International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 04
February 2018

Study on Structural Behaviour of Normal Concrete and Scc Subjected To Elevated Temperature

NARLAGIRI SNEHASREE (M.Tech.(SE)) snehasri.narlagiri@gmail.com[1]

U POORNA CHARY (Associate Professor) poornachary0406@gmail.com[2]

Department of CIVIL, [1]SVS GROUP OF INSTITUTIONS, WARANGAL, TS, (506015), INDIA

ABSTRACT

Cement concrete is a complex mixture of different materials, for which the properties may alter in different environmental conditions. The behaviour of concrete in fire depends on its mix proportions and constituents. The principle effects observed in the concrete due to elevated temperatures are loss in compressive strength, loss in weight (or) mass, change in colour and spalling of concrete. Due to these changes there is a great need of study in this region. The objective of this limited study was to provide an overview of the effects of elevated temperature on the behaviour of concrete. In meeting this objective, the effects of elevated temperature on the properties of normal concrete and self compacting concrete materials are summarized. The compressive strength was determined at different temperatures, thus providing scope of determining loss/gain in strength. In addition, modes of cooling, variation in different grades of concrete were studied. As the fire affected concrete cannot undergo destructive in practical situations, Non-destructive testing (NDT) methods, i.e., Rebound hammer test were also adopted and the results were co-related.

1. INTRODUCTION

Concrete is main ingredient used in construction where it should resist the fire. Over the last three decades, there have been significant research and development activity in concrete technology and this has led to improved concrete mixes known as High performance concrete. These HPC mixes include High Strength concrete (HSC), Self Compacting Concrete (SCC), Fibre Reinforced Concrete (FRC) and Fly ash Concrete (FAC) which are economic ,durable and have more high Strength .concrete is made by lowering the water cement ratio to as low as 0.3 due to which the strength, modulus of elasticity of the concrete increases. The ingredients of high strength concrete are the same as those used in conventional concrete with the addition of one or two admixtures, both chemical and mineral. High Strength Concrete reduces the quantity of the concrete required compared to the conventional concrete so the cost of construction will be less. High strength concrete requires less formwork so the construction time reduced while removing the formwork etc.

SCC is prepared by increasing the water cement ratio, reducing the coarser and fine aggregate volume , increasing cement volume and maintaining the coarse aggregate size as same . The behaviour of concrete in fire depends on its proportions of aggregates ,cement water-cement ratio used and types of materials and admixtures used and it is find out by thermal properties those heat transformation during the fire and temperature level. Normal strength concrete and high performance concrete micro structure follows similar trends when heated, but ultra high strength concrete behaves differently. A key property unique to concrete amongst structural materials is transient creep. Failure of structural concrete in fire varies according to the nature of the fire; the loading system and the type of structure .The spalling action is reduced by providing polymers as admixtures in the concrete.

2. LITERATURE REVIEW

The behaviour of RC members under fire is quite different from that at room temperature mainly due to the fact that under fire conditions, applied loads generally remains constant, but the strength and stiffness of the member degrade with fire exposure time. The increasing temperatures lead to gradual degradation of properties in concrete and reinforcing steel which in turn reduces the strength and stiffness of the member. With the progression of fire exposure time, this rise in temperature extends to the inner layers of concrete leading to further reduction in strength and stiffness, which will continue till the strength of the member decreases to the level of the applied loads.

Sujith Ghosh et al

This studied on the effects of high temperature up to 232ºC and high pressures up to 13.8 Mpa on the concrete .They concluded that there is a decrease in strength due to decrease in bond strength between the materials with temperature.

Sarshar R and khoury G.A et al

This theory carried out investigations to asses the influence of material and environmental factors on the compressive strength of unsealed cement paste and concrete at higher temperatures and found that both material and environmental factors were influencing the strength of concrete during the heat cycle and after cooling. Duration of high temperature did not significantly affect the residual compressive strength of the specimens except at lower temperature ranges of 100ºC. They concluded that at high temperature there is no changes in strength and while decreasing the temperature there is a much differences in strength.

