Comparative Study of Effect of Sustained High Temperature on strength Properties of Self Compacting Concrete and Ordinary Conventional Concrete

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Abstract:

Self Compacting Concrete is a material used in the construction where it is suitable for placing the concrete in difficult conditions and in structures with congested reinforcement without vibration. In case of unexpected fire, the concrete elements such as beams, columns etc will be subjected to extreme temperatures and need for assessment of their performance after fire. Hence, it is important to understand the change in the concrete strength properties due to extreme temperature exposure.

This paper presents an assessment of effect of sustained temperatures on strength properties of self compacting concrete and its comparison with ordinary Conventional Concrete. In order to study effect of sustained elevated temperature on the compressive strength, flexural strength, tensile strength & impact strength of self compacting concrete and ordinary concrete, the specimens of Self Compacting Concrete and ordinary conventional concrete were tasted in laboratory. For various tests 21 cubes(150mmX150mmX150mm), 21 cylinders (100mmdiaX200mmheight), 21 beams(100mmx100mmX500mm) and 21 plates were cast and same for the ordinary concrete. The specimens were kept in oven at required temperature (28^{0}C, 100^{0}C, 200^{0}C, 300^{0}C,400^{0}C,500^{0}C and 600^{0}C) for 5 hrs at constant temperatures. The results obtained were compared with the corresponding properties of normal concrete with the same water cement and air content.

Key words: *Elevated Temperature, self compacting Concrete, ordinary Conventional Concrete, compressive strength, tensile strength, flexural strength & impact strength*

INTRODUCTION

Concrete is a material often used in the construction of high rise buildings and special purpose. Concrete in case of unexpected fire, the concrete properties are changes after fire. Hence, it is important to understand the change in the concrete properties due to extreme temperature exposures. As the concrete used for special purpose, the risk of exposing it to high temperature also increases. To be able to predict the response of structure after exposure to high temperature, it is essential that the strength properties of concrete subjected to high temperatures be clearly understood. High temperature can cause the development of cracks. These cracks like any other cracks propagation may eventually cause loss of structural integrity and shorting of service life.

The influence of elevated temperatures on mechanical properties of concrete is of very much important for fire resistance studies and also for understanding the behavior of containment vessels, chimneys, nuclear reactor pressure vessels during service and ultimate conditions structures like storage tanks for crude oil, hot water , coal gasification, liquefaction vessels used in petrochemical industries, foundation for blast furnace and coke industries, furnace walls industrial chimney, air craft runway etc., will be subjected to elevated temperatures. So that the variation of compressive strength, performance are some of the important parameters to be investigated when concrete structures are subjected to temperatures.

Significance of Experimental work

1. To study the effect of sustained high temperature on compressive, flexure, split tensile and impact strength of self compacted concrete and ordinary conventional concrete
2. The test specimens where subjected to temperatures ranging from 100^0C to 600^0C for 5 hours, their behavior compared to that observed room temperature
3. To be able to asses the structural safety of such structures after exposure to high temperature, it is important that the effect on strength between two concrete well understood, so that the predication of behavior can be made in scientific way.
4. Concrete undergoes significant change when exposed to high temperature resulting in changing in structural properties. The question whether to retain or demolish the structure after it has been subjected to high temperature will be based on assessment of structural properties, in addition to economic consideration.

Preparation of Specimen

In order to study effect of sustained elevated temperature on the compressive strength, flexural strength, tensile strength & impact strength of self compacting concrete and ordinary concrete, a total number of 84 specimens of SCC 21 cubes (150mm×150mm×150mm), 21cylinders(100mmdia.×200mmheight), 21 beams (100mm×100mm×500mm) and 21 plates were cast and same for the ordinary concrete.

Ingredients of the mix were taken as per the mix proportion, for SCC (M_{20} Grade) by Nan-Su method. And ordinary convential concrete by IS code method. Concrete was filled in three layers. The top surface of the specimens was hand trowe led. The moulds were stripped after 24 hrs. The specimens were cured by placing them in curing tank for 28 days. After curing, the specimens were taken out & dried for one day in shed.

The specimens were kept in oven at required temperature (28ºC, 100ºC, 200ºC, 300ºC, 400ºC, 500ºC, 600ºC) for 5 hours at constant temperature. After heating, the specimens were taken out and cooled in air were tested for their compression strength test, flexural strength test , split tensile strength test and impact strength test carried out for Self Compacting Concrete and Ordinary Concrete.

TESTS CONDUCTED ON CONCRETE SPECIMENS

a) Compressive strength of concrete

Table 1 & Table 2 gives the details of the number of specimens cast for different temperatures. Cubes sizes were 150mm x 150mm x 150mm. Test being conducted using the compressive strength machine.

$$\text{Relative compressive strength} = \frac{\text{Existing comp. failure after heating}}{\text{Comp. strength of controlled cubes}} \quad \text{………… i.)}$$

b) Spilt Tensile Strength of Concrete

Table 3 & Table 4 gives the details of the number of specimens cast for different temperatures. The cylinder sizes were 150mm x 300 mm. Test being conducted using the compressive strength machine.

