# The Effect Of Pumice Aggregates And Metakaoline On Heating And Cooling Regimes On Compressive Strength

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***Abstract— The aim of the study is to find the compressive strength of concrete with Pumice aggregate (PS) and Metakaoline (MK) with different temperature exposure (both heating and cooling regimes). The different temperature conditions adopted for heating regimes are 300 and 500°C whenever for cooling methods are performed normal (at room temperature) , water and furnace cooling (Specimens in the furnace). The concrete with 20% Metakaoline replaced for cement and fine aggregate replaced with 10,20 and 30% of pumice aggregates with water binder ratio 0.41. The results show that 30% Pumice stone with 20% MK performed heater in different temperature regimes compared to other mixture in terms of compressive strength.***

**Index Terms—** ***Pumice Stone, Metakaoline, Compressive strength, heating and cooling regimes..***

## I. INTRODUCTION

High temperature, which is one of the rule physical effects that causes robustness issue in advancements, may influence the improvement to be out of organization or loss of life and property by making constant damages. Getting these damages under control is possible by removing the effect or having cautious measures against the effect. Exactly when concrete is introduced to high temperatures, its physical structure changes broadly.The high temperature impact that causes micro structural changes. The solid loses its quality and durability factors that impact high temperature protection of mortar bonds and cements are partitioned into two primary gatherings as material related elements and natural variables. To evaluate concrete at high temperatures, exposure is critical. The physical, chemical, porosity and mineralogy of the total concrete importantly affect the conduct of the solid exposed high temperatures.

Replacement pumice stone with coarse total is said to be basic lightweight cement and furthermore decrease the temperature in concrete. This substitution will be useful in Thermal plants, also a few researches have been conducted on pumice stone.Supplementary cementitious materials are frequently used to decrease concrete substance and enhance the properties of bond. The Metakaolin is used as incomplete substitution of bond and test examination is completed. The favorable circumstances like high quality, toughness and decrease in bond creation are altimet because of the consolidation of metakaolin in concrete and the ideal rate substitution of metakaolin going from 10 to 25% to acquire most extreme 28-days compressive quality of cement.

## II. LITERATURE REVIEW

The influence of elevated temperature (250°C, 500°C and 750 °C) on concrete by using pumice stone and metakaolin with different mix proportions explained by Saridemir, Severcan (2016) concludes that the most effective results are obtained in the mixture of 5% of pumice stone+10% of metakaolin against the high temperature exposures.

In this experimental study, the surface of large pumice aggregate was coated with cement + colemanite (CLM) in different mixtures and exposed to temperature from 20°C to 600°C by Özlem Sall Bideci(2016). It shows that the high temperature causes the cracks and decreases the compressive strength in concrete.

In this investigation, the effect of metakaolin in concrete for 90 days of hydration was studied by Hamdy El-Diadamony, Ahmed Amer(2015).The results indicated that substitution of up to 20% of cement by metakaoline increases the mechanical properties of concrete.

The replacement levels of cement by metakaoline at different percentage for constant water-binder ratio was carried out by Suryawanshi, Amar(2015) and it shows that 12% replacement of cement by metakaoline higher strength.

In this research work, Metakaoline was used in different proportions in concrete and the study was made to know the changes in mechanical properties as well as the effect of temperature on it by Ambroise, Dejean(1989). From this research work, it is concluded that the replacement of metakaoline with cement can produce the good strength concrete.

## III. OBJECTIVES

To Study the effect of pumice aggregates ( for course aggregate) and Metakaoline (for cement) on the compressive strength of the replacement concrete when it is exposed to heating and cooling regimes.

## IV. EXPERIMENTAL PROGRAM

**Materials**

**1.Cement:**

The Ordinary Portland Cement of 53-grade confirming to IS 12269-2013 is used.

**2. Pumice stone:**
Pumice stone is a characteristic lightweight total which is framed amid the volcanic ejection of gooey magma, for the most part silica..

**Table 1:** Test results on aggregate

| TEST | NORMAL AGGREGATE | PUMICE STONE |
|---|---|---|
| **Specific Gravity** | 2.3 | 0.769 |
| **Water Absorption ( %)** | 4.4 | 11.1 |

**3. Metakaoline:**
It is the dehydroxylated form of the clay mineral Kaolinite. The particle size of metakaolin is smaller than cement particles, but not as fine as silica fume.