Castilo C and Durrani A J

In this carried out investigations to study the effect of transient high temperatures on compressive strength of high strength concrete under both unloaded and pre loaded conditions and to compare the behaviour with that of normal strength concrete. Based on the results obtained in the study it was concluded that when exposed temperatures in the range of 100 to 300ºC.

M. Saad etal

This paper investigated the effect of temperature on physical and mechanical properties of concrete. In their study ordinary Portland cement has been replaced by silica fume and fly ash. The heat treatment temperature varied from 100 to 600ºC for three hours without any load. The specimens were heated under similar conditions for each temperature level. Comparisons between physical and mechanical properties during heat treatment were investigated. All specimens were moist cured for 28 days after casting. Results of this investigation indicated that replacement of ordinary Portland cement by 10% silica fume by weight improved the compressive strength by about 64.6% but replacement of ordinary Portland cement by 10% silica fume by ratios 20 and 30 % improved the compressive strength by about 28% at 600ºC.

International Journal of Research
Available at https://edupediapublications.org/journals

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 04
February 2018

3. EXPERIMENTAL PROGRAME

OBJECT AND SCOPE OF INVESTIGATION:

The objective of the investigation tries to answer the following questions:

1. What are the changes in structural behaviour of the concrete when it is subjected to high temperature?
2. How to quantify changes in structural behaviour of NC and SCC when these subjected to high to high temperature?
3. What is the effect of cooling regime on the strength behaviour of SCC and NC?
4. Is there any risk of spalling of concrete when it is subjected to high temperatures?
5. How the hardness of surface is changing with elevated temperatures?

In this experiment 120 cubes 60 cubes were casted with M20 and M40 NC and remaining 60 cubes were casted with the same grades of SCC.

S. NO	Grade of concrete	Temperature	No: of specimens cast 150X150X150mm (Hot state)	No: of specimens cast150X150X150mm (Air cooling)	No: of specimens cast 150X150X150mm (Water quenching)	No: of specimens cast 150X150X150mm
1.	M20	-	-	-	-	3
		400°C	3	3	3	-
		600°C	3	3	3	-
		800°C	3	3	3	-
2.	M40	-	-	-	-	3
		400°C	3	3	3	-
		600°C	3	3	3	-
		800°C	3	3	3	-
3.	M20	-	-	-	-	3
		400°C	3	3	3	-
		600°C	3	3	3	-
		800°C	3	3	3	-
4.	M40	-	-	-	-	3
		400°C	3	3	3	-
		600°C	3	3	3	-
		800°C	3	3	3	-

MIX DESIGN:

From technical point of view the rich mixes may lead to high shrinkage and cracking in the structural concrete, and to evolution of high heat of hydration in mass concrete which may cause cracking.

REQUIREMENTS OF CONCRETE MIX DESIGN:

The concrete mix design proportions are provided in Table

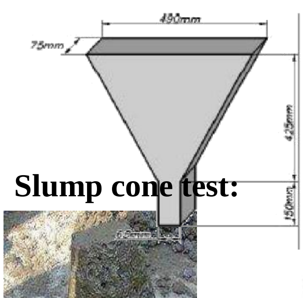
Concrete mix design proportions

	M20	M40
Cement	280	310
Fine aggregate	1000	1100
Coarse aggregate	640	690
Water-cement ratio	0.51	0.62

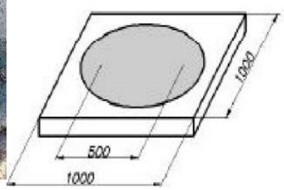
TESTS ON CONCRETE:

1Compacting Factor

International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 04
February 2018



Slump cone test:



