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Experimental study on Smart Dynamic Concrete with PPF and comparing among SDC, SCC and Conventional Concrete

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Abstract— ***SDC is a special concrete which is moderately flowable, non-segregating and by its own weight spread into place and completely fill the formwork even in the presence of dense reinforcement. SDC offers several economical and technical benefits. Use of PPF extends its possibilities.***

This experimental investigation is carried out to compare three mixes namely, Conventional concrete, Self-compacting concrete and Smart dynamic concrete. Apart from this SDC mix is prepared by adding Polypropylene fibers. The proportion of fiber addition is 0.9kg per cubic meter of concrete.

The hardened properties like compressive strength, Flexural strength and Split tensile strength is also Studied in this comparative study. The compressive strength is tested after 3, 7, 14, 28 days complete curing. The flexural and tensile resistance of three types of mixes is tested after 7 and 28 days complete curing.

From these tests and comparisons it is evident that SDC with PPF shows a highest value in tensile resistance and flexural strength compared to compressive strength.

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Index Terms— Polypropylene Fibers (PPF), Smart Dynamic Concrete (SDC), Self-Compacting Concrete (SCC)

I. INTRODUCTION

SDC is a special concrete which is highly flowable, non-segregating and by its own weight spread into place and completely fill the formwork even in the presence of dense reinforcement. SDC offers several economical and technical benefits.

The concept of Self Compacting Concrete (SCC) was first developed in Japan in the 1980's. Its use in the precast concrete is quite prevalent in several European countries and the USA. In the ready-mixed concrete industry however, the use of SCC is limited and restricted to specialized projects and applications despite all the benefits it offers. One of the main reasons why SCC is not commonly employed in the ready mixed industry is the higher cost associated with such mixes.

SCC mixes require a higher amount of cementitious material in order to achieve pre- defined self-compacting properties. Hence, it is quite easy for lower grade concrete mixes to end up with higher than specified criteria.

The production of SDC is made possible by combining an innovative Viscosity Modifying Agent (termed VMA) with a Super plasticizer. BASF's Master Glenium SKY 8600 series products are used at site. Master Glenium SKY 8600 series enables us to achieve self-compacting properties with lower fines and paste contents without the risk of excessive bleeding and tendency to segregate. The VMA plays a vital role in maintaining the homogeneity of the SDC and increase its robustness, without affecting the flows significantly and enhances plastic viscosity.

Interest in the use of SDC is rapidly growing because it has the potential to deliver considerable savings to all parties concerned. Moreover, these savings are achieved without compromising the plastic and ultimate properties of concrete making SDC an attractive proposition.

Advantages of SDC

- SDC requires minimal to no vibration due to its self -compacting properties, thereby resulting in lower energy and manpower utilization.
- Demoulding can done in just 16 hours and faster rotation of the formwork or in other words, shorter cycle times resulted in overall cost savings and more importantly, earlier completion times.
- Excellent surface finish with no honeycombing and voids is can be achieved with SDC, Hence, the repair costs of concrete members cast with SDC cab be maintained at a low level. Similarly, the need for plastering of exposed faces as is common practice in most parts of the country prior to painting can be eliminated.
- SDC reduces the carbon footprint of concrete and the construction processes because of the lower cementitious content, less energy, lower in-place costs, better finishability and enhanced durability.
- SDC is an attractive proposition for designers, contractors and owners because it is economically viable without compromising aspects such as the durability of structures.

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II. Objective of the Project

- To analyze various characteristics of Portland cement, coarse aggregate and fine aggregate used in concrete mix design.
- Mix designing of concrete as per the IS: 10262- 2009, EFNARC specifications.
- Water curing as per standard.
- To investigate the Compressive Strength and Split Tensile Strength of Smart Dynamic Concrete, using Polypropylene Fibers.
- To evaluate the Compressive strength and split tensile strength, flexural strength of Smart Dynamic Concrete, Self-Compacting Concrete, Conventional Concrete.
- Comparing the results with EFNARC specification.
- Comparative studies of different mixes.
- Rate Analysis for different Concrete used.