**4. Coarse aggregate:**
The size of 12-20mm aggregates available from local quarries are used in this specimen.

**5. Fine aggregate:**
M-sand passing through 2.80mm sieve is used in this specimen.

**6. Water:**
Drinking water was used for mixing and using.

**Mix Proportion**

Water to binder ratio is 0.41 and the Super plasticizer used is 0.5% for control mix and 0.8% for the mixture containing pumice stone and metakaoline.

Where ,

CM = Control Mix , PS = Pumise Stone , MK = Metakaoline

**Table 2:** Mix Proportion

| Mixings | Cement ($kg/m^3$) | FA ($kg/m^3$) | CA ($kg/m^3$) | Water ($kg/m^3$) | MK ($kg/m^3$) | PS ($kg/m^3$) |
|---|---|---|---|---|---|---|
| **CM** | 347 | 773 | 1025.34 | 145.8 | - | - |
| **10% PS +20%MK** | 277.6 | | 922.81 | | 69.4 | 102.5 |
| **20% PS +20%MK** | 277.6 | | 820.27 | | 69.4 | 205.1 |
| **30%PS+20 %MK** | 277.6 | | 717.74 | | 69.4 | 307.6 |

**Heating and Cooling Details**

After casting the cubes, it was kept temperature for 24hours. Then the cubes are demoulded and the dry weight was taken before putting it in the water tank for curing. After the completion of 28 days, the cubes were placed in the oven for 4hours at 105°C. Then the heating of concrete was carried out by placing the specimens in furnace at a rate of 5°C/min up to 300 and 500°C. After reaching the target temperatures, the specimens were maintained in a steady-state condition within the furnace for 2hours. Then the furnace is switched off and the specimens were exposed for cooling in different cooling regimes for 24 hours. The weight of the specimens were determined after exposed to cooling regimes to find out the percentage of weight loss and the further testing on specimen were carried out.

**Testing and Procedure**

The Compressive strength (Fcs), Ultrasonic pulse Velocity (Upv), Rebound Hammer (Rh) values were determined on the control concrete and concrete containing 20MK+10PS, 20MK+20PS, 20MK+30PS. The tests were performed in accordance with IS 516(1959),IS 13311-1(1992), IS 13311-2(1992) on cubic specimens of 100×100×100mm size at the ages of 7 and 28 days. Similar tests were also performed on the same size cubes after exposing them to 300 and 500 °C temperature at 28 days.

**V. RESULT AND DISCUSSION**

The results of compressive strength, ultra pulse velocity test and rebound hammer test are discussed below;

**Table 2:** Testing on Specimen without Heating

| Test | Control mix | | 20MK+10PS | | 20MK+20PS | | 20MK+30PS | |
|---|---|---|---|---|---|---|---|---|
| | 7 Days | 28 Days | 7 Days | 28 Days | 7 Days | 28 Days | 7 Days | 28 Days |
| $F_{cs}$ (N/ mm²) | 25.1 | 33.8 | 19.8 | 32.01 | 20.7 | 27.8 | 22.5 | 31.8 |
| | 24.6 | 34.5 | 19.1 | 31.5 | 21.0 | 30.4 | 21.9 | 32.37 |
| | 25.5 | 32.1 | 19.6 | 29.9 | 20.1 | 31.2 | 22 | 33.21 |
| $U_{pv}$ (Km/s) | 3.1 | 4.9 | 2.8 | 4.49 | 2.92 | 4.12 | 3.31 | 4.37 |
| | 2.9 | 4.56 | 2.63 | 4.2 | 3.21 | 3.73 | 2.98 | 4.12 |
| | 3.2 | 5 | 3.01 | 4.33 | 3.03 | 3.6 | 2.88 | 3.98 |
| $R_h$ | 21 | 41 | 24 | 36 | 21 | 34 | 22 | 35 |
| | 23 | 40 | 19 | 39 | 18 | 31 | 20 | 37 |
| | 20 | 37 | 16 | 35 | 23 | 32 | 18 | 33 |