The spilt tensile strength (ft) is calculated using the following expression.

$$Ft = [\frac{2P}{3.14*D*L}] \quad \text{……………. ii.)}$$

Ft = spilt tensile strength in N/mm2
P = applied load in N
D = diameter in mm
L = length in mm

c) Flexural Strength of Concrete

Table 5 & Table 6 gives the details of the number of specimens cast for different temperatures. The sizes were 100mm x 100mm x 500 mm. Test being conducted using the flexural strength machine

The flexural strength (fp) is calculated using following expression

$$Fp = [\frac{PL}{B*D2}] \qquad \text{…………… iii.)}$$

Fp = flexural strength in N/mm2
P = applied load in N
B = breadth in mm
D = depth in mm
L = length in mm of the span on which was supported.

d) Impact Strength of Concrete

Table 7 & Table 8 gives the details of the number of specimens cast for different temperatures. The sizes of plates were 250mm x 250mm x 35 mm. The drop weight method is used owing to simplicity. A steel ball weighing 12.7 N was dropped from the height of 1 m. on the specimen which was kept on the floor. The number of blows required for complete failure was noted and the impact energy was calculated as follows

Impact energy = w x h x n (N-m) …………….. iv.)
w = weight of the ball = 12.7 N
h = height of fall = 1 m.
n = no. of blows required for complete failure.

TEST RESULTS

A) Compressive Strength Test

a) Results for Ordinary Conventional Concrete

Table 1: Compressive Strength Results at Different Temperatures For OCC

Temperature	Identification of specimen	Weight before placing in electric furnace (N)	Weight after removing from electric furnace (N)	Percent-age weight loss	Avg. percent-age weight loss	Failure load (KN)	Comp. strength (MPa)	Average Comp. strength (MPa)
Reference Mix 28^0C	ROC1	85.15	85.15	0	0	690	30.08	29.06
	ROC2	89.30	89.30	0		630	27.46	
	ROC3	88.80	88.80	0		680	29.64	
100^0 C	OC11	89.00	84.05	5.56	5.28	660	28.776	28.92
	OC12	88.60	84.05	5.14		660	28.776	
	OC13	85.85	81.25	5.13		670	29.212	
200^0 C	OC21	87.10	82.75	4.99	5.39	630	27.468	27.90
	OC22	88.30	83.75	5.15		650	28.340	
	OC23	87.80	82.50	6.04		640	27.904	
300^0C	OC31	88.70	81.04	8.63	7.08	590	25.72	26.16
	OC32	87.50	82.00	6.28		600	26.160	
	OC33	87.50	81.95	6.34		610	26.60	
400^0C	OC41	88.00	80.20	8.87	8.70	550	23.98	24.12
	OC42	87.70	79.70	9.12		560	24.416	
	OC43	87.50	80.40	8.11		550	23.98	
500^0C	OC51	86.50	78.90	8.89	9.50	520	22.67	22.09
	OC52	88.00	79.10	10.11		510	22.23	
	OC53	87.80	79.45	9.51		490	21.36	
600^0C	OC61	87.90	78.10	10.70	11.20	470	20.49	20.80
	OC62	86.50	77.90	11.09		460	20.05	
	OC63	88.10	77.70	11.80		500	21.80	

b) Results for Self Compacting Concrete

Table 2 Compressive strength results at different temperatures for SCC

Temperature	Identification of specimen	Weight before placing in electric furnace (N)	Weight after removing from electric furnace (N)	Percent-age weight loss	Avg. percent-age weight loss	Failure load (KN)	Comp. strength (MPa)	Average Comp. strength (MPa)
Reference Mix 28^0C	RSC1	80.10	80.10	0	0	560	24.41	24.70
	RSC2	79.95	79.95	0		580	25.29	
	RSC3	80.00	80.00	0		560	24.41	
100^0 C	SC11	79.80	75.60	5.26	4.84	560	24.41	23.98
	SC12	79.90	76.10	4.75		550	23.98	
	SC13	79.90	76.30	4.50		540	23.544	
200^0 C	SC21	80.15	75.95	5.24	5.37	510	22.24	22.82
	SC22	78.70	74.85	4.99		520	22.67	
	SC23	79.85	75.15	5.89		540	23.544	
300^0C	SC31	79.50	73.60	7.42	7.20	500	21.80	21.22
	SC32	79.70	74.20	6.90		490	21.36	
	SC33	79.70	73.90	7.27		470	20.49	
400^0C	SC41	80.10	71.70	10.48	9.54	480	20.92	20.20
	SC42	79.80	72.50	9.14		460	20.06	
	SC43	79.90	72.70	9.01		450	19.62	
500^0C	SC51	79.40	71.70	9.75	10.84	420	18.31	18.74
	SC52	79.80	70.70	11.40		430	18.74	
	SC53	79.90	70.80	11.38		440	19.18	
600^0C	SC61	79.40	70.10	11.71	12.74	400	17.44	17.30
	SC62	80.10	69.90	12.73		370	16.13	
	SC63	79.70	68.70	13.80		420	18.31	