SCC Mix proportions

M20

C/F = 40/60

	Cement	Flyash	F.A	C.A	Water	SP430	
	270	200	1155	696	202.5	33.22	
	1	0.74	4.28	2.6	0.75	0.123	
20-16	12.5	10	4.75	2.36	1.18	0.6	0.3
0.04	0.04	0.12	0.2	0.03	0.06	0.21	0.3

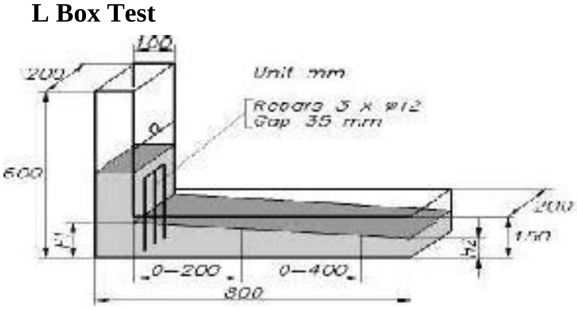
M40

C/F = 40/60

	Cement	Flyash	F.A	C.A	Water	SP430	
	420	154	1132.56	682.44	226.8	31.08	
	1	0.36	2.7	1.62	0.54	0.074	
20-16	12.5	10	4.75	2.36	1.18	0.6	0.3
0	0.05	0.05	0.3	0.03	0.06	0.21	0.3

V funnel test

L Box Test



Cube Compressive test

4. LABORATORY OBSERVATIONS RECORDED

I. COMPRESSIVE STRENGTH:

1. Compressive strength of M20 NC

Temp	At air cooling	At water quenching	At hot condition
Room temperature(27)	26.00	26.00	26.00
400	50.33	21.66	39.00
600	26.80	21.03	17.63
800	11.36	16.36	15.00

2. Compressive strength of M20 SCC

Temp	At air cooling	At water quenching	At hot condition
Room temperature(27)	27.56	27.56	27.56
400	17.71	22.27	18.77
600	9.12	17.12	18.18
800	6.05	6.54	10.75

3. Compressive strength of M40 grade NC

Temperature provided	Compressive strength under air cooling	Compressive strength under water quenching	Compressive strength under hot condition
Room temperature(27)	49.75	49.75	49.75
400	27.72	31.36	48.18
600	16.81	23.50	33.18
800	14.80	13.80	16.90

4. Compressive strengths of M40 grade SCC

International Journal of Research
Available at https://edupediapublications.org/journals

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 04
February 2018

Temperature provided	Compressive strength under air cooling	Compressive strength under water quenching	Compressive strength under hot condition
Room temperature(27)	50.60	50.60	50.60
400	18.40	13.18	29.66
600	16.80	17.95	30.00
800	10.90	12.00	15.60

Temperature provided	Compressive strength in air cooling(NC)	Compressive strength in air cooling(SCC)
Room temperature(27)	26.00	27.56
400	50.33	17.71
600	26.80	9.12
800	11.36	6.05

5.Comparison of Compressive strengths of M20 NC vs SCC under different cooling regimes.

Temperature provided	Compressive strength in water quenching (NC)	Compressive strength in water quenching (SCC)
Room temperature(27)	26.00	27.56
400	21.66	22.27
600	21.03	17.12
800	16.36	6.54

6.Comparison of Compressive strengths of M20 NC vs SCC under different cooling regimes.

Temperature provided	Compressive strength in high temperature condition (NC)	Compressive strength in high temperature condition (SCC)
27	27.00	27.56
400	39.00	18.77
600	17.63	18.18
800	15.00	10.75

7.Comparison of Compressive strengths of M40 NC vs SCC under different cooling regimes.

