# Effect of Elevated Temperature and Type of Cooling on M20 Grade Concrete Using Fibers

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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 compressive strength on M20 grade concrete with percentage of polypropylene fiber (0.22%) & steel fiber (0.5%) by volume of concrete. Tests were conducted on 150mm side cube 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 compressive. The results were analyzed and presented with comparison of compressive strength of specimens with & without fibers for different cooling conditions. The concrete containing fiber exhibited better performance than without fiber for high temperature. Strength loss was more significant on specimens cooled in water.***

**Keywords:** Elevated Temperature, polypropylene fiber, steel fiber, compressive strength.

## 1. 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 compressive 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 behavior of concrete with exposed to high temperatures is examined after cooling i.e. Dry (in air) cooling and Wet (in water) cooling.

## 2. Objectives

1. To study the effect of sustained elevated temperature ranging from 200°C to 600°C for 6 hours and then cooling in air and water on M20 grade concrete with and without steel and polypropylene fibers with reference to compressive strength.
2. To compare the results obtained, with M20grade concrete at room temperature (unheated), with and without steel and polypropylene fibers.

## 3. 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 compressive 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) Fibers – Two types of fibers used are i) Polypropylene fibers (PF) - "Nina Fiber-mesh" brand has length= 30-50mm, diameter= 0.30-0.35mm. ii) Steel fibers (SF)- "Novo-con XR" Brand continuously deformed circular steel fiber 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 fibers and 0.5% of steel fibers 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 toweled. 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 compressive 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.

## 4. 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 compressive strength of M20 grade concrete using fibers. The test specimens were subjected to temperatures ranging from 200$^0$C to 600$^0$C for 6 hour, their behavior compared to that observed room temperature.

## 5. Results

**Table 1:** Overall results of compressive strength of concrete subjected to elevated temperature for 6 hour

| *Fibers* | *Comp. strength At room temp.* | *Comp. strength At 200$^0$C temp.* | | *% decrease of Comp. strength w.r.t. room temp.* | | *Comp. strength At 400$^0$C temp* | | *% decrease of Comp. strength w.r.t. room temp.* | | *Comp. strength At 600$^0$C temp* | | *% decrease of Comp. strength w.r.t. room temp.* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Dry* | *Wet* | *Dry* | *Wet* | *Dry* | *Wet* | *Dry* | *Wet* | *Dry* | *Wet* | *Dry* | *Wet* |
| Ref. mix | 27.57 | 26.82 | 26.07 | 2.72 | 5.44 | 24.66 | 23.78 | 10.55 | 13.75 | 21.04 | 20.37 | 23.68 | 26.11 |
| PF | 32.29 | 31.49 | 31.00 | 2.47 | 3.99 | 29.78 | 29.40 | 7.73 | 8.95 | 26.67 | 26.22 | 17.40 | 18.80 |
| SF | 34.42 | 34.00 | 33.25 | 1.22 | 2.10 | 22.59 | 31.85 | 5.32 | 7.46 | 29.11 | 28.67 | 15.43 | 16.70 |

