Strengthening Studies of Self Compacting Concrete at Elevated Temperatures

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***Abstract*: In the present research, the experimental investigation was carried out to evaluate the strength propertiesand permeability (rapid chloride permeability) studies of SCC mixes at elevated temperatures up to 300ºC. Cement was replaced with three percentages (0%, 30%, 40%, and 50%) of fly ash and fine aggregate was replaced with 10% of foundry sand by weight. A total of four SCC mixes (SCC1, SCC2, SCC3, and SCC4) were developed. The control mix (SCC1) was developed without fly ash and foundry sand. Mix SCC2 was with 30% fly ash and 10% foundry sand, mix SCC3 was developed with 40% fly ash and 10% foundry sand, and the mix SCC4 was with 50% fly ash and 10% foundry sand. The specimens of each SCC mixture were heated up to different temperatures (100°C, 200°C, and 300°C). In order to ensure a uniform temperature throughout the specimens, the temperature was held constant at the maximum value for one hour before cooling. Tests were performed for compressive strength, splitting tensile strength, after curing periods of 28, 91 days.**

Key Words: Compressive Strength, Splitting Tensile Strength.

1. INTRODUCTION:

Cement-based materials are the most abundant of all man-made materials and are among the most important construction materials, and it is most likely that they will continue to have the same importance in the future. However, these construction and engineering materials must meet new and higher demands.

It is the most widely use construction material because of its ability that allows moulding into any required structural form and shape due to its fluid behaviour at early ages. However, there is a limit to the fluid behaviour of normal fresh concrete.

Under water-concreting, filling of congested sections and inaccessible areas are some of the several situations where concrete has to be placed in conditions in which compaction is extremely difficult. Thorough compaction, using vibration, is normally essential for achieving workability, the required strength and durability of concrete. Inadequate compaction of concrete.

1.2aim&Objectives:

To achieve the required fresh properties of deformability, segregation resistance and passing ability (or no blocking),

To create multileveled equations, it may be necessary to treat the equation as a graphic and insert it into the text after your paper is styled.

Number equations consecutively. Equation numbers, within parentheses, are to position flush right, as in (1),

Using a right tab stop. To make your equations more compact, you may use the solidus (/), the exp function, or appropriate exponents. Italicize Roman symbols for quantities and variables, but not Greek symbols. Use a long dash rather than a hyphen for a minus sign.

Punctuate equations with commas or periods when they are part of a sentence, as in

SCC often uses a combination of greater number of constituent materials than in normal concrete. For example, the paste can contain one or more cement replacement materials, inert fine fillers, super plasticizers, and viscosity agents. A combination of powder materials is also used to control the hardened properties, such as strength. The workability and workability retention properties are of prime importance, and studies have shown that these are influenced by the properties of individual each constituent and the physical and chemical interaction between themThe template is designed so that author affiliations are not repeated each time for multiple authors of the same affiliation. Please keep your affiliations as succinct as possible (for example, do not differentiate among departments of the same organization). This template was designed for two affiliations.

2. METHODOLOGY:

Stage 1:

- Introduces about self-compacting concrete, elevated temperature's effects onconcrete, fly ash, foundry sand and applications of self-compacting concrete at elevated temperatures.
- Gives the details of experimental programme, materials used, techniques adopted forcasting, curing, heating and testing of the specimens

Stage 2:

- Deals with the mathematical model of the experimental programme using supportvector machine approach.
- Deals with the discussion of results obtained from experimental data. The results arepresented both in tabular as well as graphical form.

3. EXPERIMENTAL PROGRAM:

3.1 Materials Used:

3.1.1 Cement:

Ordinary Portland cement (Grade 43) was used for all concrete mixes. The cement used was fresh and without any lumps. Testing of cement was done as per *BIS: 8112-1989*

Physical properties of Portlandcement

Physical Property	Value	Specifications *(BIS: 8112-1989)*
Fineness retained on 90-µm sieve (%)	1.0	10 mm
Standard Consistency (%)	30	-
Initial setting time (minutes)	65	30 min
Final setting time (minutes)	215	600 max
Compressive strength 3-days (MPa)	23.6	22.0 min
Compressive strength 7-days (MPa)	35.4	33.0 min
Compressive strength 28-days (MPa)	43.0	44.3
Specific gravity	3.12	3.15
Soundness(mm)	2.50	10 max

3.1.2. Fly ash

Investigations were made on Class F Fly ash procured from Guru Govind Singh Super Thermal Power Plant, Ropar and Punjab, India. It was tested for physical and chemical properties as per *BIS:3812-2003*. The physical and chemical properties of fly ash are given in the Table.