III. Preliminary Test Results

Table I: Tests on Cements

Test	IS Specification	Result
Standard Consistency	(IS 4031:1969-Part-4)	30%, 6mm penetration
Initial setting time	(IS 4031:1968-Part-5)	196min
Final setting time	(IS 4031:1968-Part-5)	307min
Soundness	(IS 4031:1968-Part-3)	4mm expansion
Fineness of Cement	(IS 4031 – Part – 1)	3%
Compressive Strength	(IS 4031:1968-Part-6)	3days, 28.46 7days, 38.82 28days,56.77

Slump Test Results:

Table II: Slump Test Results

Conventional concrete	160
SDC	570
SCC	700
SDC with PPF	590

Table III: Test on Aggregate

Test	IS Specification	Result
Specific Gravity of Coarse aggregate	(IS 1542-1992)	12mm, 2.6 20mm, 2.65
Water Absorption	(IS 1542-1992)	12mm, 0.7% 20mm, 0.45%
Sieve Analysis of Coarse Aggregate	IS 2386 (PART I) , 1977	12mm, FM=1.79 20mm, FM=2.09
Aggregate impact value	IS 2386 (PART IV), 1963	12mm, 15.96% 20mm, 15.38%
Aggregate Crushing value	IS 2386 (PART IV)	12mm, 23.19% 20mm, 22.28%
Specific gravity of fine aggregate	IS: 383-1973	2.55
Water Absorption	IS: 383-1973	5.3%
Sieve Analysis of fine aggregate	IS: 383-1973	FM=3
Silt content	IS: 383-1973	6.76

IV. Experimental Results and Discussion

Table IV: Comparison of Compressive Strength Of Cements

Mix classification	Cement Contents in kg/m^3	Curing period				
		1day	3days	7days	14days	28days
Conventional concrete	330	5.8	20.42	29.37	33.47	36.52
	340	7.7	22.29	32.54	37.66	40.14
	350	8.10	23.07	33.77	37.08	42.75
Smart dynamic concrete	360	7.26	18.73	29.48	33.66	36.71
	370	8.2	19.67	29.81	31.01	37.46
	380	9.22	27.82	29.33	34.33	41.88
Self-compacting concrete	400	7.24	20.40	25.76	34.59	38.98
	410	7.10	20.90	24.73	35.18	40.9
	425	8.3	25.24	29.8	36.94	42.16
SDC with PPF	370	7.20	26.19	29.41	34.45	39.09

