# High Temperature Effect On Concrete Using Fibres

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***Abstract*—The present work is aimed to study the effect of elevated temperature ranging from 200°C to 600°C on the split strength on M20 grade concrete with percentage of polypropylene fiber (0.22%) & steel fiber (0.5%) by volume of concrete. Tests were conducted on cylinder concrete specimens. The specimens were heated to different temperatures of 200°C, 400°C, and 600°C for 6 hour durations. After the heat treatment the specimens were cooled by wet and dry cooling condition and then they were tested for spilt tensile strength test. The results were analyzed and presented with comparison of spilt tensile strength of specimens with & without fibres for different cooling conditions. The concrete containing fiber exhibited better performance than without fibre for high temperature. Strength loss was more significant on specimens cooled in water.**

***Keywords*— Elevated temperature, Polypropylene fibre, Steel fibre, Spilt tensile strength.**

## I. INTRODUCTION

Fire has become one of the greatest threats to buildings. Human safety in the event of fire is one of the considerations in the design of residential, public and industrial buildings. As it is known, high temperatures caused as a result of fire decreases the concrete strength and durability of such structures. Fire resistance of concrete is primarily affected by factors like the temperature, duration and condition of the fire. On the other hand, the type of cooling, dry cooling (in air) and wet cooling (in water) affect the spilt tensile strength.

Proper evaluation of fire resistance of concrete needs more experimental data obtained under various cooling regimes such as water spraying where they cause different stresses in reinforced concrete members at high temperature and the structural member can lose load bearing capacity. Concrete structures are sometimes exposed to the effects of fire. Although there are different ways to extinguish the fire, it is generally done with water spray. In this study, the behaviour of concrete with exposed to high temperatures is examined after cooling i.e. dry (in air) cooling and wet (in water) cooling.

## II. OBJECTIVES

1.To study the effect of sustained elevated temperature ranging from $200^0$C to $600^0$C for 6 hours and then cooling in air and water on M20 grade concrete with and without steel and polypropylene fibres with reference to spilt tensile strength.

2.To compare the results obtained, with M20grade concrete at room temperature (unheated), with and without steel and polypropylene fibres.

## III. EXPERIMENTAL PROCEDURE

The experimental work includes the casting, curing and testing of M20 grade concrete exposed to elevated temperature and subjecting to different cooling conditions.

The present investigation is to evaluate the spilt tensile strength of concrete when subjected to elevated temperatures of 200°C, 400°C and 600°C. Ingredients of the mix are taken as per the mix proportion with properties a) Cement:- Portland Pozolana Cement specific gravity of cement is 3.15. b) Coarse Aggregate:- 20mm maximum size with specific gravity is found to be 2.8 and fineness modulus of is 7.15. c) Fine Aggregate:- Locally available river sand is used as fine aggregate and conforming to Zone-I. The specific gravity is 2.75 and water absorption is 1%. d) Water:- Clean potable water is used for mixing. e) Fibres – Two types of fibres used are i) Polypropylene fibres (PF) - Nina fibre-mesh brand has length= 30-50mm, diameter= 0.30-0.35mm. ii) Steel fibres (SF)- Novo-con XR Brand continuously deformed circular steel fibre has length= 38-50mm, diameter= 1.14mm.

M20 mix is used. The Mix proportion Cement: F.A: C.A is 1:1.67:3.41 with 0.22% of polypropylene fibres and 0.5%of steel fibres by volume of concrete. The water cement ratio is 0.54. Concrete is filled in three layers. The top surface of the specimens is hand towelled. The moulds are stripped after 24 hrs. The concrete are cured for 28 days. The specimens are de-mould after 24 hours of air cooling and kept for water curing for 28 days. After curing, the specimens are dried for one day in shed. Then they are placed in electric furnace at requisite temperatures of 200°C, 400°C and 600°C at constant time interval of 6 hours. After removal from furnace, they were allowed to cool in dry and wet conditions

and are tested for spilt tensile strength. Electric furnace of maximum temperature of 1000°C is used. Concrete specimens are placed in the furnace chamber which is at room temperature and then temperature is increased to reach desired degrees with increase at 10°C/min.