Physical Properties	Value
Colour	Grey
Specific gravity	2.13
Lime reactivity-average compressive strength after 28 days of mixture (MPa)	4.90

3.1.3. Coarse Aggregates

Locally available coarse aggregates having the maximum size of 10 mm were used in the present work. Aggregates used were first sieved through 10 mm sieve and than through 4.75 mm sieve. They were than washed to remove dust and dirt and dried to the saturated surface dry condition. The aggregates were tested as per Indian Standard Specifications *BIS: 383-1970*.

3.1.4. Fine aggregates

The sand used for the experimental programme was locally procured and conformed to grading zone III. The sand was first sieved through 4.75 mm sieve to remove any particles greater than 4.75 mm and then washed to remove the dust. The fine aggregates were tested as per Indian Standard Specifications *BIS: 383-1970.*

Characteristics	Value
Type	Uncrushed (natural)
Specific gravity	2.65
Moisture content (%)	0.16
Water absorption (%)	0.98
Fineness modulus	2.51
Grading zone	III

3.1.5 Foundry sand

Investigations were made on foundry sand procured from Janta Foundries, MandiGobindgarh, Punjab. The physical and chemical properties of foundry sand are given in gives the sieve analysis of 10% replacement level of sand with foundry sand.

Property	Value
Specific gravity	2.64
Bulk relative density (kg/m^3)	1775
Absorption (%)	0.45
Moisture content (%)	0.1-10.1
Clay lumps and friable particles	1- 44
Coefficient of permeability (cm/sec)	10^{-3}-10^{-6}
Plastic limit/Plastic Index	Nonplastic

3.1.6. Water

Potable tap water was used for casting and for curing ofconcrete specimens conforming to the requirements of BIS: 456-2000.

4. TESTS

This chapter deals with the findings of experimental investigations. Various tests were conducted to evaluate the effect of elevated temperatures on compressive strength, splitting tensile strength, modulus of elasticity, mass loss, porosity and rapid chloride permeability of the SCC designed mixes containing various percentages of fly ash (30%, 40%, and 50%) and 10% replacement of fine aggregate with foundry sand.

Mix	Temperature (°C)	Fly Ash (%)	Compressive strength(MPa)	
			28 days	91 days
SCC1	Normal	0	40.68	48.90
SCC1	100	0	39.26	47.65
SCC1	200	0	39.09	47.07
SCC1	300	0	41.24	48.25
SCC2	Normal	30	30.67	39.50
SCC2	100	30	29.56	38.00
SCC2	200	30	29.00	37.90
SCC2	300	30	31.45	39.00
SCC3	Normal	40	26.22	35.00
SCC3	100	40	25.13	33.91
SCC3	200	40	24.60	33.26
SCC3	300	40	25.98	34.85
SCC4	Normal	50	21.43	30.40
SCC4	100	50	19.96	29.25
SCC4	200	50	19.25	29.12
SCC4	300	50	21.20	30.20

4.1. Compressive Strength

Effect of temperature on compressive strength of the SCC mixes made with flyash and foundry sand

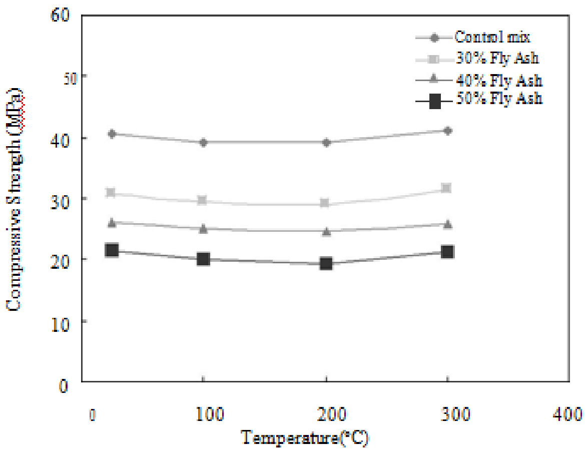

Fig. : Compressive Strength verses Temperature (28 days)