Temperature provided	Compressive strength in low temperature condition(NC)	Compressive strength in low temperature condition(SCC)
Room temperature(27)	49.75	50.60
400	27.72	18.40
600	16.81	16.80
800	14.80	10.90

8.Comparison of Compressive strengths of M40 NC vs SCC under different cooling regimes

Temperature provided	Compressive strength in water quenching (NC)	Compressive strength in water quenching (SCC)
Room temperature(27)	49.75	50.6
400	31.36	13.18
600	23.5	17.95
800	13.8	12

9.Comparisons of Compressive strengths of M20 NC vs SCC under different cooling regimes.

Temperature provided	Compressive strength in (NC)	Compressive strength in (SCC)
Room temperature(27)	49.75	50.6
400	48.18	29.66
600	33.18	30.00
800	16.9	15.6

II. TEST RESULTS ON REBOUND NUMBER

1. Rebound numbers of M20 grade NC

Temperature Provided	Rebound number under air cooling	Rebound number under water quenching	Rebound number under hot condition
Room temperature(27)	26	26	26
400	23	21	21
600	21	20	19
800	12	14	12

2. Rebound numbers of M20 grade SCC

Temperature provided	Rebound number under air cooling	Rebound number under water quenching	Rebound number under hot condition
Room temperature(27)	28	28	28
400	12	13	10
600	11	10	10
800	10	10	10

3. Rebound numbers of M40 grade NC

Temperature provided	Rebound number under air cooling	Rebound number under water quenching	Rebound number under hot condition
Room temperature(27)	45	45	45
400	25	20	22
600	13	16	14
800	10	10	10

4. Rebound numbers of M40 grade SCC

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 04
February 2018

Temperature provided	Rebound number under air cooling	Rebound number under water quenching	Rebound number under hot condition
Room temperature(27)	40	40	40
400	13	12	10
600	11	11	10
800	10	10	10

5. Comparison of M20 NC vs SCC Rebound numbers

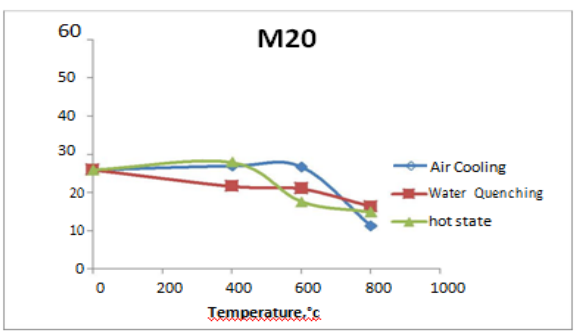
Temperature provided	Rebound number in air cooling(NC)	Rebound number in air cooling(SCC)
Room temperature(27)	27	28
400	22	13
600	21	10
800	11	10

6. Comparison of Rebound numbers of M40 NC vs SCC

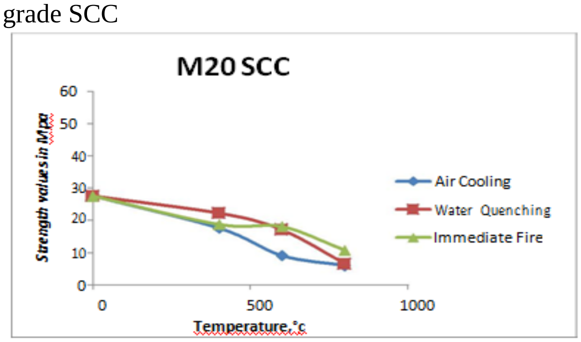
Temperature provided	Rebound number in air cooling(NC)	Rebound number in air cooling(SCC)
Room temperature(27)	46	40
400	24	13
600	14	12
800	10	09

5. RESULTS AND DISCUSSIONS

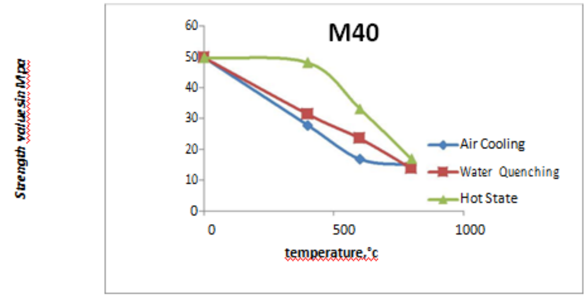
Compressive Strength Vs Temperature for M20 grade NC