B) Split Tensile strength

a) Results for Ordinary conventional Concrete

Table 3: Split Tensile strength results at different temperatures for OCC

Temperatures	Identification of specimen	Weight before placing in electric furnace (N)	Weight after removing from electric furnace (N)	Percent-age weight loss	Avg. percent-age weight loss	Failure load (KN)	Split Tensile strength (MPa)	Avg. Split tensile strength (MPa)
Reference Mix 28^0C	ROC1	41.60	41.60	0	0	125.00	3.91	3.854
	ROC2	41.55	41.55	0		132.50	4.139	
	ROC3	42.55	42.55	0		112.50	3.514	
100^0 C	OC11	39.50	37.90	4.05	4.83	120.00	3.748	3.806
	OC12	41.20	39.40	4.36		127.50	3.983	
	OC13	41.10	38.60	6.08		117.50	3.670	
200^0 C	OC21	40.70	38.30	5.89	6.26	102.50	3.202	3.227

	OC22	40.90	38.60	5.62		117.50	3.670	
	OC23	41.10	38.10	7.29		90.00	2.811	
300^0C	OC31	40.50	37.15	8.27	7.18	95.00	2.967	2.993
	OC32	40.50	37.90	6.41		92.50	2.889	
	OC33	40.80	38.00	6.86		100.00	3.124	
400^0C	OC41	41.00	37.70	8.04	8.95	90.00	2.81	2.670
	OC42	40.90	37.30	9.29		80.00	2.55	
	OC43	40.90	37.60	9.53		85.00	2.65	
500^0C	OC51	41.30	37.30	9.68	9.31	72.50	2.264	2.23
	OC52	41.10	37.30	9.24		75.00	2.340	
	OC53	41.10	37.40	9.00		67.50	2.108	
600^0C	OC61	40.80	36.40	10.78	10.83	50.00	1.59	1.88
	OC62	40.00	36.00	10.00		65.00	2.07	
	OC63	41.00	36.20	11.71		62.50	1.99	

b) Results for Self Compacting Concrete

Table 4: Spilt Tensile strength results at different temperatures for SCC

Temperatures	**Identification of specimen**	**Weight before placing in electric furnace (N)**	**Weight after removing from electric furnace (N)**	**% weight loss**	**Avg. % weight loss**	**Failure load (KN)**	**Split Tensile strength (MPa)**	**Avg. Split tensile strength (MPa)**
Reference Mix 28^0C	RSC1	35.20	35.20	0	0	102.50	3.202	3.045
	RSC2	35.00	35.00	0		92.50	2.889	
	RSC3	34.60	34.60	0		97.50	3.045	
100^0 C	SC11	34.00	32.70	3.820	4.51	100.00	3.124	2.967
	SC12	35.00	33.10	5.420		95.00	2.967	
	SC13	35.00	33.50	4.280		90.00	2.811	
200^0 C	SC21	34.50	32.50	5.790	5.65	87.50	2.733	2.603
	SC22	34.80	33.80	2.870		80.00	2.500	
	SC23	35.00	32.10	8.280		82.50	2.577	
300^0C	SC31	35.00	32.00	6.950	7.98	70.00	2.186	2.346
	SC32	34.90	31.80	8.880		75.00	2.343	
	SC33	34.50	32.10	8.110		80.00	2.500	
400^0C	SC41	35.50	32.70	7.880	8.38	72.50	2.264	2.082
	SC42	34.50	31.70	8.110		65.00	2.030	
	SC43	34.90	31.70	9.160		62.50	1.952	
500^0C	SC51	34.50	31.40	7.530	10.74	55.00	1.718	1.583
	SC52	35.20	31.10	11.640		50.00	1.560	
	SC53	35.00	31.40	10.280		47.50	1.483	
600^0C	SC61	34.80	30.20	13.210	12.16	40.00	1.249	1.190
	SC62	35.00	30.80	12.000		32.50	1.015	
	SC63	34.60	30.70	11.270		42.50	1.327	