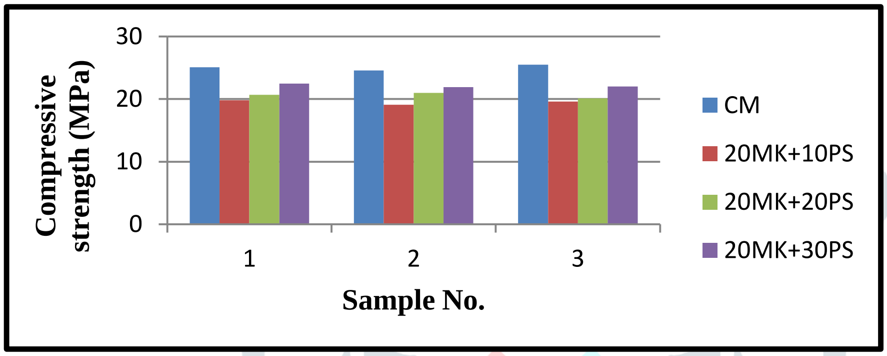


**Figure 1:** 7 Days Testing

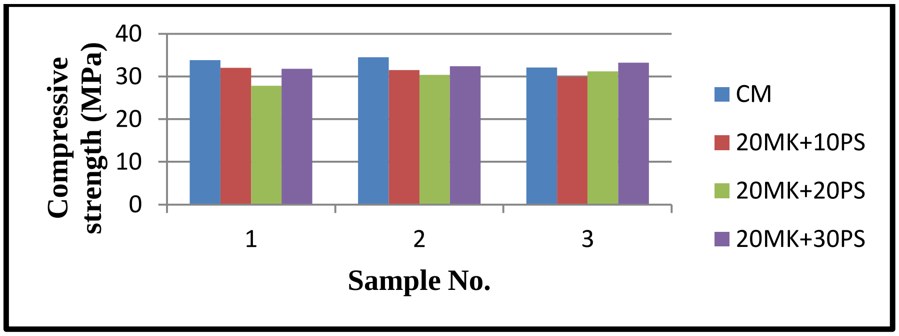


**Figure 2:** 28 Days Testing

**Table 3:**Test results of 28 Days after Cooling and Heating

| Cooling Regimes | %Weight Loss | | $F_{cs}$ (N/ mm²) | | $U_{pv}$ (Km/s) | | $R_h$ | |
|---|---|---|---|---|---|---|---|---|
| | 300°C | 500°C | 300°C | 500°C | 300°C | 500°C | 300°C | 500°C |
| | **CM** | | | | | | | |
| **Furnace** | 5.1 | 7.2 | 32.8 | 31.9 | 3.9 | 3.7 | 29 | 27 |
| **Normal Water** | 4.1 | 6.25 | 33.1 | 32.9 | 4.1 | 3.8 | 31 | 28 |
| **Room Temp.** | 4.8 | 6.4 | 31.6 | 31.9 | 3.6 | 3.4 | 27 | 25 |
| | **20MK+10PS** | | | | | | | |
| **Furnace** | 2.3 | 4.2 | 29.8 | 28.7 | 3.4 | 3.1 | 24 | 22 |
| **Normal Water** | 1.9 | 3.8 | 30.1 | 29.3 | 3.6 | 3.2 | 25 | 23 |
| **Room Temp.** | 2.1 | 3.1 | 28.6 | 27.8 | 3.2 | 2.1 | 22 | 19 |
| | **20MK+20PS** | | | | | | | |
| **Furnace** | 2.1 | 5.4 | 27.9 | 26.8 | 2.9 | 2.8 | 21 | 18 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Normal Water** | 1.6 | 3.74 | 28.3 | 27.5 | 3.2 | 2.9 | 23 | 21 |
| **Room Temp.** | 2.3 | 4.2 | 26.3 | 25.6 | 2.7 | 2.3 | 19 | 17 |
| | **20MK+30PS** | | | | | | | |
| **Furnace** | 0.98 | 2.1 | 31.7 | 30.9 | 3.7 | 3.5 | 27 | 24 |
| **Normal Water** | 0.72 | 1.78 | 32.1 | 31.6 | 3.9 | 3.6 | 28 | 25 |
| **Room Temp.** | 1.1 | 2.8 | 30.3 | 29.9 | 3.4 | 3.2 | 25 | 23 |

