Effect of Accelerated Curing on Compressive Strength of High Strength Concrete with Fly Ash

Rakkisa Naga Jyothi, B. Kameswara Rao

Abstract: ***As per Indian standard codes the concrete should be accepted or rejected on the basis of 28 days normal cured strength. Normal curing of concrete for 28 days is quite complicated, time consuming for results. There are no adequate results to quantity durability. So to avoid this time consumptions and delay of results, the accelerated curing strength can be extremely helpful. As per IS -9013 there were only prediction for 28 days strength of normal concrete from accelerated curing strength. This paper deals with some of the attempts made of fly ash concrete to get the strength from the accelerated curing test. Now a day's fly ash concrete is frequently used in the construction and there is no principle for the evaluation of fly ash concrete from accelerated concrete tests. Fly ash is a waste or by product generated from the electrical thermal plants. In this experimental work the fly ash concrete mix proportions are replaced by 70%, 60%, 50%, 40% and 30%. This paper deals with the correlation strength between 28 days normal concrete curing strength and accelerated curing tests of fly ash concrete.***

Index Terms: ***Accelerated curing tank, compression test, fly ash.***

I. INTRODUCTION

Usually, in construction fields the quality of concrete is calculated on the basis of 28 days compressive strength tests. The normal curing of concrete requires 28 days of moist curing, this process requires too long period to get the results. To overcome this problem, the accelerated curing strength is used to determine the expected strength of normal cured concrete at later stage and it is used as a quality control tool to check the quality of concrete. In accelerated curing method there were two standard methods which are commonly used to predict the strength of concrete in about 24 hours. The two methods are warm water method and boiling water method.

This paper deals with the replacement of cement with fly ash. Fly ash is produced by burnt of coal in thermal plant. It can be collected as the form of classified stack and due its fineness fly ash can be used as cement replacement. This standard interdicts the utilization of fly ash due to more carbon mix of concrete which residual carbon obstruct air entrainment and decreases the thaw resistance of concrete. Fly ash uses in concrete increases fines volume and decrease the water content and thus reduces bleeding of concrete. Fly ash has been classified into two classes: class C and class F. Class C fly ash is produced from burning lignite, and class F which is dark gray is produced from bituminous coal, as both classes have the cementations properties. The main objective of this project is:

1. To study the effective of partial replacement of cement with fly ash.
2. To evaluate the compressive strength of high volume fly ash with accelerated curing tests and normal curing.
3. Different experimental investigations were carried out for the criteria of durability of concrete.
4. By introducing alternative materials and its content the use of cement can be minimized.
5. The time consumption can be reduced by using accelerated curing test method

The concrete reaches its usual strength of about 90% in just 28 days and shrinkage cracks are formed due to insufficient strength, fast drying results in the development of tensile stresses.

Table I:.ASTM procedures for accelerated strength testing

Method	Procedure	Advantages	Limitations
Warm water	In this method the tested specimens are placed in the accelerated tank immediately after casting and maintained at 35°C (95°F) for a period of 24 hours	1.Equipment is simple 2.Test results are obtained at 25 hours	1. There is a need for over-time. 2. Strength gain, as compared with 24 h old normal moist-cured cylinders, is not high
Boiling water	In this method the tested specimens are placed in the accelerated tank after 24 h of moist – curing and then cured in a water bath for 3.5 h at 100°C(212°F)and then tested after 1 h, total given 28.5 h	1. Equipment is simple and actual accelerated curing period is short. 2. Strength gain, as compared with 28.5 h old normal moist-cured cylinders, is higher.	1. There is a need for over-time. 2. There is possibility that produces of hydration of cement may be slightly different from those obtained by normal moist curing of cylinders.

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Autogenous	In this method the tested specimens are placed in the insulated containers for 48 to 49 h.	1. There is no need for site laboratory. 2. There is no need for external heat source.	1. This is the least accurate test of the three methods. 2. The strength gain, as compared with normal 48 h normal moist-cured cylinders, is no high. 3. There is a need for excessive over-time.

Thus, concrete is placed damp during the process of curing. Usually, hydration process at higher temperatures is faster.

