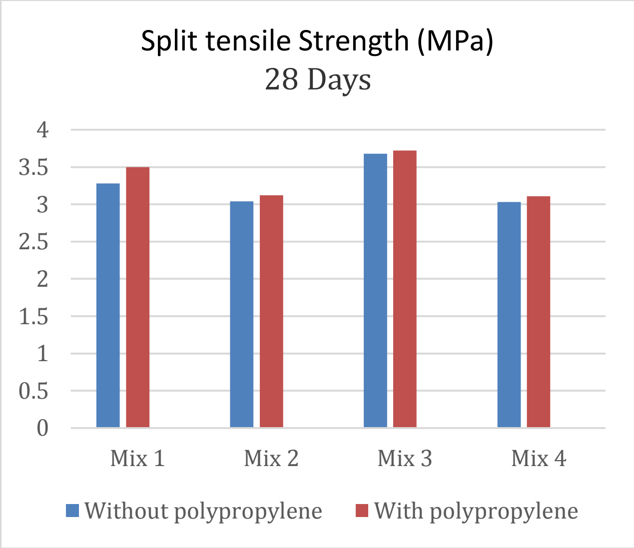


Chart -4: Tensile strength for 28 days



c) Flexural Strength

Table 5 – Flexural Strength

Mixes	Without Polypropylene		With Polypropylene	
Curing	7 days	28 days	7 days	28 days
Mix 1	8	10.5	8.5	11.25
Mix 2	5	7.5	6	8.25
Mix 3	6	9.25	7.25	10.5
Mix 4	5.5	7.25	6.5	8.5

Chart -5: Flexural Strength for 7 days

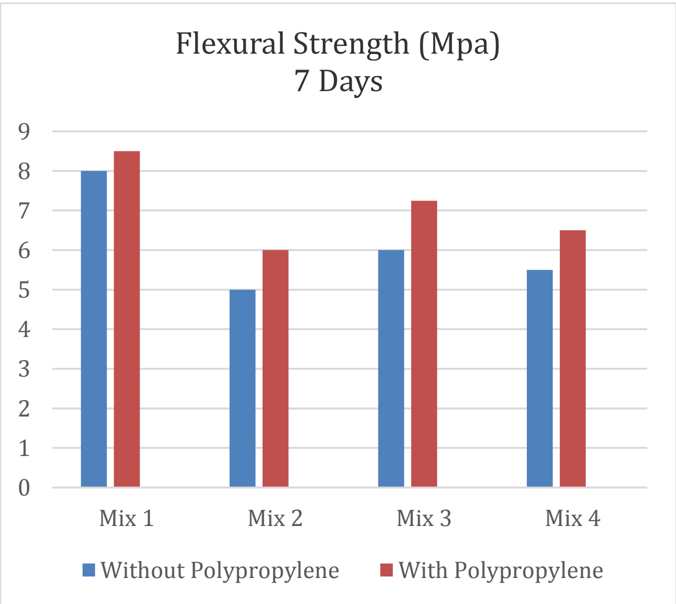
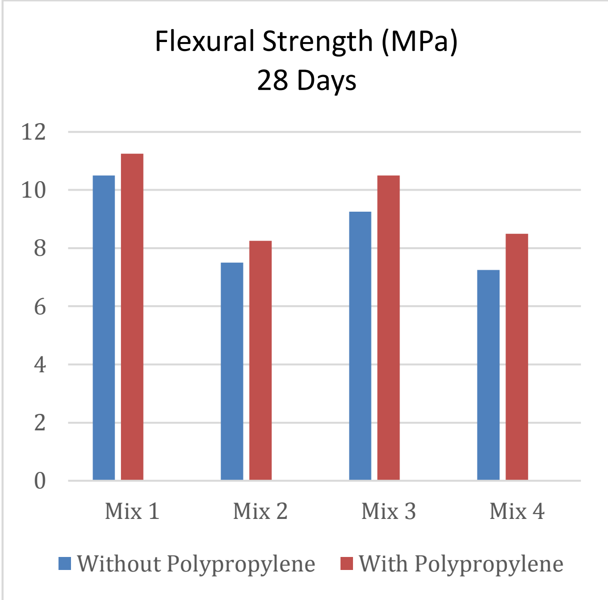


Chart -6 Flexural Strength for 28 days



MICROSTRUCTURE

Concrete has heterogeneous and complex materials. To understand those properties microstructure is very essential. The nature, quantity and distribution of phases present in a solid material are called microstructure. Larger materials of the microstructures of a material can be seen from cross section of the material but relatively finer particles are seen with the help of a microscope. The magnification capacity of scanning electron microscopes will be usually in the order of 10^5 times. In modern world there is so much research going on several aspects of concrete.In the SEM images below there are some materials which can be identifies as CSH gel, Ettringite, Hydrated cement paste, unhydrated cement paste, Voids and Micro cracks. All those can be identified with different physical appearance.

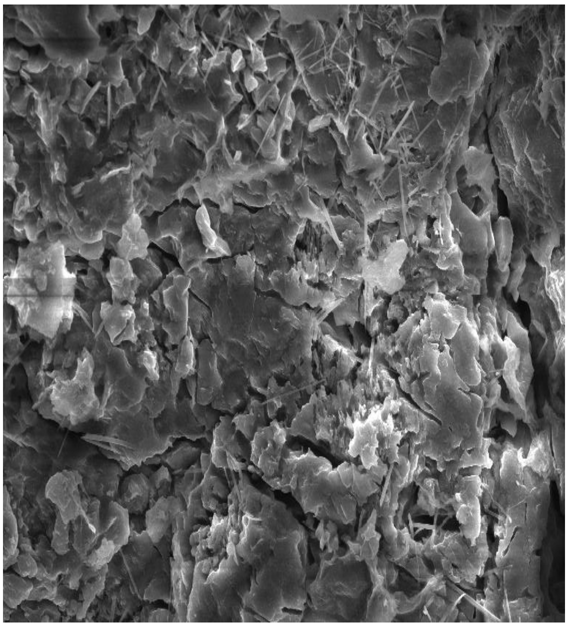


Fig -1: Mix 1 (28 days)

This SEM picture shows micro cracks as well as ettringite particles in it and CSH gel is also present and dark spots indicates pores in hydrated cement paste.

