Partial Replacement of Fly Ash in Accelerated Curing

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***Abstract*—The compressive strength of cement concrete obtained after 28 days of curing is used in the quality control of construction. However, for economical quality control, for reworking before the concrete gets hardened and for reducing the waiting time, finding the 28days compressive strength at an earlier time with a reasonable accuracy is necessary. In study, it is proposed to estimate the 28 days compressive strength of a concrete in lesser time by finding the strength at an early age accelerated curing the finding 28days strength using the previously established regression between the strength with accelerated curing and 28days strength.There are many ways of accelerating curing process of a concrete test specimen. By accelerating the gain of strength ,strength-testing schedule is shortened and thus it is contemplated that the 28 days strength can be predicted as early as one day with reasonable accuracy. In this study, thermal heating was used and the prediction of 28day strength was attempted.The concrete cube specimens were cured in two phases, initially at room temperature at maximum of about 24 hrs and later at a higher temperature of (50º C &75º C) for accelerated curing for a maximum of 5, 7.5 and 10 hrs. Using the early strength obtained after the two-phase curing and the curing parameter, linear and exponential regression equation were developed to predict the 28days compressive strength.**

Keywords*— Compressive strength,fly ash, accelerated curing

I. INTRODUCTION

The strength of concrete in a construction work is determined at its 28days compressive strength. To find this compressive strength, usually 28days of moist curing is required. The 28 days of waiting time is too long period for any corrective measure in case the strength is not desirable. That is, after 28days, by the time quality of concrete is found to be not sufficient, the concrete would have hardened significantly and might be buried by subsequent construction. This make the replacement of concrete mass of sub-quality concrete very difficult which is costly and time consuming. Suppose, if the concrete is greater strength then the required, the uneconomical mix is just a waste of costly material. These indicated a for finding the 28days characteristic strength for real good quality control. Hence for better quality control, a concrete cube test procedure is needed while the concrete is still accessible and sufficiently soft to make it removal practicable. Hence, accelerated curing techniques are becoming important.

The exothermic chemical reaction between cement and water, called hydration, harden the concrete mix. cement hydration consist of complex series of chemical reaction, which are still not completely understood. The concrete needs to be properly cured during hydration to achieve best strength and hardness. The concrete usually get about 90% of its strength in about 28days, though gaining of strength may continue for a decade or so. Hydration and hardening of concrete during the first few days is critical. Fast drying and shrinkage due to loss of water may lead to tensile stresses at a time when it has not yet gained sufficient strength, resulting is greater shrinkage cracking. Thus the concrete is kept damp duringthe curing process. usually, the hydration process is faster at higher temperature. When the hydration process is faster, the concrete gains the strength faster. However, being the hydration process rapid, the final compressive strength attained is lower in comparison to normally cured concrete which is called as the “crossover effect”.

A method by which high early age strength is achieved in concrete is called accelerated curing. The accelerated curing techniques are very useful in the prefabrication industry, which enable the removal of the reusable formwork earlier which makes business economical. Further, the accelerated curing is useful in special situations like repairing a busy road bridge where the detouring time can be minimize to a great extent by accelerated curing.

The aim of the present research is to develop a cube testing procedure with accelerated curing. The crossover effect in the case of a concrete cube can be ignored the cube is used as a test specimen which is not really a part of the construction. While the real concrete construction is being cured in a conventional manner, the cube is given the accelerated curing treatment just identify the 28days strength in advance.

There are many methods of accelerated curing being practiced. some of the methods are listed below.

1. Steam curing at atmospheric pressure.
2. Warm water curing.
3. Boiling water curing.
4. Autoclaving.
5. Microwave based curing

Fly ash is a byproduct from burning pulverized coal in electric power generating plants. During combustion, mineral impurities in the coal (clay, feldspar, quartz, and shale) fuse in suspension and float out of the combustion chamber with the exhaust gases. As the fused material rises, it cools and solidifies into spherical glassy particles called fly ash. Fly ash is collected from the exhaust gases by electrostatic precipitators or bag filters. The fine powder does resemble Portland cement but it is chemically different. Fly ash chemically reacts with the byproduct calcium hydroxide released by the chemical reaction between cement and water to form additional cementations products that improve many desirable properties of concrete. All fly ashes exhibit cementations properties to varying degrees depending on the chemical and physical properties of both the fly ash and cement. Compared to cement and water, the chemical reaction between fly ash and calcium hydroxide typically is slower resulting in delayed hardening of the concrete. Delayed concrete hardening coupled with the variability of fly ash properties can create significant challenges for the concrete producer and finisher when placing steel-troweled floors.

