STRENGTH COMPARISON BETWEEN NORMALLY CURED AND ACCELERATED CURED CONCRETE WITH PARTIAL REPLACEMENT OF SAND WITH POND ASH

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Abstract: Due to rapid industrialisation the production of waste is also getting increased in leaps and bounds. Pond ash is one of the wastes that is getting dumped in open areas which is produced from thermal power plants. Several attempts were made to utilize the pond ash as replacement to sand and cement. With advancement in technology new methods were introduced to obtain the 28 days compressive strength of concrete in 28 hours(As per IS 9013-1978-Method of making, curing and determining compressive strength of accelerated cured concrete test specimens). In the present study various proportions of pond ash (15%, 20%, 25%, 35%) as replacement to sand in M30 Grade concrete is considered. Proper proportions were obtained after getting a Mix Design and compressive strength of cubes were calculated by CTM for various curing periods (7, 14,28days).Effect of curing is evaluated in our study by using Accelerated Curing Tank.

Index Terms **- Accelerated curing method, Compressive strength, Pond ash.**

1. INTRODUCTION

Concrete is prepared by mixing cement, sand and aggregate and when it is mixed with water it becomes as a fluid material and it will undergo hydration process through which it will attain the strength and desired shape. For attaining the strength the concrete mass is placed in controlled curing conditions where proper hydration reactions will take place [1]. Through curing we can control moisture content or temperature of the concrete cubes. Curing of concrete stands for procedures devoted to promote cement hydration, consisting of control of time and humidity conditions immediately after the placement of concrete mixture in to form work [2].

The concrete achieves about 90% of its strength in 28 days under normal atmospheric conditions [3]. Concrete is kept damp during the curing process such that it won't undergo any shrinkage due to loss of water and subsequent formation of tensile cracks in the structures can be reduced. The hydration process will be faster at higher temperatures. The concrete gains its strength quickly due to faster hydration but at a certain temperature the water in the concrete may get evaporated which will build vapour pressure inside it and eventually leads to cracks when the vapour escapes out from the concrete. Hence the temperature of the curing in accelerated curing methods is restricted below the evaporation temperature[5]. The method by which early strength of the concrete is measured is known as "accelerated curing method".

2. MATERIALS USED

2.1 CEMENT

Cement is a binder substance used for construction that sets, hardens and adheres to other materials, binding them together. It is prepared by grinding together a mixture of limestone and clay, which is then heated at a temperature of 1,450°C which results in the formation of a granular substance called "clinker" (combination of calcium, silicate, alumina and iron oxide).The properties of cement are given in Table 1.

Table 1 Properties of Cement

S.No	Property	Value
1	Fineness	3%
2	Specific Gravity of cement	3.15
3	Consistency of Cement	30%

2.2 Aggregate

Aggregate, such as sand and crushed stone, is one of the concrete filler materials, and its role in the concrete is very important. The proportion of aggregate in the concrete reaches approximately 60% to 75% of the total volume of concrete. The use of aggregate in the concrete reduces volume changes, resists abrasion, provides volume stability and inculcates hardness to the concrete.

- **Fine aggregates** The fine aggregate, used in this investigation was locally available river sand which was passed through 4.75 mm sieve.
- **Coarse aggregates** The coarse aggregate, used in this investigation was obtained locally available quarry having two different sizes, one fraction was passing through 20mm sieve and its fineness modulus was 7.5, and another fraction passing through 10mm sieve and its fineness modulus is 6.8. The properties of cement are given in Table 2

Table 2 Properties of Aggregate

S.No	Property	Value
1	Specific Gravity of Fine aggregate	2.74
2	Specific Gravity of Coarse aggregate	2.72
3	Water absorption i)Fine Aggregate ii)Course Aggregate	 1.0% 0.5%

2.3 Pond Ash

Pond ash is a composite material composed of oxides of silica aluminium, ferrous, calcium, magnesium, sulphur, potassium and sodium. The chemical properties of pond ash are presented in Table

Table 3 Chemical Properties of Pond Ash

Parameter	**SiO_2**	**Al_2O_3**	**Fe_2O_3**	**CaO**	**MgO**	**SO_3**	**K_2O**	**Na_2O**	**LOI**
Pond ash	54.46	33.11	1.76	7.97	0.35	1.2	0.00	0.00	2.16

It consists of pozzolanic properties which enables it to act as binding material. It can be used as a partial replacement of cement and sand[6]. So it can be wildly used in construction of concrete structures, pavements, stabilization of soil and manufacturing of bricks.