## IV. RESEARCH SIGNIFICANCE

1. In case of accidental fire in residential & commercial building components of structures such as column, beam, slab etc. are exposed to accidental fire and then method of control to fire i.e. Air & Water cooling.
2.To be able to predict the response of structures after exposure to high temperature, it is essential that the strength properties of the concrete subjected to high temperatures be clearly understood.
3.To study the effect of sustained high temperature on spilt tensile strength of M20 grade concrete using fibres. The test specimens were subjected to temperatures ranging from 200$^0$C to 600$^0$C for 6 hour, their behaviour compared to that observed room temperature.

## V. RESULTS

1. Spilt tensile strength of concrete subjected to elevated temperature for 6 hr.

| Fibres | Tensile strength At room temp. | Tensile strength At 200$^0$C temp. | | Tensile strength At 400$^0$C temp | | Tensile strength At 600$^0$C temp | |
|---|---|---|---|---|---|---|---|
| | | Dry | Wet | Dry | Wet | Dry | Wet |
| Ref. mix | 3.97 | 3.65 | 3.47 | 3.18 | 3.03 | 2.86 | 2.81 |
| PF | 4.40 | 4.46 | 4.32 | 3.82 | 3.67 | 3.25 | 3.19 |
| SF | 4.71 | 4.74 | 4.63 | 4.19 | 3.92 | 3.51 | 3.40 |

2. % decrement in spilt tensile strength of concrete subjected to elevated temperature for 6 hr.

| Fibres | % decrease of tensile strength w.r.t. room temp. | | % decrease of tensile strength w.r.t. room temp. | | % decrease of tensile strength w.r.t. room temp. | |
|---|---|---|---|---|---|---|
| | Dry | Wet | Dry | Wet | Dry | Wet |
| Ref. mix | 8.00 | 12.59 | 19.89 | 23.67 | 28.00 | 29.2 |
| PF | 6.10 | 9.00 | 19.57 | 22.73 | 26.13 | 27.5 |
| SF | 4.43 | 6.65 | 15.50 | 20.96 | 25.40 | 26.7 |