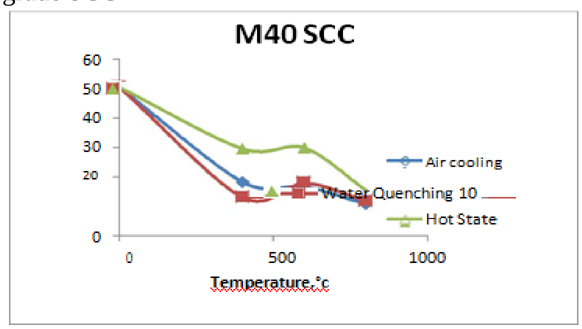
Compressive Strength Vs Temperature for M20 grade SCC



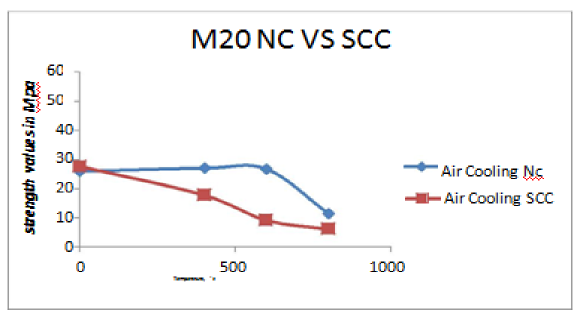
Compressive Strength Vs Temperature for M40 grade NC



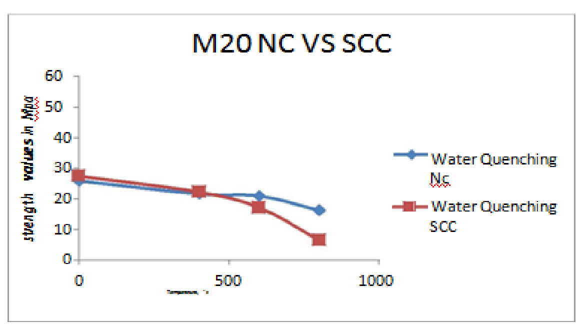
Compressive Strength Vs Temperature for M40 grade SCC



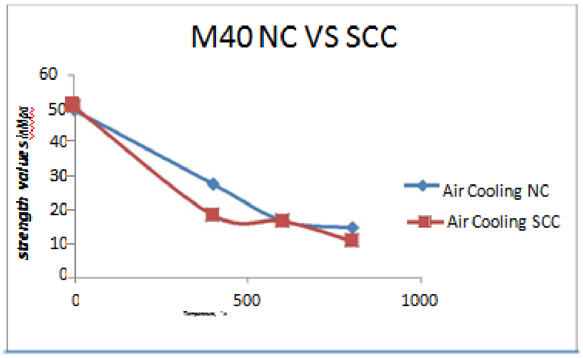
Compressive Strength Vs Temperature for M20 grade NC and SCC under Air Cooling



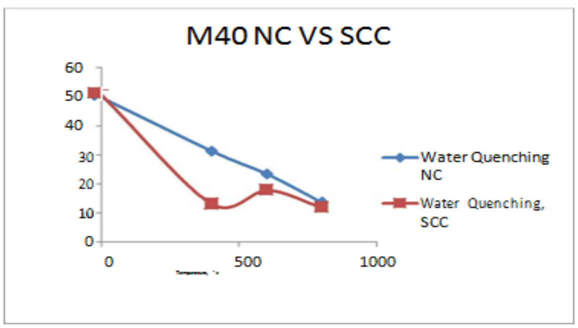
Compressive Strength Vs Temperature for M20 grade NC and SCC under Water Quenching