C) Flexural Strength Test

a) Result for Ordinary conventional Concrete

Table 5: Flexural strength results at different temperatures for OCC

Temperatures	Identification of specimen	Weight before placing in electric furnace (N)	Weight after removing from electric furnace (N)	Percent-age weight loss	Avg. percent-age weight loss	Failure load (KN)	flexural strength (MPa)	Avg. flexural strength (MPa)
Reference Mix 28^0C	ROC1	131.10	131.10	0	0	8.70	3.830	3.90
	ROC2	128.70	128.70	0		9.00	3.969	
	ROC3	129.90	129.90	0		8.90	3.924	
100^0 C	OC11	130.00	124.50	4.23	4.38	8.80	3.88	3.81
	OC12	129.00	122.80	4.80		8.60	3.80	
	OC13	129.00	123.70	4.10		8.50	3.748	
200^0 C	OC21	128.50	122.50	4.66	4.72	8.10	3.57	3.32
	OC22	127.00	121.00	4.72		7.60	3.351	
	OC23	127.00	120.90	4.80		6.90	3.042	
300^0C	OC31	128.00	120.10	6.17	5.97	7.40	3.26	3.24
	OC32	126.00	119.40	5.23		7.60	3.35	
	OC33	129.00	120.60	6.51		7.10	3.131	
400^0C	OC41	127.50	118.20	7.29	7.30	6.10	2.690	2.80
	OC42	126.50	117.20	7.35		6.60	2.910	
	OC43	128.00	118.70	7.26		6.40	2.822	
500^0C	OC51	128.50	117.20	8.79	8.80	5.80	2.557	2.48
	OC52	128.50	117.40	8.63		5.50	2.425	
	OC53	129.00	117.40	9.00		5.60	2.469	
600^0C	OC61	126.00	111.80	11.26	11.15	4.40	1.940	2.08
	OC62	129.00	114.70	11.08		5.20	2.293	
	OC63	129.50	115.10	11.12		4.60	2.028	

b) Result for Self Compacting Concrete

Table 6: Flexural strength results at different temperatures for SCC

Temperatures	Identification of specimen	Weight before placing in electric furnace (N)	Weight after removing from electric furnace (N)	Percent-age weight loss	Avg. percent-age weight loss	Failure load (KN)	flexural strength (MPa)	Avg. flexural strength (MPa)
Reference Mix 28^0C	RSC1	114.00	114.00	0	0	8.40	3.704	3.714
	RSC2	112.50	112.50	0		8.30	3.660	
	RSC3	113.00	113.00	0		8.60	3.792	
100^0 C	SC11	113.50	109.40	3.61	3.85	8.10	3.572	3.630
	SC12	113.50	109.10	3.87		8.20	3.616	
	SC13	113.00	108.40	4.07		8.40	3.704	
200^0 C	SC21	113.00	107.10	5.22	5.26	7.60	3.351	3.240
	SC22	113.30	107.40	5.20		7.10	3.131	
	SC23	113.50	107.40	5.37		7.40	3.263	

300^0C	SC31	114.00	106.20	6.84	6.94	6.90	3.042	2.98
	SC32	114.00	106.30	6.75		6.70	2.954	
	SC33	112.00	103.90	7.23		6.70	2.954	
400^0C	SC41	116.00	105.70	8.87	8.16	6.20	2.734	2.740
	SC42	113.50	103.70	8.63		6.20	2.734	
	SC43	113.40	105.50	6.97		6.30	2.778	
500^0C	SC51	111.00	99.60	10.27	10.42	5.40	2.381	2.30
	SC52	114.00	102.60	10.00		4.90	2.160	
	SC53	113.70	101.20	11.00		5.00	2.340	
600^0C	SC61	113.00	99.25	12.16	13.30	3.70	1.631	1.778
	SC62	112.80	96.50	14.45		4.10	1.808	
	SC63	113.50	98.40	13.30		4.30	1.896	

D) Impact Strength Test

a) Result for Ordinary conventional Concrete

Table 7: Impact strength results at different temperatures for OCC

Temp.	Identification of specimen	Wt. before placing (N)	Wt. after removing (N)	% weight loss	Avg. % Wt loss	No. of blows required to cause		Impact energy (N-m) to cause		Avg. impact energy (N-m)	
						Initial crack	Final failure	Initial crack	Final failure	Initial crack	Final failure
Reference Mix 28^0C	ROC1	61.20	61.20	0	0	4	9	50.80	114.30	59.26	105.83
	ROC2	60.50	60.50	0		5	8	63.50	101.60		
	ROC3	60.50	60.50	0		5	8	63.50	101.60		
100^0 C	OC11	60.00	57.40	4.33	4.77	3	8	38.10	101.60	50.80	93.13
	OC12	58.50	55.80	4.61		4	7	50.80	88.90		
	OC13	59.50	56.30	5.37		5	7	63.50	88.90		
200^0 C	OC21	61.00	57.00	6.55	6.26	3	5	38.10	63.50	42.33	67.73
	OC22	60.50	56.90	5.95		3	6	38.10	76.20		
	OC23	60.40	56.60	6.29		4	6	50.80	76.20		
300^0C	OC31	62.20	57.70	7.23	6.97	2	4	25.40	50.80	29.63	55.03
	OC32	60.10	56.10	6.65		3	5	38.10	63.50		
	OC33	59.90	55.70	7.01		2	4	25.40	50.80		
400^0C	OC41	59.50	54.30	8.73	8.30	1	3	12.70	38.10	21.17	42.33
	OC42	57.80	52.50	9.16		2	3	25.40	38.10		
	OC43	60.00	55.80	7.00		2	4	25.40	50.80		
500^0C	OC51	61.20	54.20	11.43	11.0	1	2	12.7	25.40	8.47	29.63