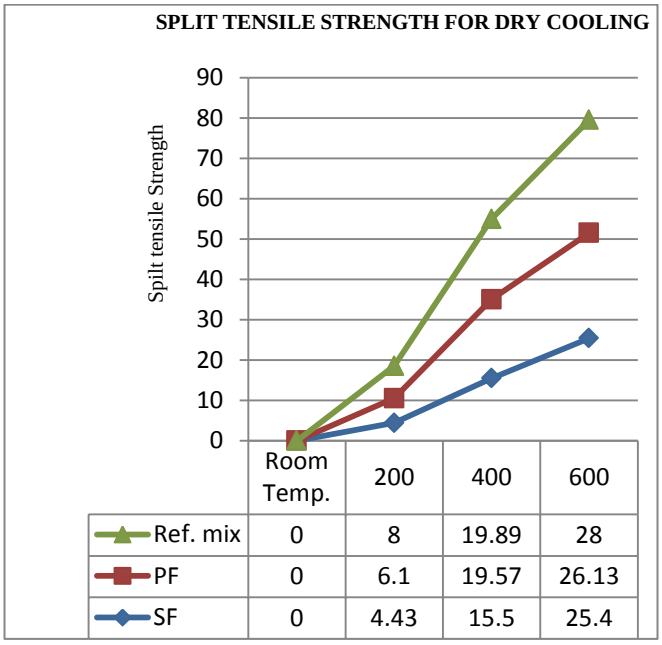



Fig1 Split tensile strength after elevated temperature for dry cooling

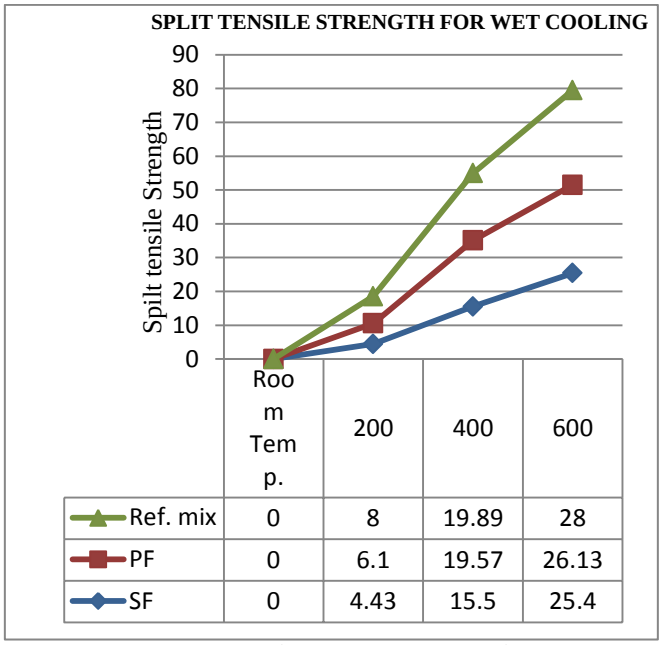
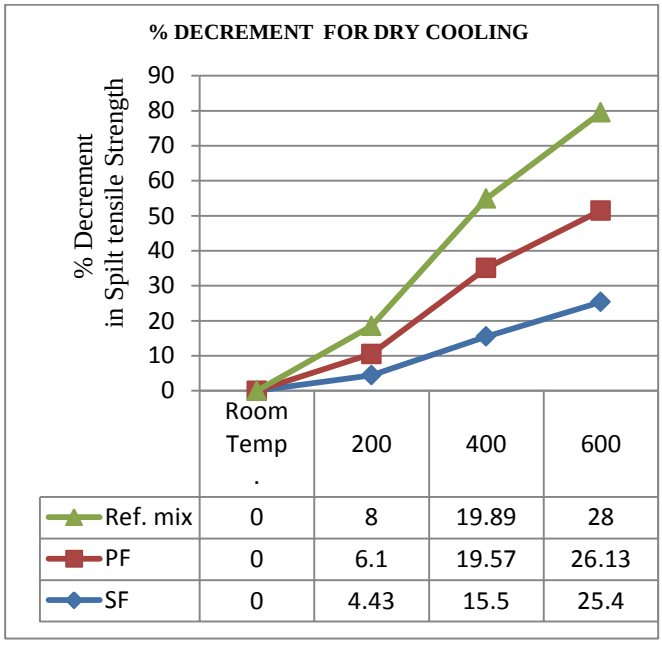