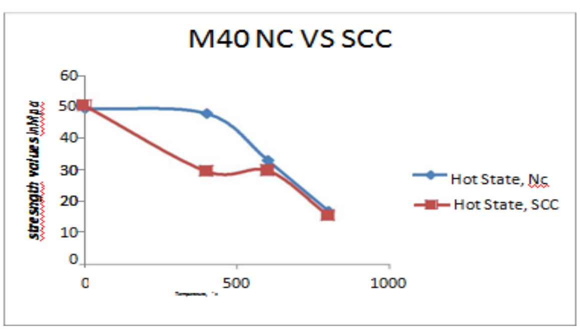
Compressive Strength Vs Temperature for M40 grade NC and SCC under Air Cooling



Compressive Strength Vs Temperature for M40 grade NC and SCC under Water Quenching

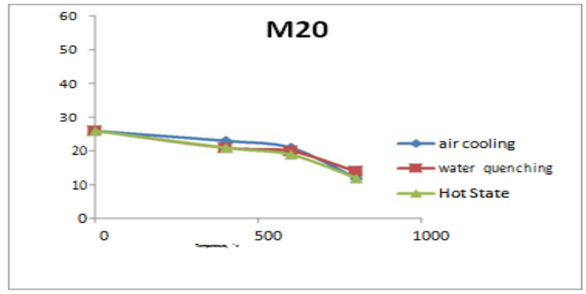


Compressive Strength Vs Temperature for M40 grade NC and SCC under Hot Condition

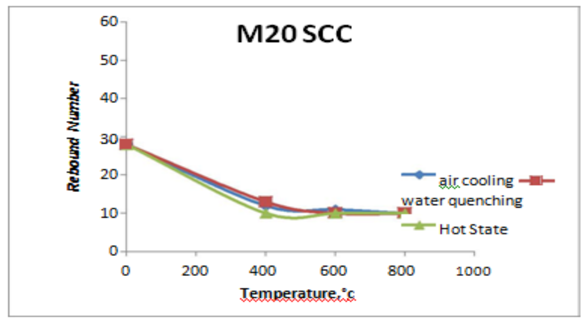


2 Graphs representing rebound number:

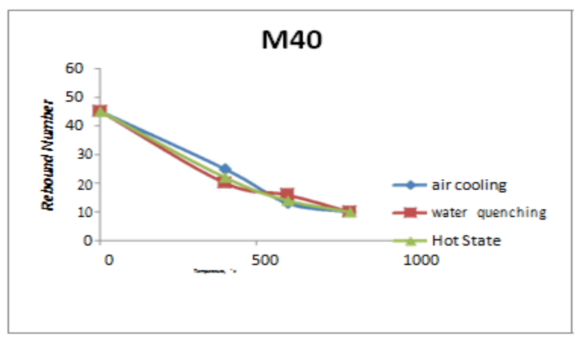
Rebound Number Vs Temperature for M20 grade NC



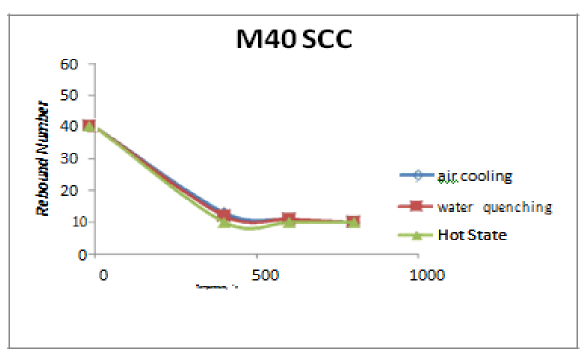
Rebound Number Vs Temperature for M20 grade SCC