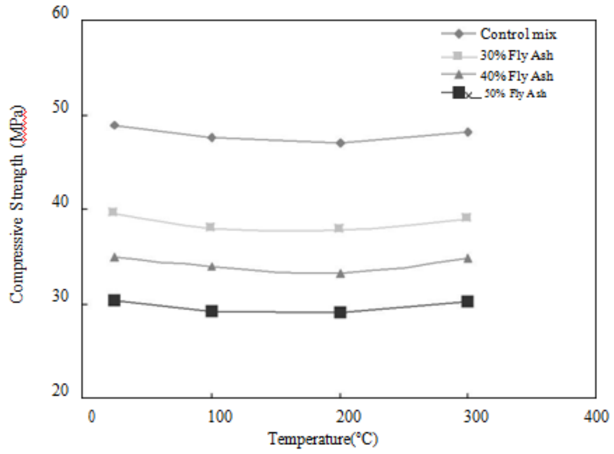

Fig .: Compressive Strength verses Temperature (91 days)

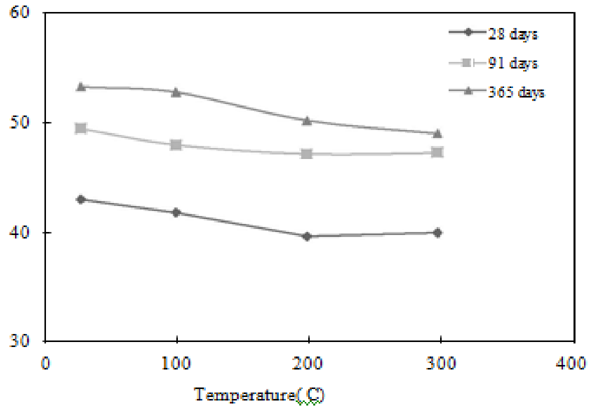

Fig: Compressive Strength verses Temperature (without fly ash)

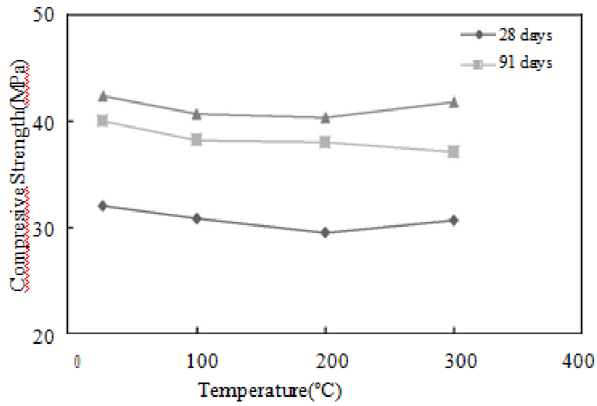

Fig. : Compressive Strength verses Temperature (with 30% fly ash)

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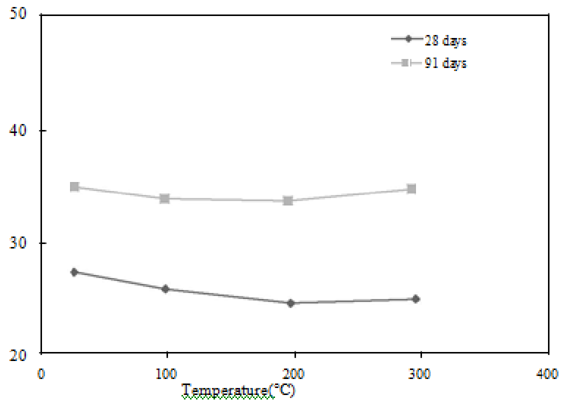