Two types of fly ash are commonly used in concrete: Class C and Class F. Class C are often high-calcium fly ashes with carbon content less than 2%; whereas, Class F are generally low-calcium fly ashes with carbon contents less than 5% but sometimes as high as 10%. In general, Class C ashes are produced from burning sub-bituminous or lignite coals and Class F ashes bituminous or anthracite coals. Performance properties between Class C and F ashes vary depending on the chemical and physical properties of the ash and how the ash interacts with cement in the concrete. Many Class C ashes when exposed to water will react and become hard just like cement, but not Class F ashes. Most, if not all, Class F ashes will only react with the byproducts formed when cement reacts with water. Class C and F fly ashes were used in this research project.Currently, more than 50% of the concrete placed in the U.S. contains fly ash. Dosage rates vary depending on the type of fly ash and its reactivity level. Typically, Class F fly ash is used at dosages of 15% to 25% by mass of cementations material and Class C fly ash at 15% to 40%. However, fly ash has not been used in interior, steel-troweled slabs because of the inherent problems or challenges associated with fly ash variability and delayed concrete hardening. Rate and uniformity of concrete hardening are critical parameters in establishing the window-of-finishability and can influence directly the quality of final floor finish. Delayed or nonuniform concrete hardening significantly increases the risk of premature or improper finishing resulting in poor quality steel-troweled finishes. Until now, building owners, concrete suppliers, and finishers have been reluctant to replace cement with fly ash in steel-troweled floors because of the increased risks associated with the fly ash. These risks include surface stickiness, delayed concrete hardening, and early volume shrinkage cracking caused by delayed setting.

The objective of the present study is to develop a laboratory test procedure for predicting the 28days compressive strength of concrete cubes by reducing the time required through accelerated curing with the help of boiling water. The prediction model is contemplated as a multiple regression model which uses the early strength obtained through accelerated curing, and the parameters.

II. MATERIALS

A. Cement

Ordinary Portland cement is the most common type of cement in general usage. It is a basic ingredient of concrete, mortar and plaster.

B. Water

Combing water with a cementitious material forms a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it and allows it to flow more freely.

Less water in the cement paste will yield a stronger, more durable concrete; more water will give a free-flowing concrete with a higher slump.

C. Natural Aggregates

Mineral aggregates consist of sand and gravel, stones and crushed stone.

The sources of mineral aggregates are by directly extracting from the original sources like river basins or by manufacturing them into a desired shape from the parent rock in a crasher mill.

D.Non Natural Aggregates

This category consists of aggregates that are artificial in origin. The reasons for their advent in concrete construction are:

i) Environmental considerations are increasingly affecting the supply of aggregate.

ii) There are strong objections to opening of pits as well as to quarrying.

iii) At the same time, there are problems with the disposal of construction demolition waste and with dumping of domestic waste.

Wide varieties of materials come under the general heading of solid wastes. These range from municipal and household garbage, or building rubble, such as brick and concrete, through unwanted industrial by products such as slag and fly ash or discarded or unused materials such as mine tailings.

Recycled tire rubbers can be categorized under municipal wastes. Table 2.1 below shows the different solid wastes that have been considered as aggregates for concrete with their composition and the associated industry.

III. METHODS

A.Material Collection

First we collected cement 1bag M30 OPC 0f 43 grade, Fly Ash ,sand , aggregate , water immersion heater (1000 watt) ,thermostat , thermometer ,water bucket for curing process.

done properly.

B. Batching Of Material

Batching may be done by the weight or volume batching. In this project we are using weight batching.

C. Mixing Of Concrete

Mixing of concrete may be done by hand or by machine. Mixing by machine is always preferred. Concrete mixers are used for mixing concrete and are of two types, continuous mixers or batch mixers.

D. Curing Of Concrete

The following methods of curing are adopted depending on the type of work

Direct curing

In this method water is directly applied on the surface for curing. In this process the surface is continuously cured by stagnating water. These methods are used for horizontal surfaces. Vertical surfaces can be cured by covering moist gunny bags or straws.

Membrane curing

In this method steps are taken to prevent water evaporation from finished concrete surfaces. This is done by covering the surfaces with water proof papers, polythene papers or by spraying with patented compounds or bituminous layer to form an impervious film on the concrete surface.

Steam curing

In this approach is widely used in precast concrete units. Here the precast units are kept under warm and damp atmosphere of a steam chamber.

IV.EXPERIMENTAL ANALYSIS AND DISCUSSION

Testing of concrete may be classified in several types. In our project we used compressive test of concrete test.