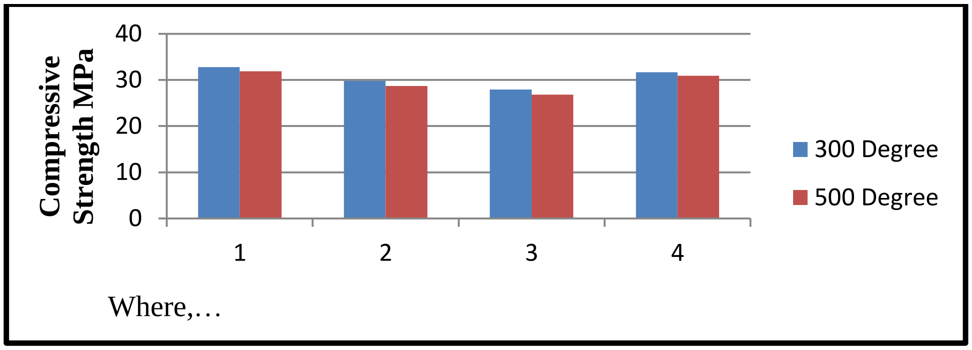


**Figure 3:** Test Results from Furnace Cooling

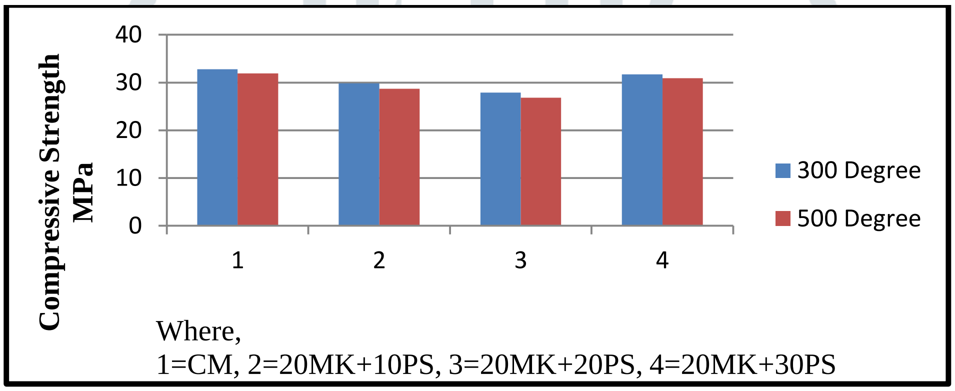


**Figure 4:** Test Results from Normal Water Cooling

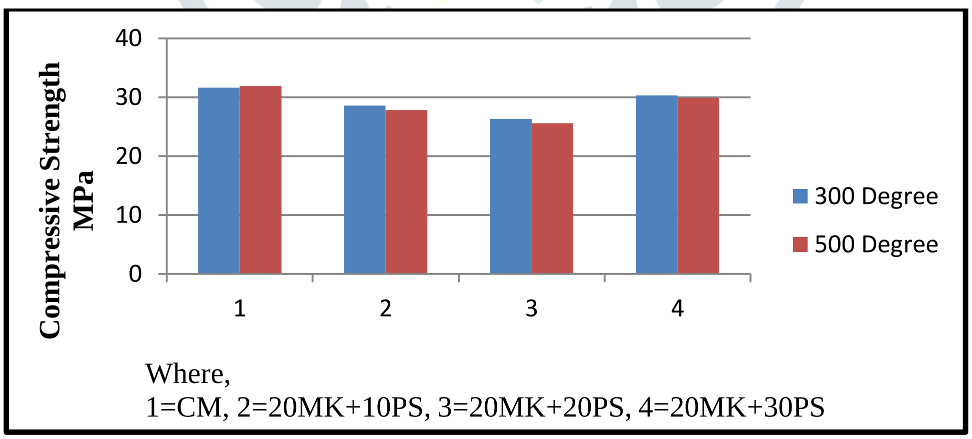


**Figure5:** Test Results from Room Temperature Cooling

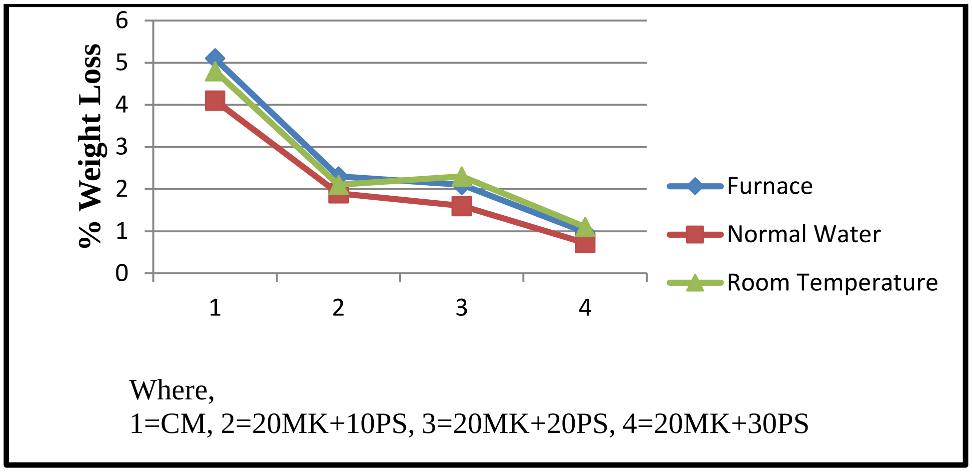


**Figure 1:** % Weight Loss at 300°C

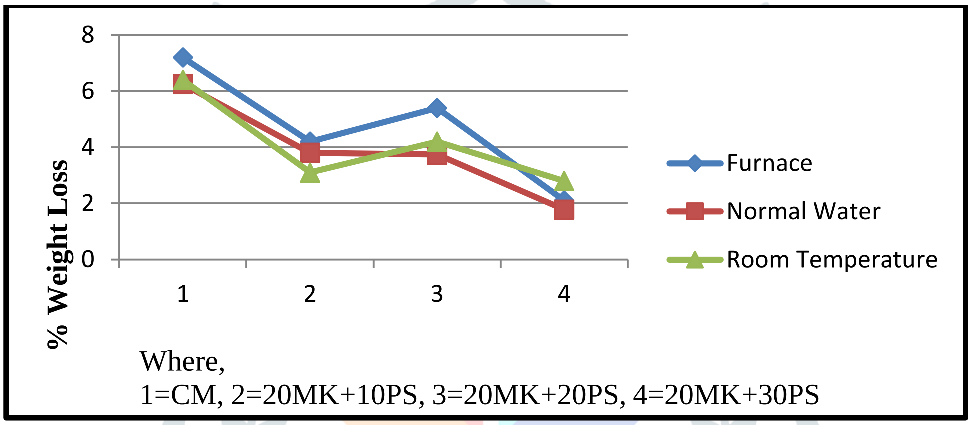


**Figure 7:** % Weight Loss at 500°C

## VI. CONCLUSION

In this experimental study on Pumice stone and metakaoline in concrete, as per the above results we got, it is concluded that ;

**1**.The enhancement of Compressive strength ($F_{cs}$) , Ultrasonic pulse Velocity ($U_{pv}$) , Rebound Hammer ($R_h$) values of concrete containing 20MK+30PS is nearly equal to the control mix(CM) concrete value. The concrete mixtures containing 20MK+10PS, 20MK+20PS did not give that much good results in Compressive strength ($F_{cs}$), Ultrasonic pulse Velocity ($U_{pv}$), Rebound Hammer ($R_h$) tests performed.

**2**.After the specimens are exposed to heating at 300°C and 500°C, there was a weight loss in specimens and the percentage of weight loss in furnace cooling is more as compared in normal water and room temperature cooling.

**3**.The weight loss in the concrete containing 30% PS + 20% MK was found to be very less when compared to the conventional concrete mix.

**4**.The values of Compressive strength ($F_{cs}$), Ultrasonic pulse Velocity ($U_{pv}$), Rebound Hammer ($R_h$) tests were found to be decreased after exposed to heating at 300°C and 500°C.

**5**.From the test results, it is concluded that the Pumice stone can be used as a replacement in concrete to reduce the dead load and to give the better performances against heating effects.

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