Due to hydration process the strength gained by concrete is fast. However, cracks are developed in concrete due to vapour pressure, while the water vapour tries to escape from concrete. Ultimately, due to overheating strength of concrete will be affected. Hence, the temperature of curing should be well below the water evaporation temperature. The method used to gain high early strength in concrete is called "accelerated curing method". In accelerated curing method, concrete is subjected to heat so as to hasten the chemical actions involved in hardening or hydration processes. When hydration occurs at a rapid pace, there is a rapid hardening and a rapid gain of strength. Hydration, being an exothermal chemical reaction gives off heat; and if heat is applied externally, hydration will be accelerated. Accelerated curing is achieved by using numerous methods, with varying degrees of success. The major methods for the purpose of accelerating curing process of concrete been divided into two categories: physical processes and admixtures. As the development in material technology was improved, there are number of admixtures available like (mineral and chemical) which can be used. However, compared with increased curing temperatures, the use of admixtures accelerators will develop numerous difficulties. Class-F fly ash, it was the fineness, not the chemical composition that has significant effect on compressive strength of mortars. The finer fly ash mortars gained higher compressive strength than those with the coarser ones. The addition of ultra-fine fly ash (UFA) to cement paste, mortar and concrete can improve their fluidity, but some coarse fly ash can't reduce water. This paper investigates the effect of replacement of fly ash for different proportions of cement and deal with the strength parameters. Different fineness of fly ash were chosen, and their replacement levels were 30%, 40%, 50%, 60%, 70% respectively. The experiment results show that the compressive strength for different proportions been considered. The Table 1 shows the procedure for accelerated cutting testing methods.

II. MATERIALS

The various materials used in this research work are cement, fly ash, coarse aggregate, fine aggregate, super plasticizer, water and accelerated curing.

A. Cement

Cement is a material used as binder that sets and hardens independently; it has a special property which can bind different materials along. In this project Ordinary Portland cement is used without any specified grade of cement.

B. Fly Ash

Fly ash is a by- product of power plants and the specific gravity of fly ash is 2.25. Cement is partially replaced with fly ash to study the properties of fly ash concrete. To study the impact of partial replacement of cement by fly ash with accelerated curing on the properties of concrete, experiments were conducted on different concrete mixes. Fly ash used for the purpose of this investigation was obtained from Ibrahimpatnam Thermal power plant (IBM) Vijayawada.

C. Coarse aggregate

The coarse aggregates used are conforming to IS: 383 and the results of tests like Specific gravity for 10mm and 20mm are 2.89 and 2.91 respectively.

D. Fine aggregate

The fine aggregate used were conforming to the requirements of IS: 383 and specific gravity is 2.63.

E. Super plasticizer

Super plasticizer based on naphthalene formaldehyde sulphonate polymer used from SWC, confirming to IS 9103: 2003.

F. Water

The pH value of water was tested and it lies in between 6.0 and 7.0

G. Accelerated curing

Accelerated curing test method was developed to cater the need of early assessment of compressive Strength for concrete. This study has been conducted to find out the correlation of compressive strength.

III. DESCRIPTION OF WORK

A. Accelerated test procedure: (IS 9013- 1978)

Once the specimen been casted, they should be stored in a place which is free from vibration and to be stored in moist air with a temperature of at least 27 ± 2°C for 23 hours and relative humidity of about 90 percent from the time of addition of water to the ingredients.

Specimens are to be lowered wisely into the curing tank and should remain totally immersed around 3 $^1/_2$ hours. The temperature of water in the tank should be around 100°C and temperature of water should not drop more than 3°C after the placing of specimens into tank and should return boiling within 15 minutes.

Once the curing was done for 3 $^1/_2$ hour in the curing tank, the specimen to be removed from the boiling water, which should undergo cooling and de moulding of specimens to be done at 27 ± 2°C.

B. Compressive strength determination

In this test sample fly ash concrete is filled in the mould of size 15cm × 15cm × 15cm and top of mould is strike off. A total number of 54 cubes were casted. Fly ash is added in place of cement in concrete.