Fig. Compressive Strength verses Temperature
(with 40% fly ash)

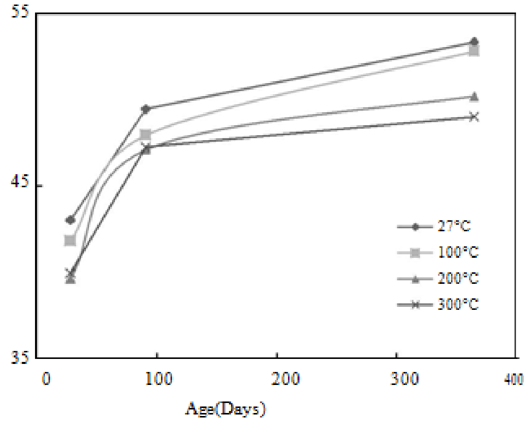

Fig: Compressive Strength verses Age
(with 30% fly ash)

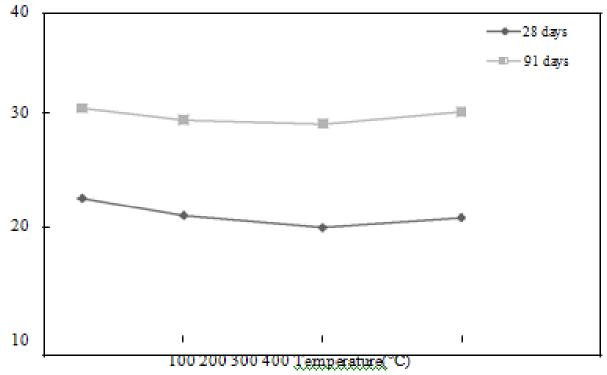

Fig.: Compressive Strength verses Temperature
(with 50% fly ash)

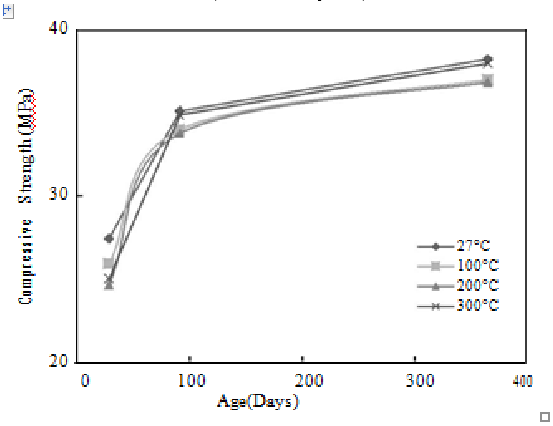

Fig: Compressive Strength verses Age
(with 40% fly ash)

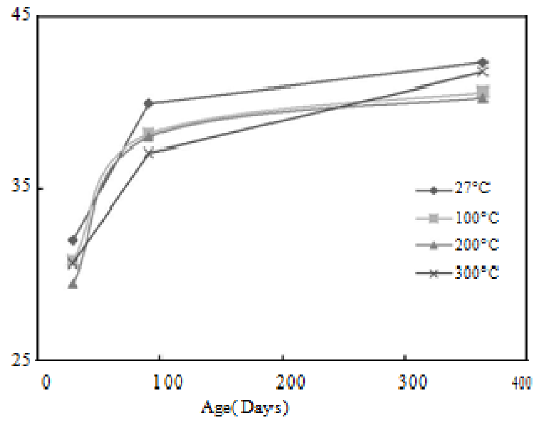

Fig: Compressive Strength verses Age
(without fly ash)

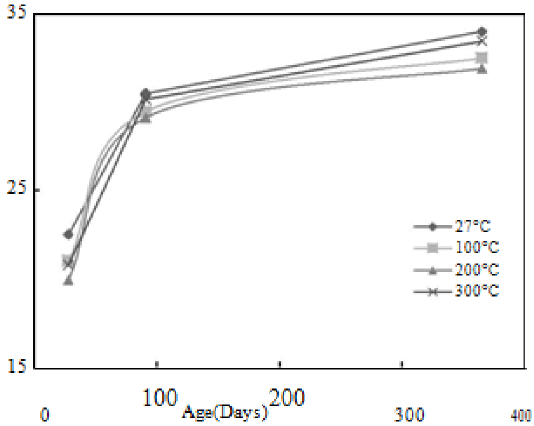

Fig: Compressive Strength verses Age
(with 50% fly ash)