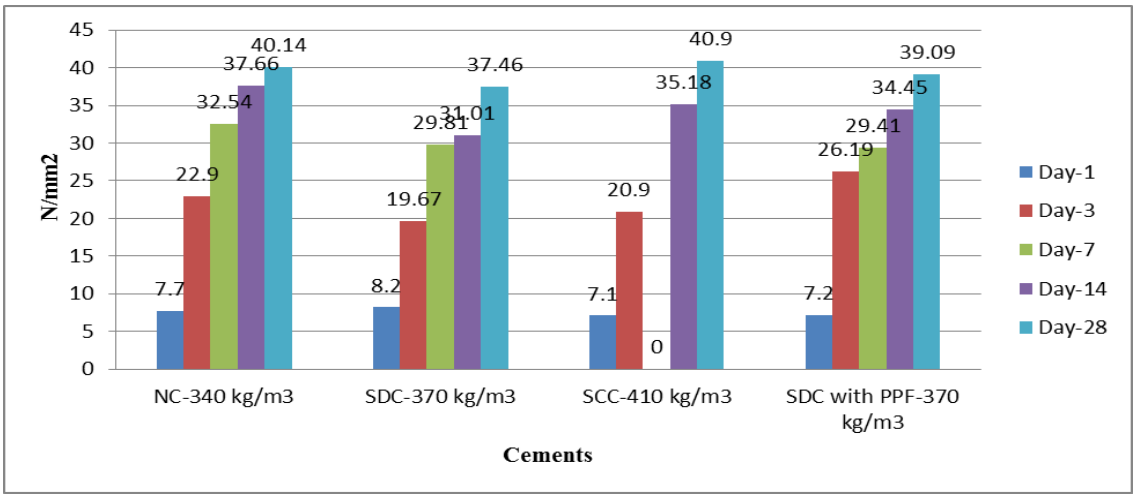

Fig **1:** Compressive Strength of NC, SDC, SCC, SDC with PPF

Table V: Comparison of Tensile Resistance

Mix classification	Cement Contents in kg/m^3	Curing period	
		7 days	28 days
Conventional concrete	330	1.98	2.83
	340	2.02	2.95
	350	2.18	3.17
Smart dynamic concrete	360	1.82	2.26
	370	1.92	2.73
	380	2.02	2.88
Self-compacting concrete	400	1.2	1.69
	410	1.37	1.86
	425	1.54	2.09
SDC with PPF	370	2.72	4.27

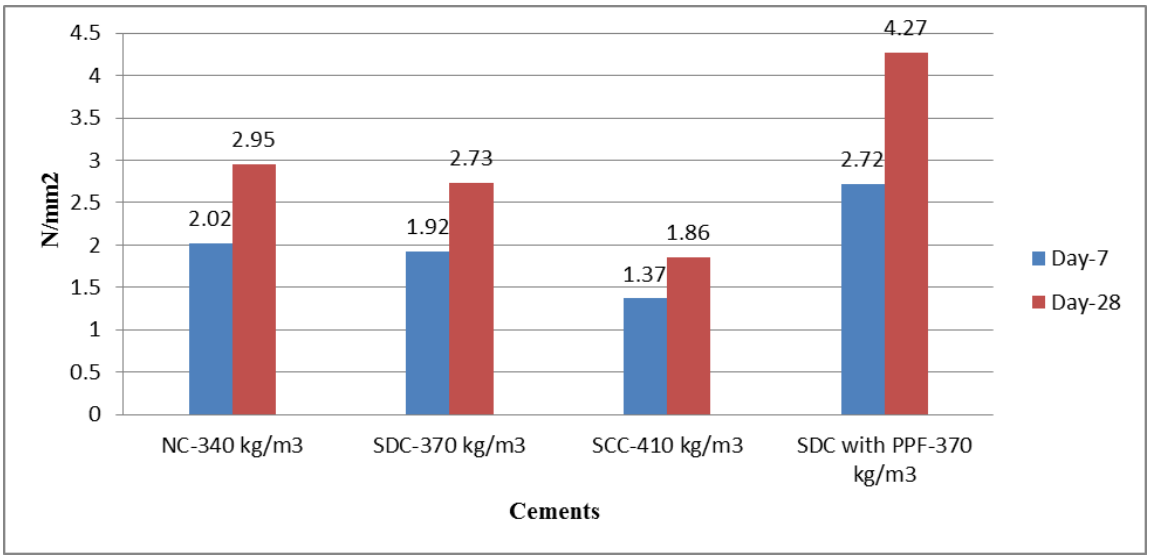

Fig **2:** Tensile Resistance of Different Mixes

Table VI: Comparison of Flexural Strength

Mix classification	Cement Contents in kg/m^3	Curing period	
		7 days	28 days
Conventional concrete	330	4.48	6.4
	340	4.83	6.9
	350	5.04	7.2
Smart dynamic concrete	360	3.8	6.1
	370	4.3	6.4
	380	4.62	6.6
Self-compacting concrete	400	3.85	5.5
	410	4	5.8
	425	4.34	6.22
SDC with PPF	370	5.04	7.2