### 5.1 Compressive Strength after Elevated Temperature

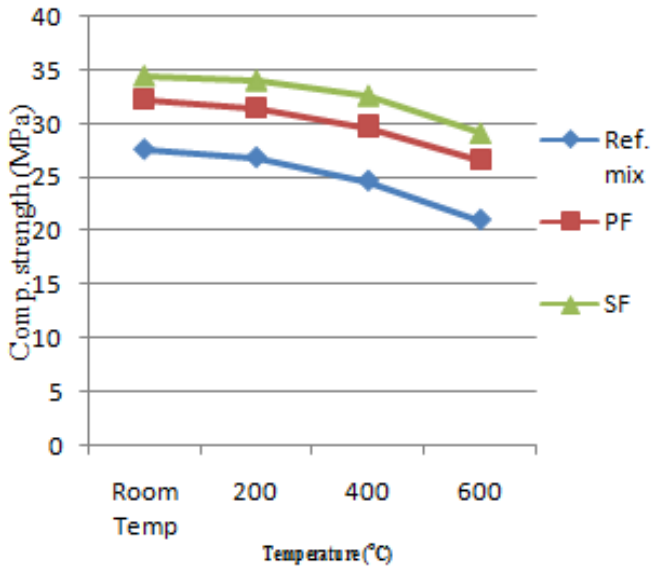


**Figure 1:** For Dry cooling

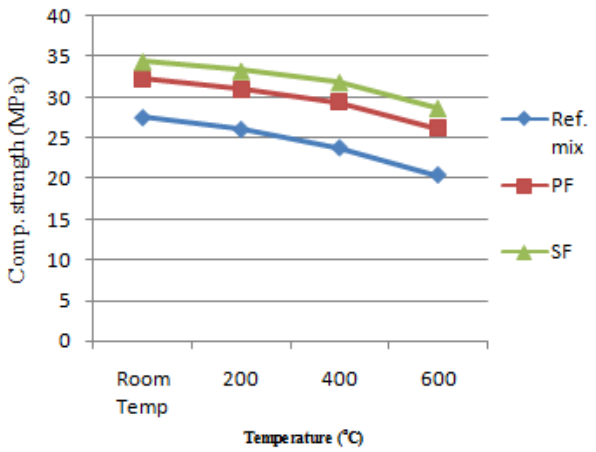


**Figure 2:** For wet cooling

As per above figures, the effect of elevated temperature on concrete specimens show decrease in compressive 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 compressive strength loss is always more than dry cooling condition. Strength decreases from 26.82MPa to 21.04MPa without fiber, 31.49MPa to 26.67MPa with polypropylene fiber and 34.00MPa to 29.11MPa with steel fiber for dry cooling & 26.07MPa to 20.37MPa without fiber, 31.00MPa to 26.22MPa with polypropylene fiber and 33.25MPa to 28.67MPa with steel fiber with respect to increase of temperature from 200°C to 600°C.

### 5.2 Percentage Decrement in Compressive Strength

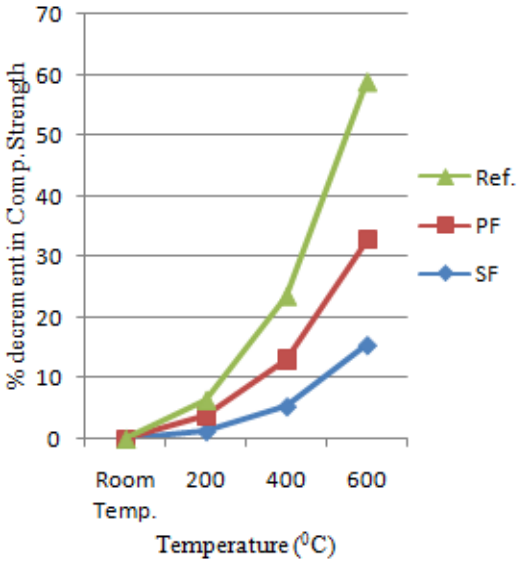


**Figure 3:** For dry cooling

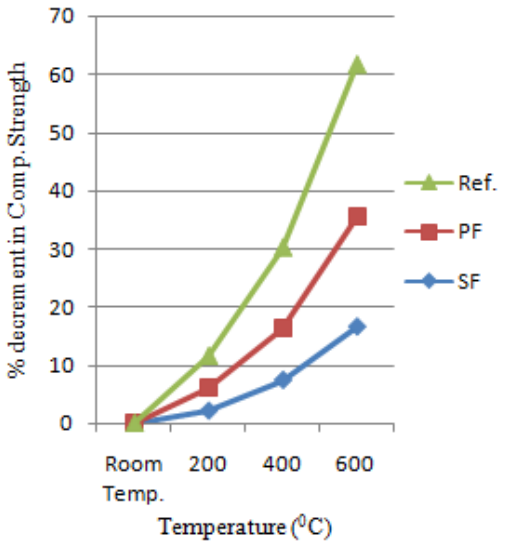


**Figure 4:** For wet cooling

As per Figure, it is observed that, the % decrement of compressive strength of concrete specimen with and without fibers for elevated temperature is less than that of the reference specimens with and without fibers (i.e. concrete at room temperature). For dry cooling by 2.72% for 200$^0$C, 10.55% for 400$^0$C & 23.68% for 600$^0$C using without fiber, by 2.47% for 200$^0$C, 7.73% for 400$^0$C & 17.40% for 600$^0$C using Polypropylene fibers, by 1.22% for 200$^0$C, 5.32% for 400$^0$C & 15.43% for 600$^0$C using steel fibers. For wet cooling by 5.44% for 200$^0$C, 13.75% for 400$^0$C & 26.11% for 600$^0$C using without fiber, by 3.99% for 200$^0$C, 8.95% for 400$^0$C & 18.80% for 600$^0$C using Polypropylene fibers, by 2.10% for 200$^0$C, 7.46% for 400$^0$C & 16.70% for 600$^0$C using steel fibers.

## 6. Conclusions

1. The compressive strength of concrete specimens containing fiber show higher strength as compared to concrete specimens without fiber. As fibers bridge the cracks and control crack width, hence increase load carrying capacity and strength. Also fibers, improve resistance to spalling of concrete at high temperature.
2. The compressive strength is decreased as the test temperature is increased.

a) M20 grade concrete with and without fiber (PF 0.22% & SF 0.5%) exhibited decrease in compressive strength with increase in temperature. Such decrement is greater for wet cooling condition.
b) It is found that the maximum compressive strength is obtained for the concrete containing PF & SF for all temperatures with comparison of concrete without fiber.
c) The maximum percentage decrement in compressive strength of concrete is 23.68%, 17.40%, 15.43% with reference specimen (i.e. concrete at room temperature) of dry cooling condition and 26.11%, 18.80%, 16.70% with reference specimen (i.e. concrete at room temperature) of wet cooling condition for ref. mix (without fiber), polypropylene fiber and steel fiber.

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 10.90% and 0% to 6.86% for dry and wet cooling conditions, respectively for M20 grade concrete with ref. mix, PF & SF.

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