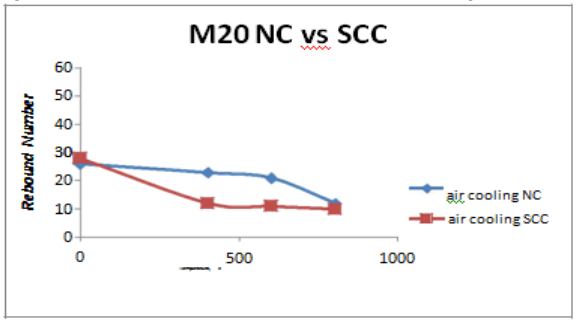
Rebound Number Vs Temperature for M40 grade NC



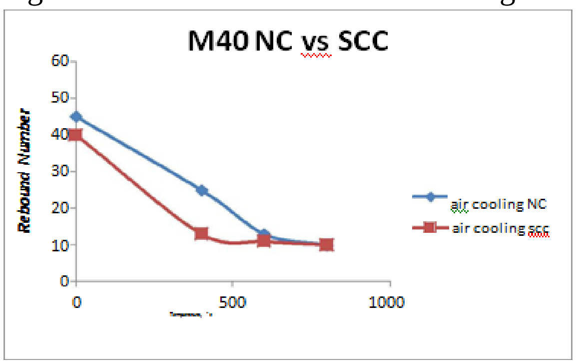
Rebound Number Vs Temperature for M40 grade SCC



Rebound Number Vs Temperature for M20 grade NC and SCC under Air Cooling



Rebound Number Vs Temperature for M40 grade NC and SCC under Air Cooling



6. CONCLUSIONS

1. Compressive strength of the concrete decreased as temperature increases. Loss of Compressive strength SCC is more than the loss in NC.
2. In case of NC the strength decrease on an average is observed to be 16.6%, 25.5% and 43% and SCC values are 30.1%, 47% and 72.1% at 400°c, 600°c and 800°c respectively.
3. Higher strength concretes have higher percent loss in strength than lower strength concrete. However the difference becomes less significant at temperatures greater than 400°c.

Of the three states of 'testing of specimens' i.e.

1. Testing after air cooling
2. Testing after water quenching
3. Testing in hot state,
4. Normally referred to as cooling regimes, more percent decrease in strength
5. observed in case of 'testing after air cooling' in both NC and SCC.
6. Testing after water quenching resulted in higher loss in strength compared to the strength obtained in testing at hot condition.

REFERENCES

I. T. Z. Harmathy, "Thermal Properties of Concrete at Elevated Temperatures," J. of Materials 5, 47–74 (1970).

II. EFNARC.2005,Specification and guidelines for self compacting concrete

III. Persson,Bertil.2001,"A comparison between mechanical properties of self Compacting concrete and the corresponding properties of normal concrete."Cement and concrete Research 31.2:pp.193-198

IV. D. T. Lankard et al., "Effects of Moisture Content on the Structural Properties of Portland Cement Concrete Exposed to Temperatures Up to 500°F," SP-25 Temperature and Concrete, pp. 59–102, American Concrete Institute, Farmington Hills, Michigan, 1971.

V. Study on compressive strength behaviour of normal concrete and self compacting concrete subjected to elevated temperatures D.Rama Seshu, A.Pratusha Magazine of Concrete Research , Volume 65, lssue 7,1 Apr 2013.

VI. D. H. H. Quon, Phase Changes in Concrete Exposed to Sustained High Temperatures, Division Report MRP/MSL 80-111(TR), Mineral Sciences Laboratories, CAANMET,

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 04
February 2018

Ottawa, Canada, August 1980. 13.

VII. L. T. Phan and N. J. Carino, "Fire Performance of High Strength Concrete: Research Needs," Applied Technology in Structural Engineering, Proceedings ASCE/SEI Structures Congress 2000, 8–10 May 2000, Philadelphia, Pennsylvania. 23. S. E.

VIII. Pihlajavaara, "An Analysis of the Factors Exerting Effect on Strength and Other Properties of Concrete At High Temperature," Paper SP 34-19