Petrographic investigation to assess condition of concrete exposed to fire

Mr. Nikhil k. patil[1], Ass. Prof. S.P. Patil[2]

[1]*M-Tech (Student), Sanjay Ghodawat University, Kolhapur*
[2]Ass. *Professor, Civil Engineering Department, SGU, Kolhapur.*

Abstract - *The durability properties of concrete after exposed to different temperature were studied in this paper. The results of durability property tests exposed to varying degrees of temperature indicate that the cement quantity, water cement ratio, and cooling type are the most important elements influencing the residual strength of concrete. Concrete specimens were heated to 200°C, 400°C, 600°C, and 800°C in an electric boogie furnace. The specimens were then allowed to cool naturally (gradual cooling) . To determine durability properties, the Rapid chloride permeability test performed. According to test result, the structure of the interior pores and micro cracks has a big impact on the proportion of chloride ions that get into the concrete sample. Due to significant cracking, the RCPT values of all the concrete mixes after being exposed to a high temperature of 800°C were more than 400 C.*

Key Words: *temperature, durability properties, rcpt*

1. INTRODUCTION

Because fire affects the structural integrity of concrete structures, it remains one of the most significant potential threats. Concrete's physical, strength, and serviceability properties are all negatively affected by fire. As a result, it's crucial to investigate the fire resistance of concrete.

The cause of this phenomena is concrete's limited heat conductivity at high temperatures, which restricts the depth of fire damage penetration. Concrete does not produce harmful flames during a structure fire. The most serious issue in a building fire is public safety. Codes and standards describe the fire protection requirements for structural members in terms of fire resistance ratings based on tests performed according to predetermined standard procedures.

In unheated concrete specimens, increasing the water-to-cement ratio reduced compressive strength, however in heated specimens, a greater water-to-cement ratio resulted in less compressive strength reduction. Furthermore, the pace at which concrete weakens when subjected to high temperatures is dependent on the rate of heating. Because water evaporates slowly, no reduction in strength was detected when concrete specimens were gently heated between 100 and 200°C. However, a rapid increase in the rate of heating causes a rise in vapour pressure, which can lead to concrete cracking. Furthermore, the majority of the study on the residual qualities of concrete after a fire was conducted under natural air-cooling circumstances. The circumstances during a fire and natural air cooling appear to be distinct from the cooling regimes in a real fire, when

2. Preperation and casting

2.1 Material Used

Throughout the experiment, ordinary Portland Cement (OPC) of grade 53 is utilized. All properties of cement are tested by referring IS 12269-1987. Fineness of cement is 1.33%. Standard consistency of cement paste is 32%. Hence the sample of cement tested so, as found out to be satisfactory according to IS 12269-1987.

As a fine aggregate, locally accessible river sand with specific gravity 2.75 has been used and coarse aggregates with a size of 20 mm having specific gravity 2.96 were used.

Armixplast 111 admixture is used. It is supplied as a brown colour liquid. It has been particularly prepared to provide excellent workability or to generate high-quality concrete with lower permeability and improved density. The laboratory tap water was used.

2.1 Mix design for M30 grade concrete

Mix design for M30 grade concrete is done as per IS 10262-2009. The table shows the mix design for M30 grade concrete.

Table 1. Mix proportion

Weight	W/c ratio	Cement	Fine aggregate	Coarse aggregate
Ratio	0.45	1	2.14	4.185
Kg/m³	153	340	728.45	1422.9

2.2 Casting

All the specimens were prepared in accordance with Indian Standard Specification IS 516-1959. Prepare the test sample of concrete of dimension 50 mm thickness × 100 mm diameter for the purpose of testing for determining permeability.

Fig -1: Casting of specimens

2.3 Testing of specimens at elevated temperature

The concrete specimens that have been drying for 24 hours have now been removed and placed into the furnace for heating at various temperatures. The concrete specimen heated for 200˚c, 400˚c, 600˚c, 800˚c. Through a boogie, the specimens are placed in the furnace, and the temperatures are set for the required time. When the target temperature is set, the furnace's coils on four sides heat the specimens through radiation. The furnace has two displays (a) set value display in which the temperature to heat the specimen is set in it and the temperature will be attained on the given time. (b) program value display which displays the temperature that is attained in the coil on the given time. The furnace will turn off once the temperature for the specified time has been reached. The specimens are then removed from the furnace and placed in a a closed area for air cooling.

Fig -2: Testing of specimens

2.4 procedure of Rapid chloride permeability test

In this test, a water-saturated 50mm long and 100mm diameter concrete specimen was subjected to a 60 V applied DC voltage for 6 hours using the apparatus shown in figure. One reservoir contains 3.0% NaCl solution and the other reservoir contains 0.3 %N NaOH solution. The total charge passed was determined and this was used to rate the concrete. We can set the record time as 30 minutes and also the long time as 6 hours and 30 minutes. The data logger will take the readings of corresponding cells at every record time with its initial readings. At the end of long time, the system should stop after taking the final reading. RCPT CELLS made up of acrylic material as per ASTM C 1202.

Average current flowing through one cell is calculated by,

$$I = \frac{900 * 2 * I\ Cummulative}{1000} \quad \text{in Coulombs}$$

Where,

Icummulative=(I0+I360)/2+I30+I60+I90+I120+I150+I180+I210+I240+I270+I300+I330

I0= Initial Current reading in mA.