								0			
	OC52	63.50	56.90	10.39		1	3	12.7 0	38.10		
	OC53	60.70	53.80	11.36		0	2	0	25.40		
600^{0}C	OC61	61.30	52.50	14.59	13.5	0	2	0	25.40	0.00	21.17
	OC62	60.70	52.90	12.85		0	2	0	25.40		
	OC63	60.70	52.70	13.17		0	1	0	12.70		

b) Result for Seff Compacting Concrete

Table 8: Impact strength results at different temperatures for SCC

Temp.	Identification of specimen	Weight before placing (N)	Weight after removing (N)	% weight loss	Avg. % weight loss	No. of blows required to cause		Impact energy (N-m) to cause		Avg. impact energy (N-m)	
						Initial crack	Final failure	Initial crack	Final failure	Initial crack	Final failure
Reference Mix 28^{0}C	RSC1	54.50	54.50	0	0.00	5	7	63.50	88.90	59.27	88.90
	RSC2	54.00	54.00	0		5	7	63.50	88.90		
	RSC3	52.70	52.70	0		4	7	50.80	88.90		
100^0 C	SC11	54.00	52.20	3.330	3.77	5	7	63.50	88.90	50.80	76.20
	SC12	54.00	52.90	2.030		4	6	50.80	76.20		
	SC13	53.60	50.40	5.970		3	5	38.10	63.50		
200^0 C	SC21	53.10	50.90	4.140	4.74	3	5	38.10	63.50	42.33	67.73
	SC22	54.00	51.40	5.060		3	5	38.10	63.50		
	SC23	53.70	51.00	5.030		4	6	50.80	76.20		
300^{0}C	SC31	54.70	51.50	5.85	6.47	2	3	25.40	38.10	29.63	46.57
	SC32	53.50	49.80	6.91		3	4	38.10	50.80		
	SC33	54.20	50.60	6.64		2	4	25.40	50.80		
400^{0}C	SC41	53.00	47.40	10.56	9.83	1	2	12.70	25.40	16.93	29.63
	SC42	52.50	47.60	9.33		1	2	12.70	25.40		
	SC43	54.00	48.80	9.62		2	3	25.40	38.10		
500^{0}C	SC51	53.50	47.40	11.40	12.11	1	2	12.70	25.40	4.23	16.93
	SC52	53.30	46.60	12.57		0	1	0.00	12.70		
	SC53	53.30	46.70	12.38		0	1	0.00	12.70		
600^{0}C	SC61	55.10	47.10	14.51	15.50	0	1	0.00	12.70	0.00	8.47
	SC62	54.20	45.60	15.86		0	1	0.00	12.70		
	SC63	54.00	45.30	16.11		0	0	0.00	0.00		

RESULT

A) Overall Comparative Results of Compressive Strength of OCC and SCC at various Temperature

The Table 9: gives the comparative results of Compressive strength of OCC and SCC when subjected to sustained temperature along with percentage change.

Table 9: Comparative results of Compressive strength of OCC & SCC

	Temperature	% Decrease in Compressive strength	
		OCC	SCC
Compressive strength	28ºC	0.00	0.00
	100 ºC	0.50	2.91
	200 ºC	4.00	7.61
	300 ºC	10.00	14.10
	400 ºC	17.00	18.21
	500 ºC	24.00	24.13
	600 ºC	28.50	30.00

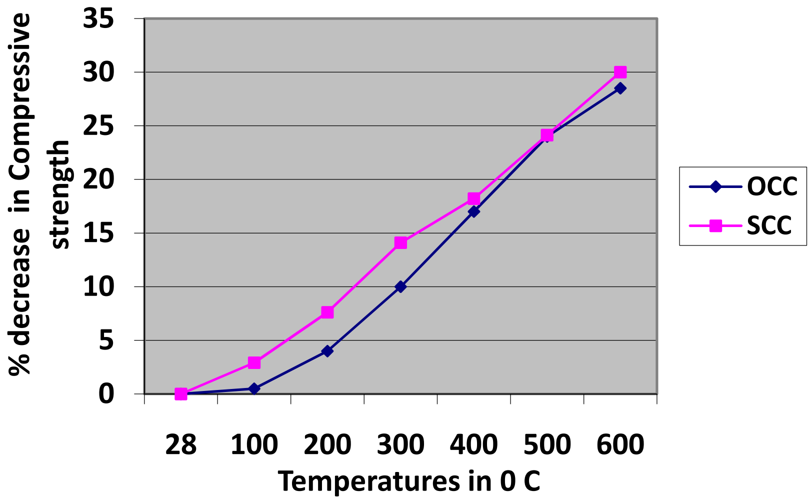

Fig. 1 Percentage decrease in Compressive strength for OCC and SCC at various temperatures.

B) Overall Comparative Results of Split Tensile Strength of OCC and SCC at various Temperature

The table 10 gives the comparative results of Split tensile strength of OCC and SCC when subjected to sustained temperature along with percentage change.