A. Mix design

M-30 grade

1.strength of concret = 30+ (4.6×1.65)
= 37.59 N/mm^2.

2.water cement ratio :
Target strength = 37.57 N/mm^2
= 0.38

3.water and sand content :
Cubic meter of concrete = 186 kg
Absoulte volume = 35 %

Required water content $= 186 + \frac{186\times3}{100}$
= 191.6 N/mm^2

Cement content

Water cement ratio = 0.38
Water = 191.6
Cement = 191.6/0.38
= 504.21 kg/m^3

Sieve number	Opening size
4	4.75
8	2.36
16	1.18
30	0.600
50	0.300
100	0.150
140	0.106
200	75
Pan	-

Coarse and fiine aggregate concrete

$$V=[w+\frac{c}{s_c}+\frac{1}{p}.\frac{f_a}{s_{fa}}]\times\frac{1}{1000}$$

$$0.98= [\ 191.6 + \frac{504.21}{3.25}+\frac{1}{0.315}\times\frac{f_a}{2.60}\ ]\times\frac{1}{1000}$$

f_a=514.605 kg/m^2

0.98= [191.6 + 504.21/3.25 +1/0.315 ×c_a/2.60] ×1/1000

ca =1119.06 kg/m^3
cement=504.21 kg/m^3
sand =514.60 kg/m^3
aggregate=1119.06 kg/m^3

FOR 1 CUBE

0.15×0.15×0.15m =0.003375
Cement =0.003375 × 504.21
=1.70 kg
Sand =0.003375 × 514.60
=1.736 kg
Aggregate =0.003375×1119.06
=3.7768 kg

Mixing ratio

1:1.02:2.22

B. Sieve Analysis Test

The grain size analysis is widely used in classification of soils. The data obtained from grain size distribution curves is used in the design of filters for earth dams and to determine suitability of soil for road construction, air field etc… information obtained from grain size analysis can be used to predict soil water movement although permeability test are more generally used.

Objectives

The standard grain size analysis test determines the relative proportions of different sizes as they are distributed among certain size ranges

Apparatus

- Stack of sieves including pan and cover [75,0,106,0,150,0,300,0,6001.18,236and 4.75]
- Balance(with accuracy to 0.01g)
- Mechanical sieve shaker
- Oven
- The balance to be used should be sensitive to the extent of 0.1% of total weight of sample taken

Test procedure

1. Collect a representative dry fine aggregate. Sample having largest particles of the size of No.4 sieve openings (4.75mm) should be about 1000 grams.
2. Determine the mass of the sample accurately to 0.1g(W)
3. Prepare a stack of sieves. A sieve with larger openings is placed above a sieve with smaller openings . The sieve at the bottom should be No.200. A bottom, pan should be placed under sieve No 200. As mentioned before the sieves that are generally used in a stack are No.4,8,16,30,50,100,140 and 200; however, more sieves can be placed in between.

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4. Pour the fine aggregate prepared in step 2 into the stack of sieves of sieves from the top
5. Place the cover on the top of the stack of sieves
6. Run the stack of sieves through a sieve shaker for about 10 to 15 minutes
7. Stop the sieve shaker and remove the stack of sieves
8.Weigh of the amount of soil retained on each sieve and the bottom pan.

Weight of the fine aggregate + pan = 1349.2g
Weight of the pan = 349.2g
Weight of the fine aggregate (Wt) = 1000g

Sieve Analysis of sand

Table :2 Sieve Analysis of sand

Sieve number	Opening size	Mass of retained[C1)	% of Retained (C2)	% of Passing (C3)
4	4.75	0	0	100
8	2.36	100	10	90
16	1.18	260	26	64
30	0.600	240	24	40
50	0.300	190	20	20
100	0.150	110	11	9
140	0.106	60	6	3
200	75	25	2.5	1.5
Pan	-	15	1.5	0

Calculation:
Mass retained =

$$\frac{\text{Percentage of reatained}}{\text{Weight of the fine aggregate}} \times 100$$

4.3

Curing time	50 ºc **(MPa)**	75 ^{0} **(MPa)**
5 hrs.	38	41
7.5 hrs.	42	46
10 hrs.	45	51