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4.2. Splitting Tensile Strength

The results of splitting tensile strength test for different fly ash contents (0%, 30%, 40%, and 50%) and foundry sand incorporating different temperatures (27ºC, 100ºC, 200ºC, and 300ºC) at the end of different curing periods (28, 91 days) are given in Table 4.2. The splitting tensile strength test results of SCC mixes at various temperatures have also been plotted in Figs.

Mix	Temperature (°C)	Fly Ash (%)	Splitting tensile strength(MPa)	
			28 days	91 days
SCC1	Normal	0	3.56	3.78
SCC1	100	0	3.21	3.42
SCC1	200	0	3.00	3.26
SCC1	300	0	2.85	3.14
SCC2	Normal	30	2.00	2.24
SCC2	100	30	1.84	2.00
SCC2	200	30	1.62	1.87
SCC2	300	30	1.56	1.75
SCC3	Normal	40	1.68	1.80
SCC3	100	40	1.45	1.62
SCC3	200	40	1.36	1.56
SCC3	300	40	1.20	1.45
SCC4	Normal	50	1.35	1.54
SCC4	100	50	1.26	1.48
SCC4	200	50	1.00	1.22
SCC4	300	50	0.94	1.14

4.2.1. Effect of temperature on splitting tensile strength of the SCC mixes made with fly ash and foundry sand

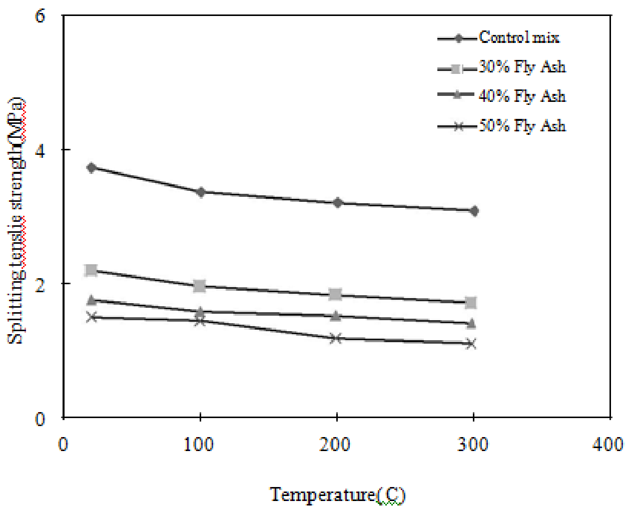

Fig. : Splitting Tensile Strength verses Temperature (91 days)

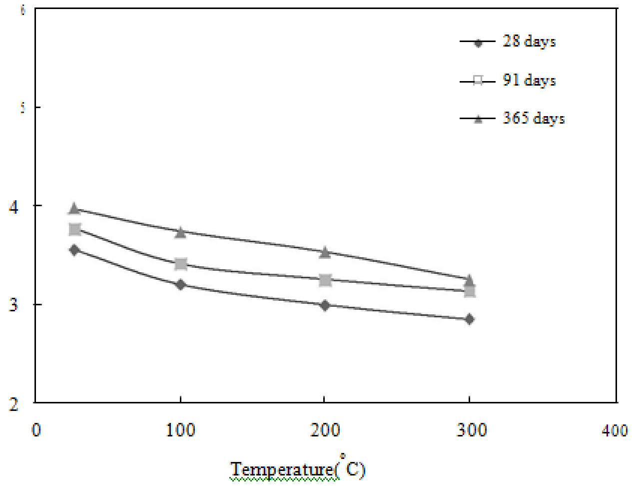

Fig.: Splitting Tensile Strength verses Temperature (without fly ash)