3.0 Accelerated Curing Methods

- Boiling water method
- Warm water method
- Rising temperature curing method

3.1. Boiling Water Method

- The test specimens should be casted and left undisturbed for 23 hours ± 15 minutes in moist air having at least 90% humidity and at a temperature of 27 ± 2°C.
- Then the specimens should be lowered into the curing tank and they should be totally immersed in water for a period 3 hours and 30 minutes ± 5 minutes. The water in the curing tank should be maintained at a temperature of 100ºC.After curing for 3 hours and 30 minutes in the curing tank, the test specimens should be removed from the boiling water and cooled by immersing them in a cooling tank with water at a temperature of 27 ± 2ºC for 2 hours.
- Finally the cubes should be demolded once they are cooled.

The strength attained is calculated by using the formula

$$R_{28} \text{ (Strength at 28 days)} = 8.09 + 1.64\, R_a$$

R_a = accelerated curing strength in MPa

3.2. Warm Water Method

- The specimens shall be left to stand undisturbed in their moulds in a place free from vibration at a temperature of 27 ± 2ºC for at least one hour.
- The time between the addition of water to the ingredients and immersion of the test specimens in the curing tank shall be at least 1 hour and 30 minutes but shall not exceed 3 hours and 30 minutes.
- The specimens in their moulds shall be gently lowered into the curing tank and shall remain totally immersed at 55 ± 2°C for a period of not less than 19 hours 50 minutes.
- The specimens shall then be removed from the water, marked for identification, removed from the mould and immersed in the cooling tank at 27 ± 2°C before the completion of 20 hours 10 minutes from the start of immersion in the curing tank. They shall remain in the cooling tank for a period of not less than one hour.

The strength is calculated by formula

$$R_{28} = 12.65 + R_a$$

R_a = accelerated curing strength in MPa

3.3. Rising Temperature Curing Method

- In this method, after the specimens have been made, they shall be stored in a place free from vibration, in moist air of at least 90% relative humidity and at a temperature of 27 ±2°C for 23 hours ±15 minutes from the time of addition of water to the ingredients.

- The specimens shall then be gently lowered into the curing tank when water is at room temperature. Then the temperature of the water is gradually increased to 100°C within next five hours and kept constant for next 1 hour and 30 minutes.
- The temperature of water shall not drop more than 3°C after the specimens are placed and shall return to boiling within 15 minutes. After curing in the tank for a specified period, the specimens were removed from the boiling water, removed from the moulds and cooled by immersing in cooling tank at 27 ± 2°C for 2 hours.

The strength is calculated by formula

$$R_{28} \text{ (Strength at 28 days)} = 8.09 + 1.64R_a$$

R_a = accelerated curing strength in MPa

3.4 Accelerated Curing Tank

Fig.1. Accelerated Curing Tank

- The accelerated curing tank shown in Figure 1 is designed to accommodate casted cubes and is fully insulated.
- It consists of a hinged lid, heater, thermostat and recirculation pump.
- Provision for two removable racks is provided to allow free circulation of water around each cube.
- The pump, drain valves and electrical equipment are housed in a compartment located at one end of the tank.

4. Experimental results

In the present study the rising temperature method is adopted as accelerated curing method and compressive strength tests were performed on concrete cubes of M30 Grade concrete.

Table 4 Comparison of Compressive Strength of Normally Cured Concrete Cubes with Respect to Accelerated Curing (Rising Temperature) Method

Percentage replacement of pond ash	**R_a N/mm^2**	**Compressive Strength of cubes by Accelerated curing ,R_{28}N/mm^2**	**Compressive Strength of Normally cured Concrete in N/mm^2**	**Percentage decrease in compressive strength**
0%	13.30	29.90	40.88	26.85%
15%	20.00	40.89	44.44	7.98%
20%	19.77	40.59	41.33	1.98%
25%	18.66	38.69	40.00	3.275%
35%	11.55	27.03	35.11	23.00%