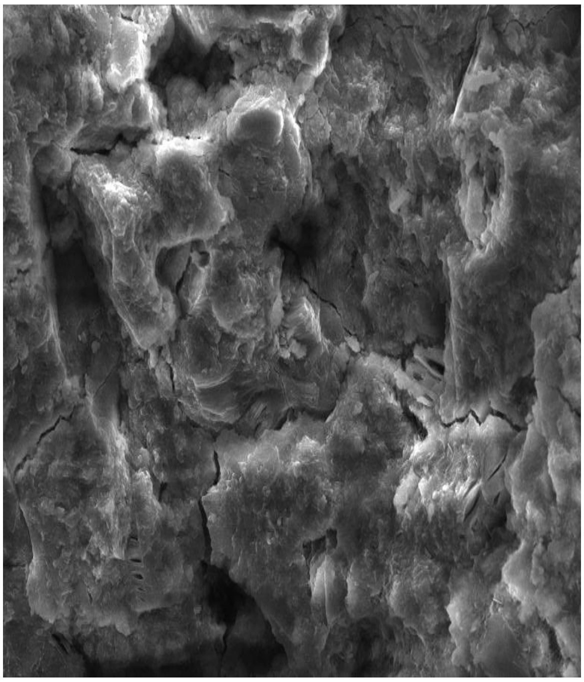


Fig -2: Mix 2 (28 days)

Here in this we can see the formation of Dense CSH gel and also bright spots which indicates unhydrated cement particles and we can also observe micro cracks in it.

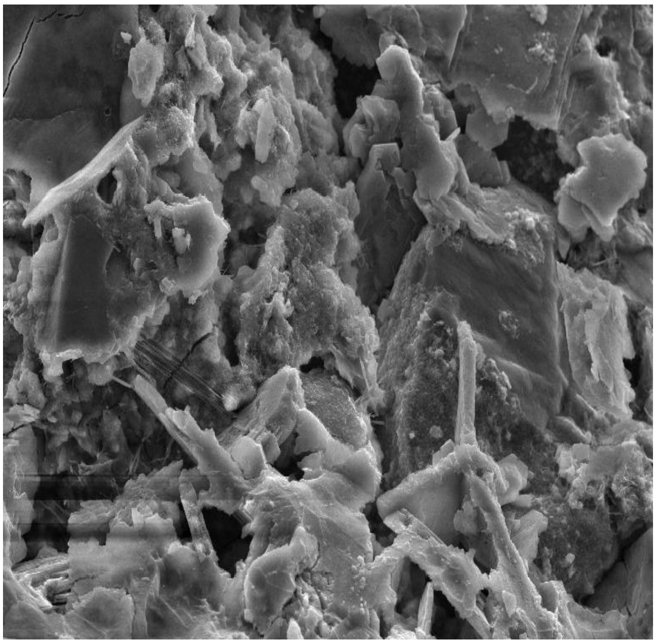


Fig -3: Mix 5 (28 days)

This image shows sense dense CSH gel along with micro cracks and void at some parts of the mix. Plate like crystals of CSH gel is also found in this mix. It also contains calcium hydroxide.

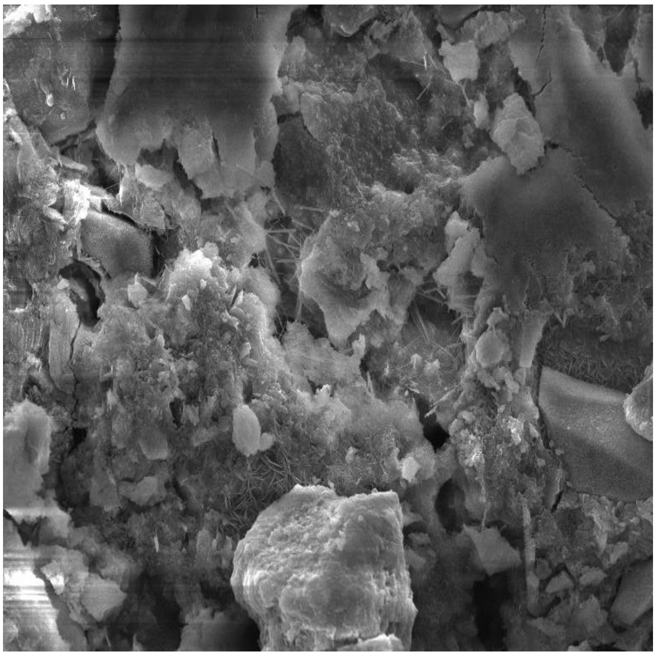


Fig -4: Mix 6 (28 days)

This SEM image shows some densely formed CSH gel along with some ettringite particles in it. It also shows hydrated cement paste.

VII. CONCLUSION

Based on the experimental program the following conclusion can be made

- Nan Su Method of mix design can be used for making Self compacting concrete
- All the mix proportion chosen falls within the EFNARC guidelines
- By this study one can say that increasing the dosage of superplasticizers increases the workability of concrete
- The strength of all the mixes are increased when fibre are added
- Compressive strength, Split tensile strength and flexural strength of concrete specimens which has polypropylene fibres shows higher strength than specimens which doesn't have Polypropylene.

VIII. REFERENCES

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