IV. RESULTS AND DISCUSSION

The compressive test results for plain concrete 28 days and 90 days are mentioned in the Table II and III below and the predicted values are also mentioned.

Table II: Compressive strength values for 28 days

S. No.	w/c	Compressive strength for accelerated curing	Compressive strength for 28 days of fly ash concrete
1	0.3	29.22	33.37
		32.24	35.62
		39.06	43.03
2	0.4	22.62	25.25
		28.16	32.22
		34.74	38.92
3	0.5	22.11	25.55
		22.76	26.73
		26.33	30.29

Table III: Compressive strength values for 28 days

S. No.	w/c	Compressive strength for accelerated curing	Compressive strength for 28 days of fly ash
1	0.3	31.64	63.40
2	0.4	22.84	47.99
3	0.5	16.26	25.92

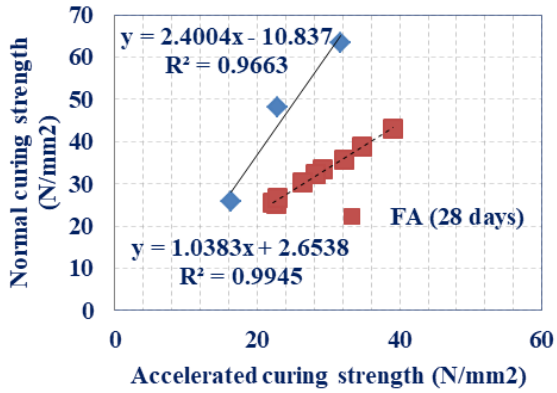

Figure 1:.Compressive strength values for 28 days

Table IV:.Compressive strength values for 90 days

S. No.	w/c	Compressive strength for accelerated curing	Compressive strength for 90 days of fly ash concrete
1	0.3	29.22	45074
		32.24	51.20
		39.06	53.27
2	0.4	22.62	30.04
		28.16	39.66
		34.74	42.47
3	0.5	22.11	27.96
		22.76	38.92
		26.33	41.88

Table V: Compressive strength values for 90 days

S. No.	w/c	Compressive strength for accelerated curing	Compressive strength for 90 days of fly ash
1	0.3	31.64	57.92
2	0.4	22.84	60.44
3	0.5	16.26	33.03

The Figure1 and 2 shows the regression equations for the compressive strength values for 28 days and 90 days.

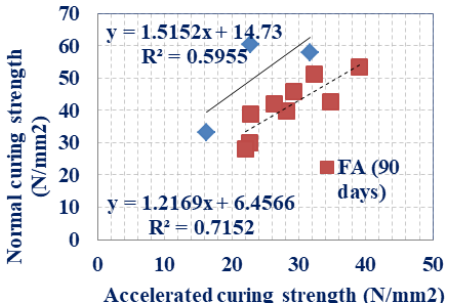

Figure 2: Compressive strength values for 90 days

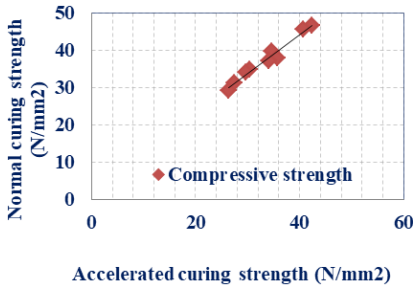

Figure 3: Compressive strength values for 0.3 w/c for 28 days

Table VI: Compressive strength values for 0.3 w/c for 28 days

S. No.	Compressive strength for accelerated curing	Compressive strength for 28 days
1.	30.48	34.88
2.	29.76	34
3.	27..42	31.33
4.	34.72	39.77
5.	35.68	38
6.	26.32	29.11
7.	42.42	46.55
8.	40.66	45.55

Table VII: Compressive strength values for 0.4 w/c for 28 days

S. No.	Compressive strength for accelerated curing	Compressive strength for 28 days
1.	30.48	20.22
2.	29.76	30
3.	27..42	25.55
4.	34.72	29.11
5.	35.68	34
6.	26.32	33.56