Table 10 Comparative result of Split tensile strength of OCC & SCC

Temperature	% Decrease in Split tensile strength	
	OCC	SCC
28ºC	0.00	0.00
100 ºC	1.25	2.56
200 ºC	16.26	14.51
300 ºC	22.34	22.96
400 ºC	30.72	31.62
500 ºC	42.13	48.01
600 ºC	51.21	60.91

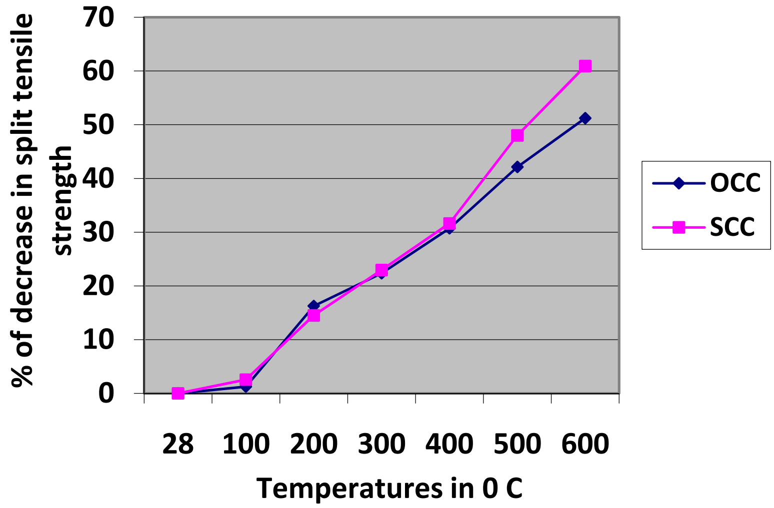

Fig. 2 Percentage decrease in Split tensile strength for OCC and SCC at various temperatures.

C) Overall Comparative Results of Flexural Strength of OCC and SCC at various Temp

The Table 11: gives the comparative results of Flexural strength of OCC and SCC when subjected to sustained temperature along with percentage change.

Table 11: Comparative result of flexural strength of OCC & SCC

Test Name	Temperature	% Decrease in Flexural strength	
		OCC	SCC
Flexural strength	28ºC	0.00	0.00
	100 ºC	2.31	2.26
	200 ºC	14.87	12.76
	300 ºC	16.92	19.76
	400 ºC	28.20	26.22
	500 ºC	36.41	38.07
	600 ºC	46.67	52.12

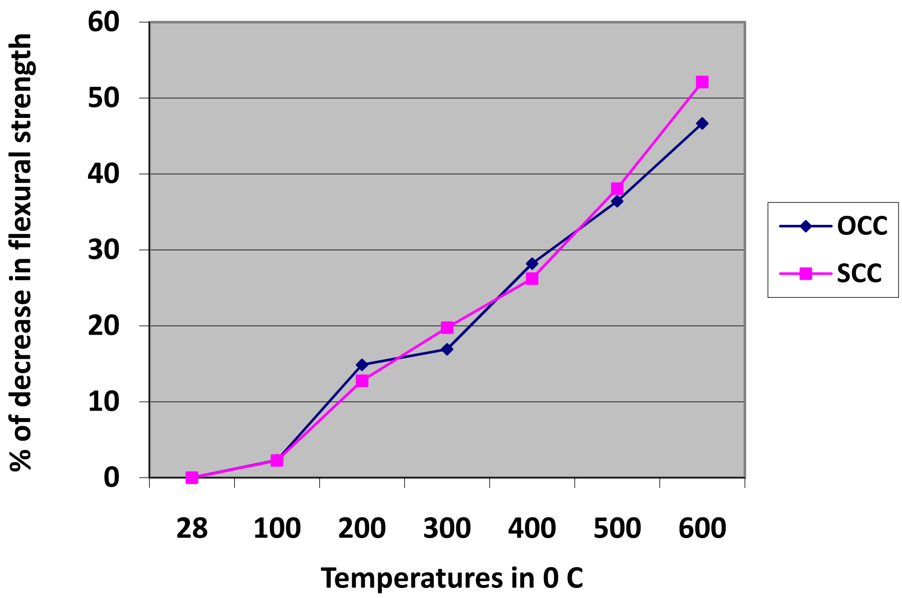

Fig. 3 Percentage decrease in Flexural strength for OCC and SCC at various temperatures

D) Overall Comparative Results of Impact Strength of OCC and SCC at various Temp

The Table 12 gives the comparative results of Compressive strength of OCC and SCC when subjected to sustained temperature along with percentage change.