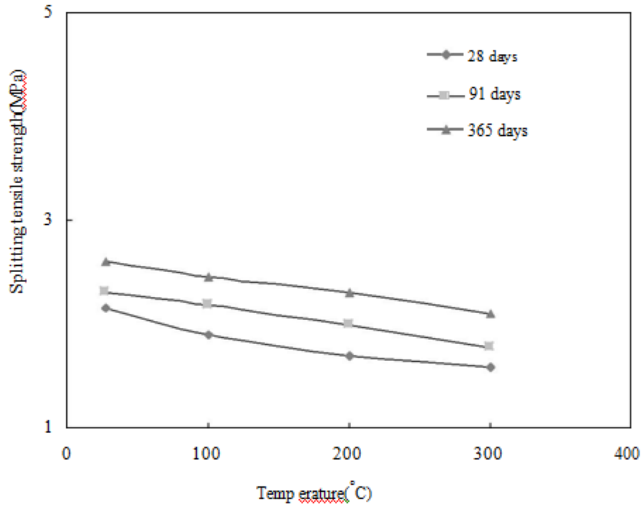

Fig.: Splitting Tensile Strength verses Temperature (with 30% fly ash

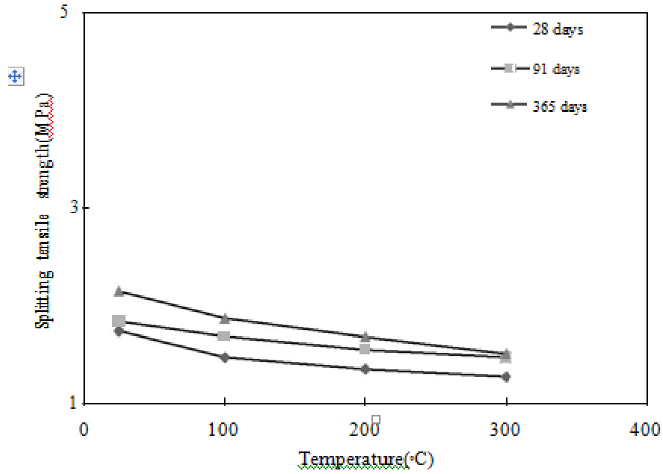

Fig.: Splitting Tensile Strength verses Temperature (with 40% fly ash)

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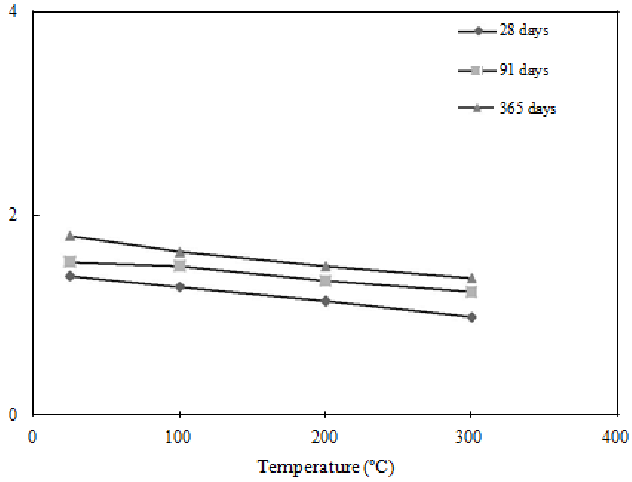

Fig.: Splitting Tensile Strength verses Temperature (with 50% fly ash)

4.2.2. Effect of age on splitting tensile strength of the SCC mixes made with fly ash and foundry sand at varying temperatures

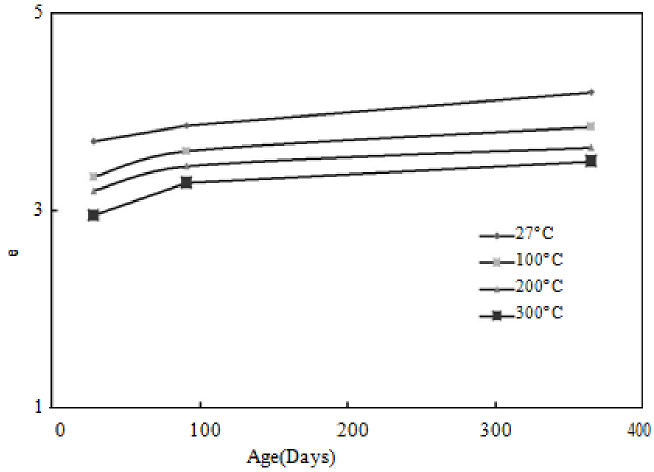

Fig: Splitting Tensile Strength verses Age
(without fly ash)