7.	42.42	38
8.	40.66	43
9.	34.12	35.78

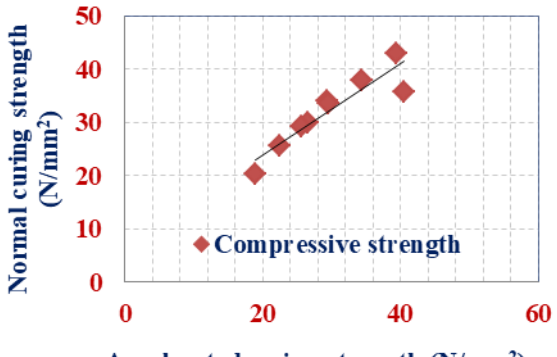

Figure 4.Compressive strength values 313131for 0.4 w/c for 28 days

Table VIII: Compressive strength values for 0.5 w/c for 28 days

S. No.	Compressive strength for accelerated curing	Compressive strength for 28 days
1.	30.48	24.67
2.	29.76	24.22
3.	27..42	27.78
4.	34.72	27.33
5.	35.68	22.44
6.	26.32	30.44
7.	42.42	29.11
8.	40.66	28.22
9.	34.12	33.56

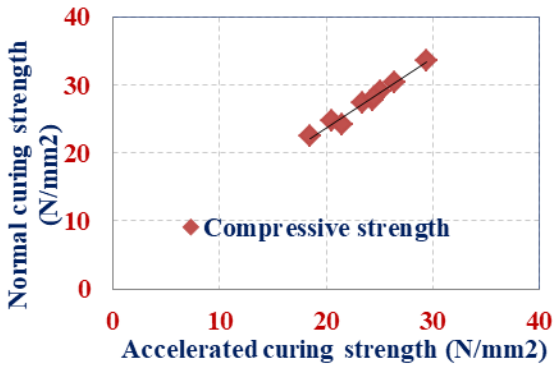

Figure 5.Compressive strength values for 0.5 w/c for 28 days

Table IX: Compressive strength values for 0.3 w/c for 90 days

S. No.	Compressive strength for accelerated curing	Compressive strength for 90 days
1.	30.48	44
2.	29.76	46.62
3.	27..42	46.62
4.	34.72	51.50
5.	35.68	54.16
6.	26.32	47.95
7.	42.42	43.51
8.	40.66	61.71
9.	34.12	54.61

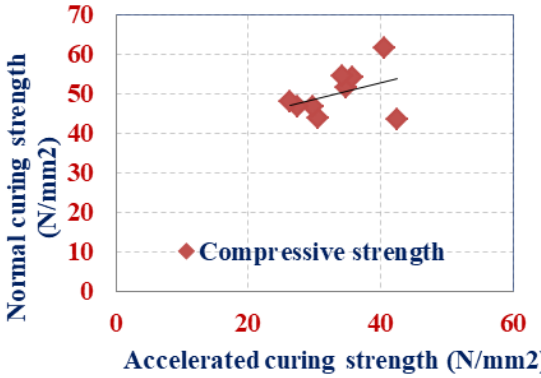

Figure 6.Compressive strength values for 0.3 w/c for 90 days

Table X: Compressive strength values for 0.4 w/c for 90 days

S. No.	Compressive strength for accelerated curing	Compressive strength for 90 days
1.	30.48	27.52
2.	29.76	29.30
3.	27..42	33.3
4.	34.72	48.84
5.	35.68	49.72
6.	26.32	20.42
7.	42.42	48.84
8.	40.66	35.52
9.	34.12	43.06

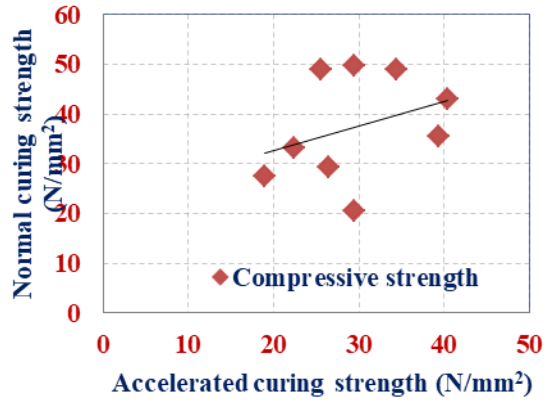

Figure 7.Compressive strength values for 0.4 w/c for 90 days

Table XI: Compressive strength values for 0.5 w/c for 90 days

S. No.	Compressive strength for accelerated curing	Compressive strength for 90 days
1.	30.48	36.85
2.	29.76	29.53
3.	27..42	27.52
4.	34.72	35.52
5.	35.68	37.74
6.	26.32	43.51
7.	42.42	36.40
8.	40.66	51.06
9.	34.12	38.18