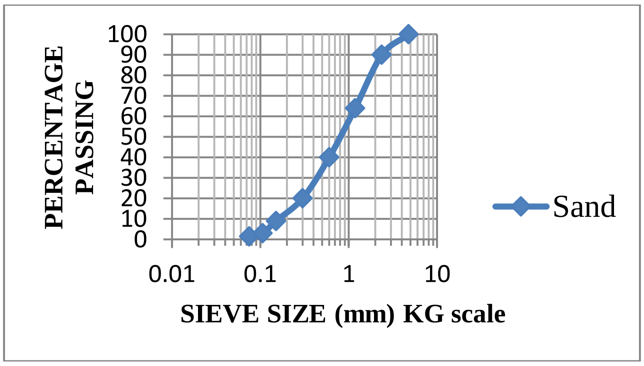


Fig : 1

C. Specific Gravity Test
The specific gravity of an aggregate is considered to be a measure of strength or quality of the material. Stones having low specific gravity are generally weaker than those with higher a

Specific gravity of a material may be defined as the ratio of density of the material to density of water at a specified temperature.

Apparatus
1. A balance of capacity not less than 3kg,readable and accurate to 0.5 gm and of such a type as to permit the weighing of the vessel containing the aggregate and water.
2. Pycnometer of about 1 liter capacity having a metal conical screw top with a 6 mm hole at its apex. The screw top shall be water tight.

Procedure
1. The empty weight of the pycnometer is measured
2. The sample of weight 250g is taken in pycnometer and the weight is measured
3. Water filled in the pycnometer along with the sample. The entrapped air is removed by rotating the pycnometer on its side, the hole in apex of the cone being covered with a finger. The outer surface of the pycnometer wiped and weighted
4. The content in the pycnometer is now removed. Now it is filled fully by water up to apex. The weight is noticed as

Observation
Weight of empty pycnometer (g) - W1
Weight of pycnometer + sample (g) - W2
Weight of pycnometer + sample + water (g) - W3
Weight of pycnometer +water (g) - W4

Formula

$$\text{Specific gravity} = \frac{\text{weight of dry sample}}{\text{Weight of equal volume of water}}$$

Table : 2

Age	Strength
5hour	41MPa
7.5hour	46MPa
10hour	51MPa

$$\text{Specific gravity} = \frac{[w2 - w1]}{[w4-w1]-[w3-w2]}$$

Calculation
Specific Gravity Of Sand
Weight of empty pycnometer (W1) =632 g
Weight of pycnometer + sample (W2) = 884 g
Weight of pycnometer + Sample +Water (W3) = 1732 g
Weight of pycnometer + Water (W4) = 1571 g

$$\text{Specific gravity} = \frac{[884-632]}{[1571-632]-[1732-884]}$$

D. Compressive Strength Test

Compression testing machine, concrete cube, scale

Test procedure

1. Remove the specimen from water after specified curing time and wipe out excess water from the surface.
2. Take the dimension of the specimen to the nearest 0.2m
3. Clean the bearing surface of the testing machine
4. Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.
5. Align the specimen centrally on the base plate of the machine.
6. Rotate the movable portion gently by hand so that it touches the top surface of the specimen.
7. Apply the load gradually without shock and continuously at the rate of 140kg/cm2/minute till the specimen fails
8. Record the maximum load and note any unusual features in the type of failure.