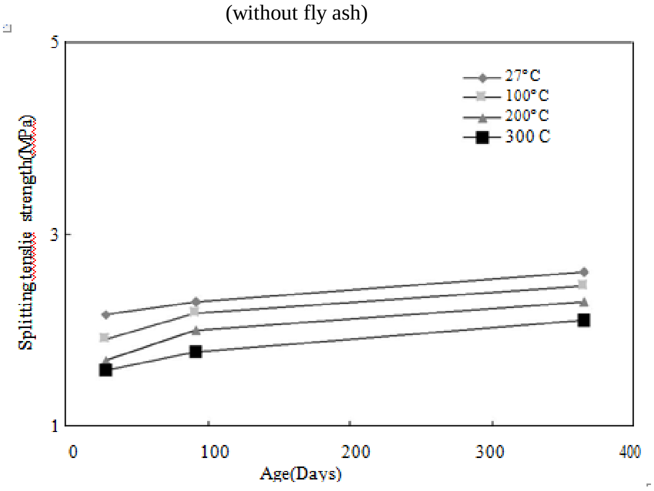

Fig: Splitting Tensile Strength verses Age
(with 30% fly ash)

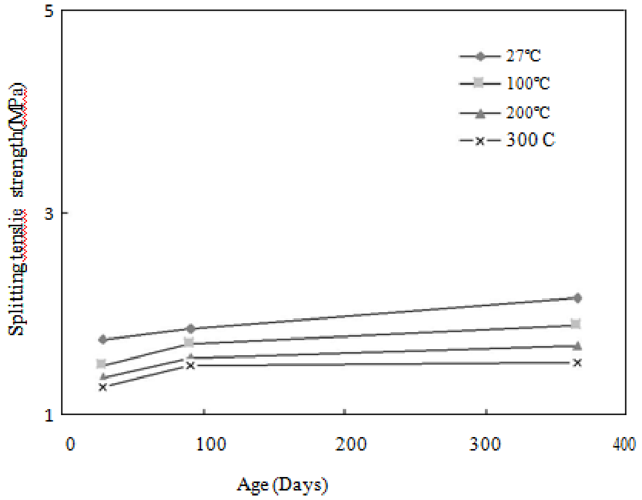

Fig: Splitting Tensile Strength verses Age
(with 40% fly ash)

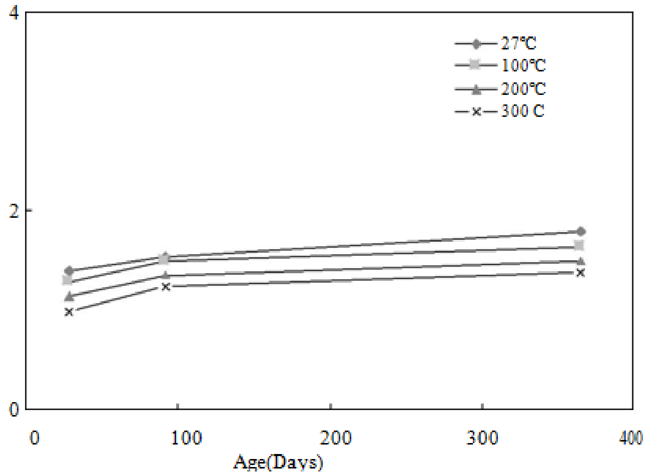

Fig: Splitting Tensile Strength verses Age (with 50% fly ash)