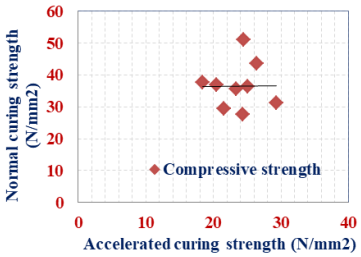

Figure 8: Compressive strength values for 0.5 w/c for 90 days

Table XII: Compressive strength values for plain concrete 28 days

S. No.	Compressive strength for accelerated curing	Compressive strength for 28 days
1.	38.22	24.67
2.	26.22	24.22
3.	30.5	27.78
4.	21.33	27.33
5.	22.66	22.44
6.	24.56	30.44
7.	16.44	29.11
8.	16	28.22
9.	16.35	33.56

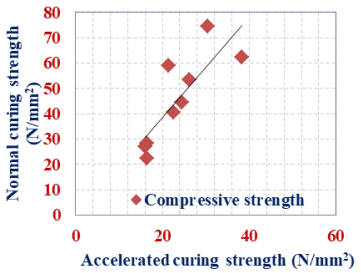

Figure 9: Compressive strength values for plain concrete 28 days

Table XIII: Compressive strength values for plain concrete 90days

S. No.	Compressive strength for accelerated curing	Compressive strength for 90 days
1.	38.22	63.55
2.	26.22	49.77
3.	30.5	60.44
4.	21.33	61.33
5.	22.66	52.44
6.	24.56	67.55
7.	16.44	35.11
8.	16	29.33
9.	16.35	34.66

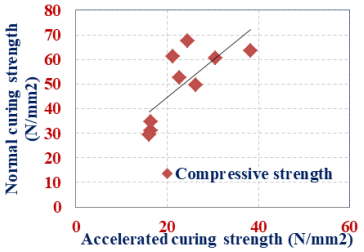

Figure 10.Compressive strength values for plain concrete 90 days

Table XIV: Predicted values for 28 days

S. No.	Compressive strength for accelerated curing	Compressive strength for 28 days of fly ash concrete	Predicted values
1	29.22	33.37	32.99
	32.24	35.62	36.12
	39.06	43.03	43.20
2	22.62	25.25	26.14
	28.16	32.22	31.14
	34.74	38.92	38.72
3	22.11	25.55	25.61
	22.76	26.73	26.28
	26.33	30.29	29.99

Table XV: Predicted values for accelerated

S. No.	Compressive strength for accelerated curing	Compressive strength for 28 days of fly ash	Predicted values
1	31.64	63.40	65.11
2	22.84	47.99	44.01
3	16.26	25.92	28.19

Table XVI: Predicted values for 90 days

S. No.	Compressive strength for accelerated curing	Compressive strength for 90 days of fly ash concrete	Predicted values
1	29.22	45074	41.99
	32.24	51.20	45.66
	39.06	53.27	53.95
2	22.62	30.04	33.96
	28.16	39.66	40.70
	34.74	42.47	48.70
3	22.11	27.96	33.34
	22.76	38.92	34.13
	26.33	41.88	38.47

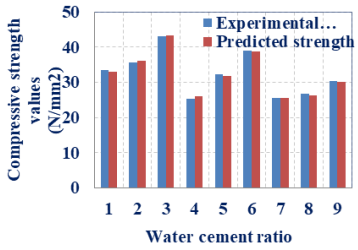

Figure 11: Predicted Compressive strength values for plain concrete 28 days

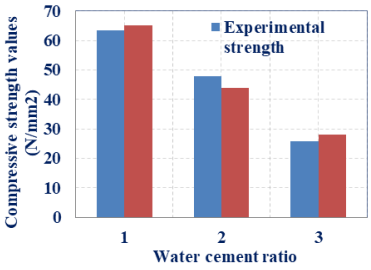

Figure 12: Predicted Compressive strength values for accelerated curing of 28 days