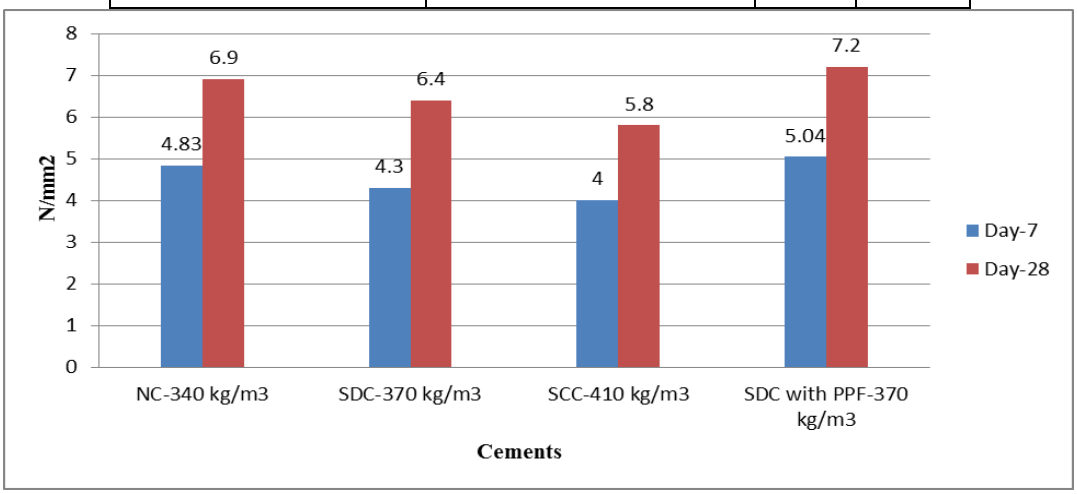

Fig 3: Flexural Strength of Different Mixes

Rate Analysis:

Table VII: Rate Analysis of Different Cement Mixtures

	Normal			SDC			SCC		
	Wt	Coef	Rate per m^3	wt	coef	Rate	wt	coef	rate
Cement	340	7.6	2584.0	370	7.6	2812	400	7.6	3040
Silica fumes	0			0			30	21.33	639.9
20mm	634.21	0.594	376.7	113.41	0.594	67.36554	0	0.594	0
12.5mm	460.99	0.545	251.2	645.11	0.545	351.585	657.18	0.545	358.1631
Msand	826.73	0.66	545.6	1091.35	0.66	720.291	1072.71	0.66	707.9886
Admixture	2.72	42	114.2	2.96	42	124.32	3.44	42	144.48
Labour cost	100	1	100.0	50	1	50	50	1	50
Machinery	132	1	132.0	105.6	1	105.6	105.6	1	105.6
Total cost per m^3	Normal = Rs. 4103.8			SDC = Rs. 4231.2			SCC = Rs. 5046.1		

V. CONCLUSION

For the Comparison, three different concrete were chosen namely, conventional concrete, SDC and SCC. The grade of the mix is M30 grade of concrete. For all the different mixes workability of concrete, compressive strength, tensile resistance and flexural strength were tested and compared. The following conclusions on the project are made;

- SDC can be used as a substitute to normal conventional concrete because of its zero repair works in post concrete (honey combs causes 15% extra cost for repair/grouting.
- As SDC is homogeneous high viscous mix, it can be poured from the max. 4mt height without any segregation.
- SDC does not require electrical vibrator for compaction.
- SDC pumping is more easy and smooth to any distance.
- Good glassy surface finishing can be achieved, so that plastering can be avoided (direct paint can be apply over concrete surface).
- 50% of labour charges can be avoided while placing concrete (as it is self-flowing and self-compacting concrete, it does not require much man power while placing).
- Flow of SDC is from 550-650.
- Among the Compressive strength obtained on three mixes of conventional concrete, 340kg/m^3 cement content with w/c ratio of 0.45 shows high strength.
- Among the Compressive strength obtained on three mixes of SDC, 370kg/m^3 cement content with w/c ratio of 0.45 shows high strength.
- Among the Compressive strength obtained on three mixes of SCC, 410kg/m^3 cement content with 30kg of silica fume with w/c ratio of 0.47 shows high strength.
- Above cement content shows better result even for tensile resistance and flexural strength.
- SDC with PPF shows a highest value in tensile resistance and flexural strength compare to compressive strength.

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