Table 12 Comparative result of impact strength of OCC & SCC

Test Name	Temperature	% Decrease in Impact strength	
		OCC	SCC
Impact strength	28ºC	0.00	0.00
	100 ºC	12.00	14.28
	200 ºC	35.98	24.26
	300 ºC	48.00	47.61
	400 ºC	60.00	66.67
	500 ºC	72.00	80.95
	600 ºC	80.00	90.47

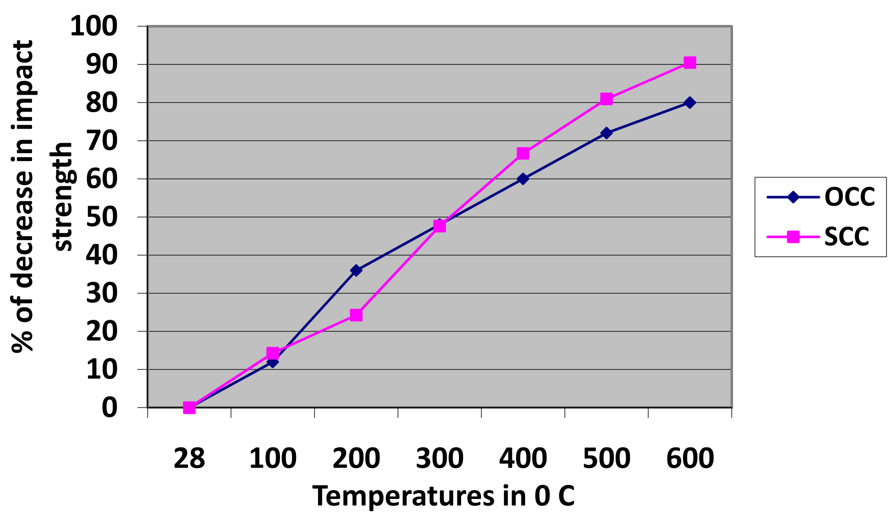

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Fig. 4 Percentage decrease in Impact strength for OCC and SCC at various temperatures.

Effect of Temperature on Compressive Strength

From the Table 1 & Table 2, It has been observed that the compressive strength of conventional concrete and self compacting concrete, when subjected to 100ºC, 200ºC, 300ºC, 400ºC, 500ºC and 600ºC temperature for 5 hours, the corresponding compressive strength was 28.92 Mpa and 23.98 Mpa, 27.90 Mpa and 22.82 Mpa, 26.16 Mpa and 21.22 Mpa, 24.12 Mpa and 20.20 Mpa, 22.09 Mpa and 18.74 Mpa and 20.80 Mpa and 17.30 Mpa respectively. i.e. the percentage decrease in the compressive strength, for OCC is 0.5% , 4.0%, 10.0% , 12.0%, and 24.0% and 28.50% and for SCC is 2.91 %, 7.61 %, 14.10 %, 18.21 %, 24.13 % and 30.0 % as compared to reference mix (at room temperature).

Fig. 1 shows the percentage change in compressive strength between ordinary concrete and self compacting concrete at various temperatures. The compressive strength of self compacting concrete and ordinary concrete is dropped considerably up to 200ºC. In practice, when temperatures reaches the 300ºC, the calcium hydroxide in the cement will begin to dehydrate, generating more water vapour and also bringing about significant reduction in the compressive strength of the ordinary concrete and self compacting concrete in range of 300ºC and 600ºC. But the compressive strength loss in self compacting concrete is seen more than the ordinary concrete because of the quantity of cement required is about 5-20% less than that of ordinary concrete.

Effect of temperature on Split Tensile Strength

From the Table 3 & 4, It has been observed that the split tensile strength of conventional concrete and self compacting concrete, when subjected to 100ºC, 200ºC, 300ºC, 400ºC, 500ºC, 600ºC temperature for 5 hours, the corresponding split tensile strength was 3.806 Mpa and 2.967 Mpa, 3.227 Mpa and 2.603 Mpa, 2.993 Mpa and 2.346 Mpa, 2.670 Mpa and 2.082 Mpa, 2.230 Mpa and 1.583 Mpa and 1.880 Mpa and 1.190 Mpa respectively. i.e. the percentage decrease in the split tensile strength, for OCC is 1.25%, 16.26%, 22.34%, 30.72% ,42.13% and 51.21%, and for SCC is 2.56 %, 14.51 % , 22.96 % , 31.62 % and 48.01 % and 60.91 % as compared to reference mix (at room temperature).

Fig. 2 shows the split tensile strength for ordinary concrete and self compacting concrete as a function of maximum temperature. Similar to the compressive strength, the tensile strength showed significant losses with the increase in the exposed temperature. The results shown in Fig. 2 indicated that the self compacting concrete having fly ash and cement quantity 5-20% less than ordinary concrete suffered significant loss in strength at the temperature of 600ºC.

Effect of temperature on Flexural Strength

From the Table 5 & Table 6, It has been observed that the flexural strength of conventional concrete and self compacting concrete, when subjected to 100ºC, 200ºC, 300ºC, 400ºC, 500ºC, 600ºC temperature for 5 hours, the corresponding flexural strength was 3.810 Mpa and 3.630 Mpa, 3.320 Mpa and 3.240 Mpa, 3.240 Mpa and 2.980 Mpa, 2.800 Mpa and 2.740 Mpa, 2.480 Mpa and 2.300 Mpa and 2.080 Mpa and 1.778 Mpa respectively. i.e. the percentage decrease in the flexural strength, for OCC is 2.31%, 14.87%, 16.92%, 28.20%, 36.41% and 46.67% and for SCC is 2.26%, 12.76%, 19.76%, 26.22%, 38.07% and 52.12 % as compared to reference mix (at room temperature).