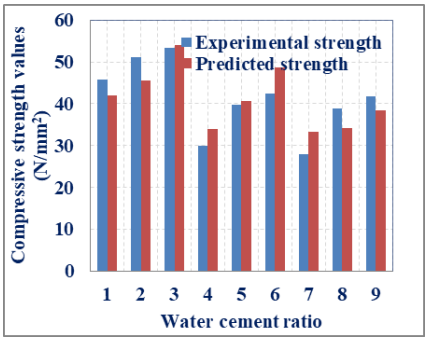

Figure 13: Predicted Compressive strength values for plain concrete 90 days

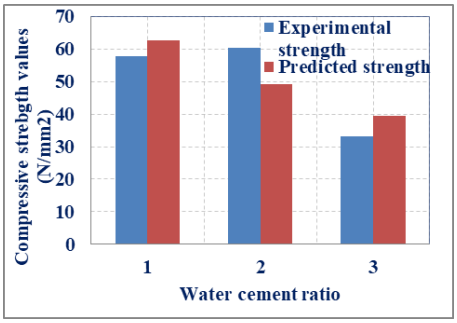

Figure 14.Predected Compressive strength values for accelerated curing of 28 days

Table XVII: Predicted values for accelerated 90 days

S. No.	Compressive strength for accelerated curing	Compressive strength for 90 days of fly ash	Predicted values
1	31.64	57.92	62.67
2	22.84	60.44	49.35
3	16.26	33.03	39.36

V. CONCLUSION

Based on the experimental investigation of compressive strength there is a slight increase of results when compared with accelerated curing tests to 28 days and 90 days of normal concrete. In this research work based on the comparison between 28 days moist curing and accelerated curing it obtained that the strength of cubes by boiling water is slightly greater when compared to normal curing and strength of accelerated curing is less when compared to strength of 90 days moist curing. The research is made to correlate the values between normal curing strength and accelerated curing strengths of fly ash.

REFERENCES

1. T.R.Neelakantan, S.Ramasundaram and R.Vinoth "Prediction of concrete strength using microwave based accelerated curing parameters by neutral network"International Journal of Engineering and Technology, Vol 5 No 1 Feb-Mar 2013.
2. Pujari Sainath and Ponnala Ramaiah "Partial replacement of cement with fly ash and it's compressive strength" "*International journal of Research In advanced Engineering Technology*", volume 5, Issue 3, August 2016.
3. P. R. Wankhede and V. A. Fulari "Effect of fly ash and properties of concrete" *International Journal of Emerging Technology and Advanced Engineering",* Volume 4, Issue 7, July 2014.
4. Brent Vollen weider "Various methods of accelerated curing for precast concrete applications and their impact on short and long term compressive "reach paper, 2016.
5. Gokhan Bayal, Ara Arman, and Ray Ferrell *"accelerated curing of fly ash-lime soil mixtures*" Transportation research record 1219.
6. Sudhir "A comparative case study of compressive strength of m45 and m40 grade concrete by accelerated curing test method and normal 28 days curing" *International Journal of Engineering Trends and Technology (IJETT)* – Volume 46 Number 7 April 2017.
7. Felix F. Udoeyo1, Robert Brooks, Philip Udo-Inyang and Richard O. Nsan "early prediction of laterized concrete strength by accelerated testing".
8. Khushal Chandra Kesharwani, AmitKumar Biswas, Anesh Chaurasiya,andAhsanRabbani,"Experimental study on use of fly ash in concrete "*International Research Journal of Engineering and Technology (IRJET*), Volume: 04, Issue: 09
9. Indian Standard "Method of making, curing and determining compressive strength of accelerated-cured concrete test specimens" IS : 9013 -1978 (Reaffirmed 2008)

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