Fig2 Split tensile strength after elevated temperature for wet cooling

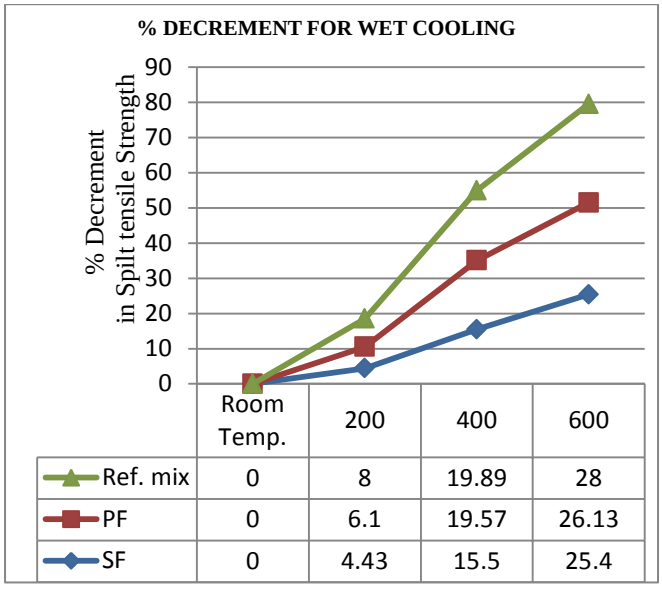
As per figure1 and figure 2, the effect of elevated temperature on concrete specimens show decrease in split tensile strength with increase in temperature. Effect of wet cooling shows that, there is always maximum strength loss compared to effect of dry cooling. In wet cooling condition split strength loss is always more than dry cooling condition. Strength decreases from 3.65MPa to 2.86MPa without fibre, 4.46MPa to 3.25MPa with polypropylene fibre and 4.74MPa to 3.51MPa with steel fibre for dry cooling & 3.47MPa to 2.81MPa without fibre, 4.32MPa to 3.19MPa with

polypropylene fibre and 4.63MPa to 3.41MPa with steel fibre with respect to increase of temperature from 200°C to 600°C.




| | Room Temp. | 200 | 400 | 600 |
|---|---|---|---|---|
| Ref. mix | 0 | 8 | 19.89 | 28 |
| PF | 0 | 6.1 | 19.57 | 26.13 |
| SF | 0 | 4.43 | 15.5 | 25.4 |

Fig 3 % decrement in split tensile strength after elevated temperature for dry cooling




| | Room Temp. | 200 | 400 | 600 |
|---|---|---|---|---|
| Ref. mix | 0 | 8 | 19.89 | 28 |
| PF | 0 | 6.1 | 19.57 | 26.13 |
| SF | 0 | 4.43 | 15.5 | 25.4 |

Fig 4 % decrement in split tensile strength after elevated temperature for wet cooling

As per figure 3 & figure 4 it is observed that, the % decrement of split tensile strength of concrete specimen with and without fibres for elevated temperature is less than that of the reference specimens with and without fibres (i.e. concrete at room temperature). For dry cooling by 8.00% for 200$^0$C, 19.89% for 400$^0$C & 28.00% for 600$^0$C using without fibre, by 6.10% for 200$^0$C, 19.57% for 400$^0$C & 26.13% for 600$^0$C using Polypropylene fibres, by 4.43% for 200$^0$C, 15.50% for 400$^0$C & 25.4% for 600$^0$C using steel fibres. For wet cooling by 12.59% for 200$^0$C, 23.67% for 400$^0$C & 29.20% for 600$^0$C using without fibre, by 9.00% for 200$^0$C, 22.73% for 400$^0$C & 27.50% for 600$^0$C using Polypropylene fibres, by 6.65% for 200$^0$C, 20.96% for 400$^0$C & 26.75% for 600$^0$C using steel fibres.

## VI. CONCLUSION

The split tensile strength is decreased as the test temperature is increased.

1) M20 grade concrete with and without fibre (PF 0.22% & SF 0.5%) exhibited decrease in split tensile strength with increase in temperature. Such decrement is greater for wet cooling condition.

2) It is found that the maximum split tensile strength is obtained for the concrete containing PF & SF for all temperatures with comparison of concrete without fibre.

3) The maximum percentage decrement in split tensile strength of concrete is 28.00%, 26.13%, 25.40% with reference specimen (i.e. concrete at room temperature) of dry cooling condition and 29.20%, 27.50%, 26.75% with reference specimen (i.e. concrete at room temperature) of wet cooling condition for ref. mix (without fibre), polypropylene fibre and steel fibre.

4) There is weight loss for M20 grade concrete subjected to elevated temperature from 200°C to 600°C. Weight loss is in between 0% to 9.55% and 0% to 5.92% for dry and wet cooling conditions, respectively for M20 grade concrete with ref. mix, PF & SF.

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