R_{28} (Strength at 28 days) = 8.09 + 1.64 Ra

R_a = accelerated curing strength in MPa

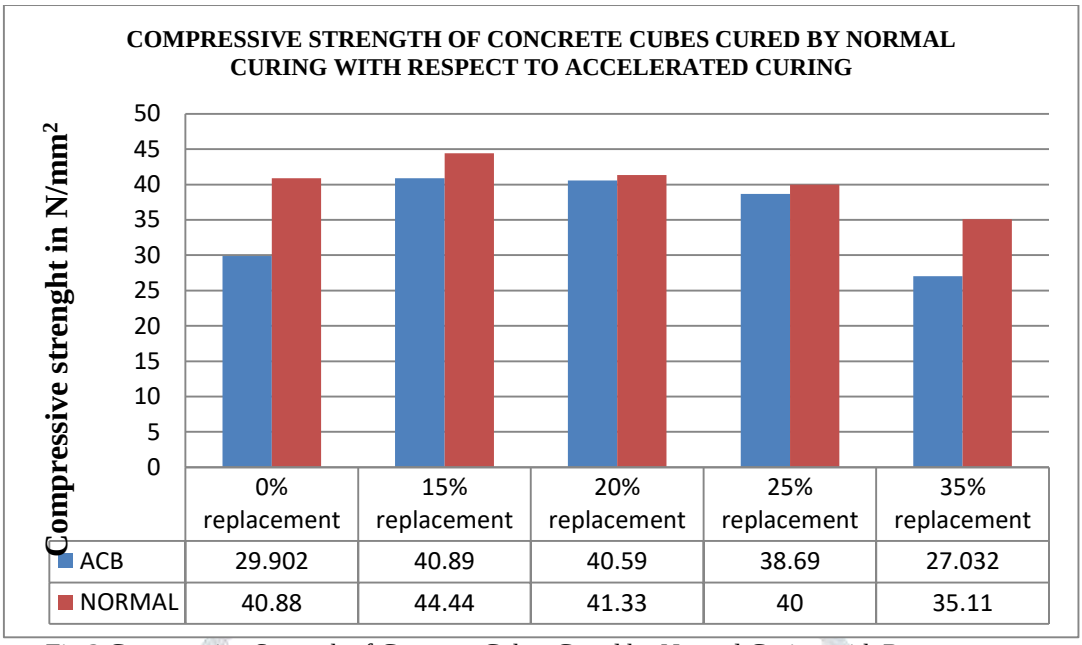


Fig.2.Compressive Strength of Concrete Cubes Cured by Normal Curing with Respect to Accelerated Curing

5. Results and discussions

1. For conventional concrete cubes the compressive strength obtained by accelerated curing is 29.90 N/mm^2 whereas under normal curing condition a compressive strength of 40.88N/mm^2 is obtained.
2. For 15%, 20%, 25% there is no much variation is observed in the compressive strength obtained from accelerated and normally cured concrete cubes.
3. For 35% pond ash replacement the compressive strength obtained by accelerated curing concrete cubes got reduced by 23% with respect to compressive strength of normally cured concrete cubes.
4. The strength obtained by the concrete cubes cured by accelerated curing by rising temperature curing method is less when compared with normal curing for conventional and various percentage replacement of pond ash.

6. Conclusion

28 days compressive strength of concrete is considered for checking the quality of concrete mix. But in this modern era of construction 28days period of curing is quite a long period to wait and to adopt proper quality corrective measures as the concrete might have hardened by that time and if any other construction activities are taken place in between those 28 days they will hinder the corrective measures. On the other hand if the strength obtained by concrete mass is more than required a new trial mix can be considered for limiting the usage of cement. Hence, standard 28 days cube testing of concrete is not feasible for quality control, to answer all these issues a new method known as accelerated curing methods are introduced.

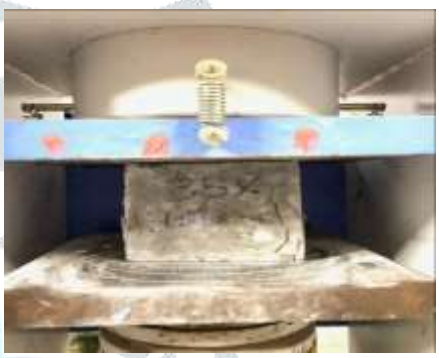
Figure 3 Curing of the Concrete Cubes at a Temperature of 100^o C

4(a) 0% replacement

4(b) 15% replacement

4(c) 20% replacement

4(d) 25% replacement



4(e) 35% replacement

Figure 4 Compressive Testing for Accelerated Cured Concrete Cubes of M30 Grade with various pond ash replacements.

7.0 References

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