I30= Current Reading after 30 minutes in mA

I60= Current Reading after 60 minutes in mA

I90= Current Reading after 90 minutes in mA

I120= Current Reading after 120 minutes in mA

I150= Current Reading after 150 minutes in mA

I180= Current Reading after 180 minutes in mA

I210= Current Reading after 210 minutes in mA

I240= Current Reading after 240 minutes in mA

I270= Current Reading after 270 minutes in mA

I300= Current Reading after 300 minutes in mA

I330= Current Reading after 330 minutes in mA

I360= Current Reading after 360 minutes in mA

The Chloride Permeability of concrete can be determined by using the values shown in table

Table 2. Chloride ion penetration based on charge passed values

Charge passing (coulomb)	Chloride Permeability	Typical of
>4000	High	High W/C ratio (>0.60) conventional PCC
2000 – 4000	Moderate	Moderate W/C ratio (0.40–0.50) conventional PCC
1000 – 2000	Low	Low W/C ratio (<0.40) conventional PCC
100 – 1000	Very low	Latex-modified concrete or internally-sealed concrete
<100	Negligible	Polymer-impregnated concrete, Polymer concrete

We may compare the outcomes using the table above. The RCPT test is performed on a concrete specimen with the desired strength.

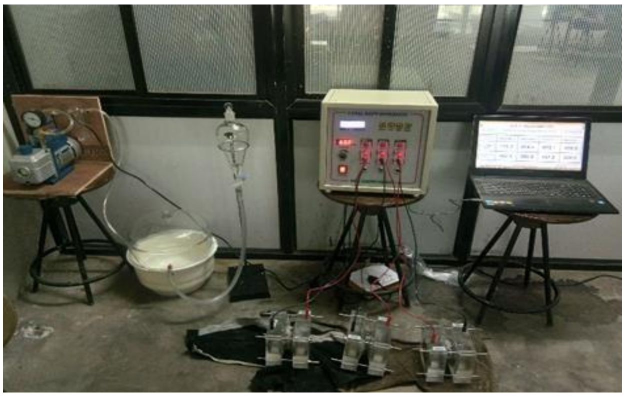

Fig -3: RCPT setup

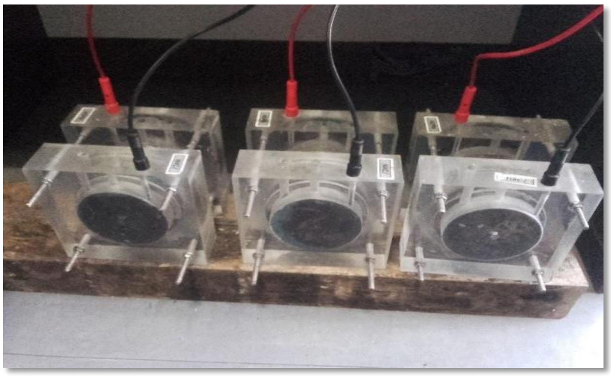

Fig -4: RCPT specimens

3. Results

As per the ASTM C1202 Rapid Chloride Permeability Test (RCPT) was conducted for different temperature like 200,400,600,800˚c after 28days of casting RCPT specimens was tested and the results are following

Table 3. RCPT Result

	CURRENT -1 (mA)	CURRENT -2 (mA)	CURRENT -3 (mA)	Average (mA)
Temperature				
0˚c	1685.52	1690.29	2033.46	1803.09
200˚c	1935.25	1986.8	2045.66	1989.23
400˚c	2241.27	2296.53	2168.55	2235.45
600˚c	4220.57	3989.52	4323.27	4177.12
800˚c	5128.45	5298.57	5324.69	5220.57

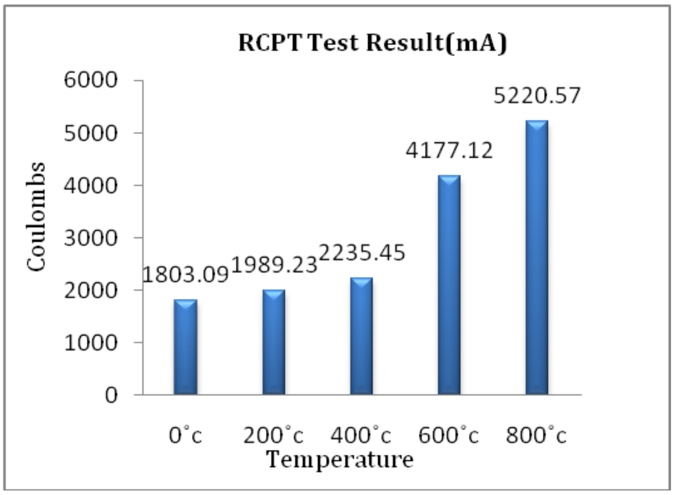

Fig -4: RCPT Test Result

When a testing, the RCPT specimens are we know the actual current passing in concrete moulds by the use of the electrical indication rapid chloride permeability test, the fig shows the graph between Temperature vs. current passing in coulombs.

4. CONCLUSION

1. The structure of the interior pores and micro cracks has a big impact on the proportion of chloride ions that get into the concrete sample.
2. For concrete exposed to 0˚c & 200˚c temperature the charged passed values are in between 1000-2100, so we concluded that low chloride ion penetration.
3. For concrete exposed to 400˚c temperature the charged passed values are in between 2000-3000, so we concluded that moderate chloride ion penetration.
4. Due to significant cracking, the RCPT values of all the concrete mixes after being exposed to a high temperature of 800°C were more than 400 C.
5. The increase in rapid chloride permeability is 3 to 4 times at 800°C to that of rapid chloride permeability at room temperature.
6. For concrete exposed to 600˚c & 800˚c temperature the charged passed values are above 4000, so we concluded that high chloride ion penetration.

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