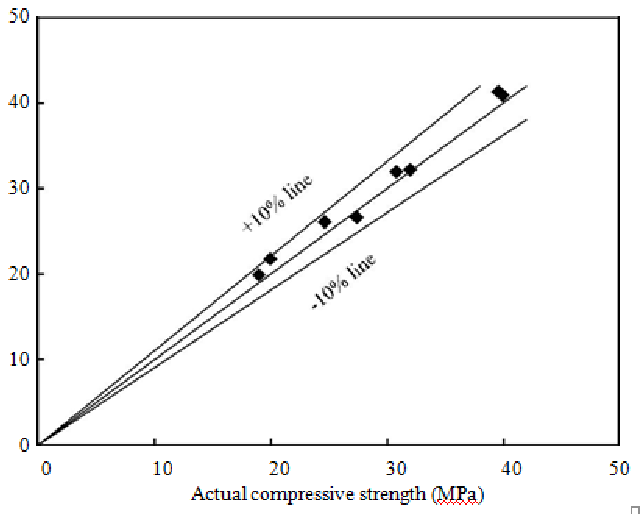

Fig: Actual Compressive Strength verses Predicted Compressive Strength

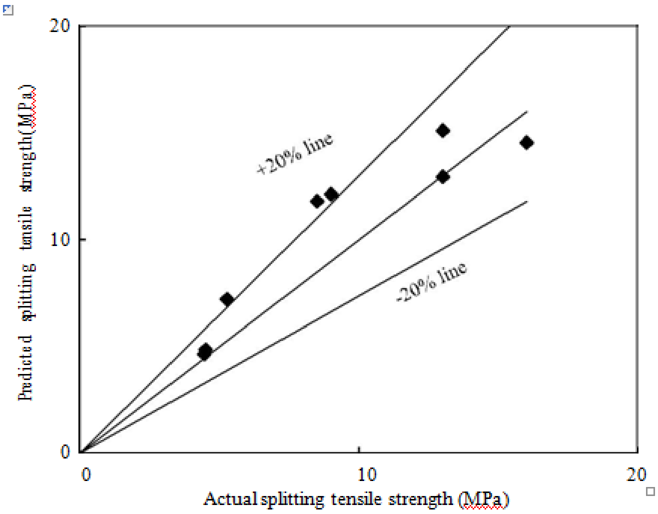

Fig.: Actual Splitting Tensile Strength verses Predicted Splitting Tensile Strength

5 CONCLUSIONS

The present work investigated the influence of fly ash as replacement of cement, and influence of foundry sand as a partial replacement of fine aggregate on the various strength and permeability properties of SCC at elevated temperatures. On the basis of the results of present study, the following conclusions are drawn:

5.1. Compressive Strength

High volume replacement of Ordinary Portland Cement with fly ash generally leads to lower early age strength. However this strength decrease was minimized by carefully selecting the material i.e. by replacing 10% of fine aggregate with foundry sand.

At the w/b ratio of 0.36 to 0.42, all the SCC mixes (SCC1-SCC4) can be produced with adequate fresh properties such as slump flow test and U-box test were found to be satisfactory, i.e. passing ability, filling ability and segregation resistance are within the specified range when sand is replaced with foundry sand and cement with high volume fly ash.

Although fly ash reduces the strength, it is still possible to produce SCC with compressive strengths ranging from 30.67 to 19.25 MPa, 39.50 to 29.00 MPa, and 42.25 to 31.75 MPa at 28, 91 days respectively at elevated temperatures. High volume fly ash SCCs with different compressive strength can be selected for use in different applications.

5.2. Splitting Tensile Strength

The splitting tensile strengths developed were from 0.94 to 2.00, 1.14 to 2.24 and 1.28 to 2.28 MPa at 28, 91 days respectively. The splitting tensile strength continued to decrease in a similar way as was observed between 27°C and 200°C, due to the departure of bound water, corresponding to a large mass loss.

Splitting tensile strength increased with a decrease in the percentage of the fly ash and the water-to-cementitious materials ratio at all ages.

Splitting tensile strengths of all SCC mixes was found to increase with increase in age.

At elevated temperatures, the rate of splitting tensile strength loss is higher than the rate of compressive strength loss. Thus it can be concluded that the splitting tensile strength is more sensitive to elevated temperatures.

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