Fig. 4 shows the effect of heating on the flexural strength for ordinary concrete and self compacting concrete in relation to the corresponding strength before heating. Similar to compressive and tensile strengths of concrete, the flexural strength decreased with temperature. Once again the binder material type had influenced the extent of strength loss. (i.e. more flexural strength loss seen in self compacting concrete than the ordinary concrete.)

Effect of temperatures on Impact Strength

From the Table 7 & Table 8, It has been observed that the impact strength of conventional concrete and self compacting concrete, when subjected to 100ºC, 200ºC, 300ºC, 400ºC, 500ºC, 600ºC temperature for 5 hours, the corresponding impact strength was 93.130 N-m and 76.200 N-m, 67.730 N-m and 67.330 N-m, 55.030 N-m and 46.570 N-m, 42.330 N-m and 29.690 N-m, 29.630 N-m and 16.93 N-m, and 21.170 N-m and 8.470 N-m respectively. i.e. the percentage decrease in the flexural strength, for OCC is 12.00%, 35.98%, 48.00%, 60.00%, 72.00% and 80.00% and for SCC is 14.28%, 24.26 %, 47.61 %, 66.67 % and 80.95% as compared to reference mix (at room temperature).

Fig. 4 shows the percentage change in the impact strength between the ordinary concrete and self compacting concrete at various temperatures. When concrete is subjected to impact type of loading condition, energy is absorbed in process of plastic deformation of matrix material. The phenomenon that absorbs the least amount of energy for its occurrence becomes prominent and leads to fracture. In case when smaller particles are incorporated in the matrix, crank length increases considerably during the process of fracture. The more energy is consumed in self compacting concrete when temperature is rising from 300ºC upto 600ºC.

CONCLUSION

Based on the results of this experimental work the following investigation can be made.

1. As temperature is increased to 200^0C the compressive, split tensile flexural strength and impact strength of specimens is decreased by 4.00%, 16.26%, 14.87% and 35.98% respectively to the room temperature strength for Ordinary Concrete. For Self Compacting Concrete, the reduction in compressive strength, split tensile strength, flexural strength and impact strength is 7.61%, 14.51%, 12.76%, 24.26% respectively.
2. As temperature is increased to 400^0C the compressive, split tensile flexural strength and impact strength of specimens is decreased by 17.00%, 30.72%, 28.20% and 60.00% respectively to the room temperature strength for Ordinary Concrete. For Self Compacting Concrete, the reduction in compressive strength, split tensile strength, flexural strength and impact strength is 18.21%, 31.62%, 26.22%, 66.67% respectively.
3. As temperature is increased to 600^0C the compressive, split tensile flexural strength and impact strength of specimens is decreased by 28.50%, 51.21%, 46.67% and 80.00% respectively to the room temperature strength for Ordinary Concrete. For Self Compacting Concrete, the reduction in compressive strength, split tensile strength, flexural strength and impact strength is 30.00%, 60.91%, 52.12%, 90.47% respectively.
4. SCC has a higher strength loss than OCC in the temperature range between 200^0C to 600^0C.
5. SCC is more susceptible to explosive spalling when exposed to temperature above 300^0C upto the 600^0C.

REFERENCES

[1] A. Ian Fletcher, S. Welch and J. L. Torero (Nov. 2007) "Behavior of Concrete Structures in Fire", Thermal Science, BIBLID, pp. 37-52.

[2] A. Mittal, M. B. Kaisare and R.G. Shetti (Jun 2004), "Use of SCC in a Pump House at TAPP 3&4, Tarapur", The Indian Concrete Journal, pp.30-33.

[3] A. Noumowe, H. Toutanji, A. Daoud and H. Toutanji (Mar. 2006), "High Strength Self Compacting Concrete Exposed to Fire Test", American Society of Civil Engineers, Reston, pp.754-758.

[4] B. Persson (Nov. 2004), "Self Compacting Concrete at Fire Temperature" Division of Building Materials, Lund Institute of Technology, Sweden, pp. 575-584.

[5] SS

[6] B. B. Limaye, N. Raghvan, K .S. R. K. Verma, R. S.Pandit and Vinod Rajyogan (Jan. 2004), " The Use of Self Compacting Concrete as Backpack Concrete in Tunnel for Khopoli New Water Conductor System", ICFRC, Chennai, pp. 893-904.

[7] B. Sivarama Sharma and S. Manohar. (Dec. 2003), "Advances of Self Compacting Concrete in Indian Scenario", The Indian Concrete Journal, pp. 1503-1508.

[8] D. Chattopadhyay and S Subramaniam (Jan. 2002), "Experiments for Mix Proportioning of Self Compacting Concrete", The Indian Concrete Journal, pp.13-20.