V. OBSERVATION:

Crushing load
Compressivestrength $=51\times10^{3}$ N/mm^2
\# 25000

$= 24$ N/mm^2

VI. RESULT AND GRAPH

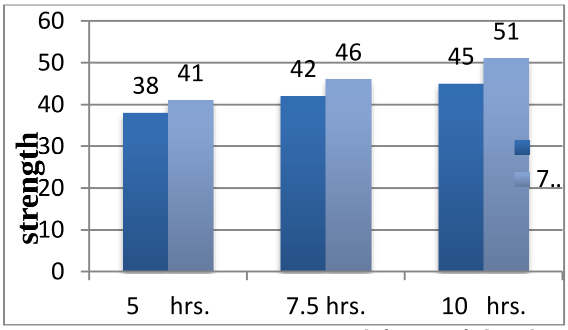


Fig : 2 Compressive strength for 0 % of Fly Ash

Compressive Strength of 25% Of Fly Ash

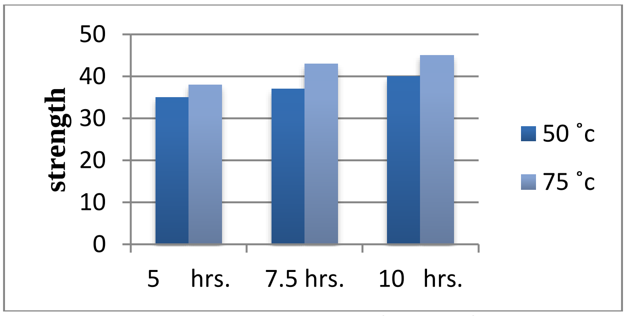


Fig : 3 Compressive Strength for 50% Of Fly Ash

Table : 3

Curing time	50 (MPa)	75 (MPa)
5 hrs.	29	32
7.5 hrs.	31	34
10 hrs.	33	37

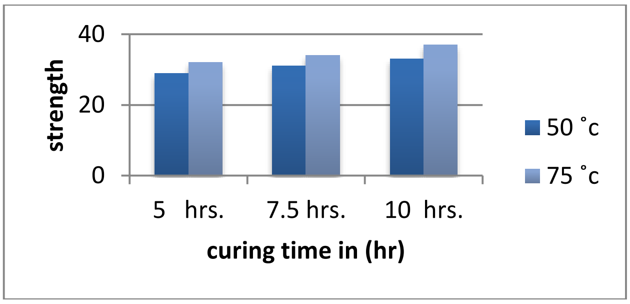
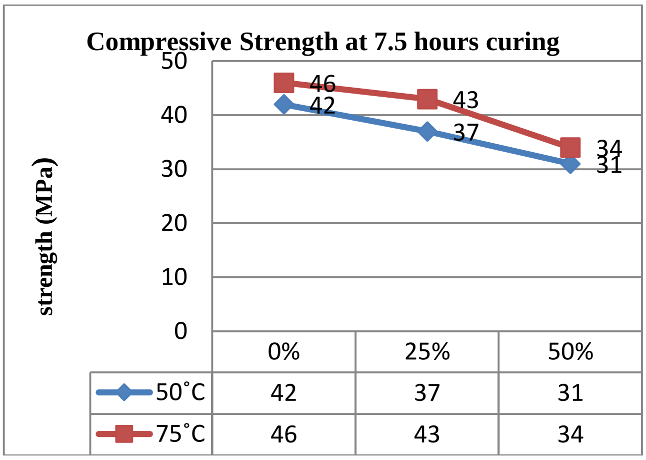
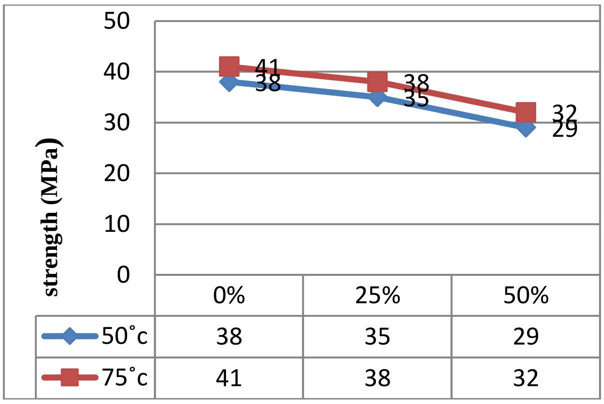


Fig : 4

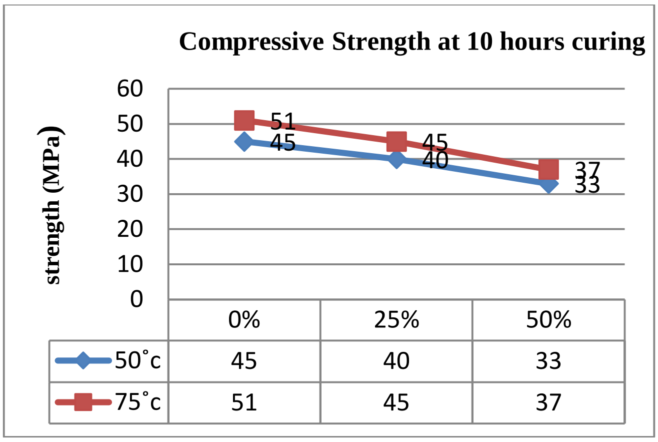


Graph : 1

Compressive Strength at 5 hours curing



Graph: 2



Graph : 3

VII. CONCLUTION

- By seeing the graph of0% replacement the maximum value of 40 Mega Pascal obtained at 75ºCelsius temperature of 10hrs duration. From the graph of 25% replacement the maximum value of 33Mega Pascal obtained at 75ºCelsius temperature of 10hrs duration.
- By seeing the graph of 50% replacement the maximum value of 26Mega Pascal obtained at 75ºCelsius temperature of 10hrs duration.
- By comparing the entire above graph the peak value obtained at 10hrs in thermal curing at 75ºCelsius temperature.
- Finally the result show almost we are getting near by 90% of 28 days normal curing strength.

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