Accelerated Method of Concrete Mix Proportioning by Incorporating Fly Ash and Silica Fume

P. Nikitha, B. Kameswara Rao

***Abstract:** The strength of concrete in construction works is calculated after 7days or 28 days of curing. If the strength is not achieved for 28 days, it is extended for 28 days more. This procedure is too long for some of the construction activities. Accelerated curing method is used to get the compressive strength values after 24 hours. By using those values, the prediction of 28 days compressive strength is possible. This paper deals with the accelerated curing of Fly ash and silica fume specimens and compared with conventional concrete. Cement is partially replaced with Fly ash and silica fume with varying percentages (70%, 60%, 50%, 40% and 30%) in water cement ratios (0.3, 0.4 and 0.5). As per IS 9013:1978, the correlation graph of compressive strength is for plain concrete. This work comprises of developing the correlation for fly ash and silica fume specimens under accelerated curing. By this research, a new equation is developed by using compressive strength values of accelerated curing to assess the compressive strength attained in 28 days.*

***Index Terms:** Accelerated curing, Compressive strength, Fly ash, Silica fume.*

I. INTRODUCTION

The nature of concrete is determined on the support of standard compressive strength test conducted for 150mm cube specimen or 150mmx300mm cylinder specimen at the time of 28 days. If later 28 days, the quality of concrete is not up to the mark, at that time it is very difficult to change due to concrete hardness. On the other side, the concrete contains disproportionate strength than required it would be very late to prevent excessive use of concrete material on mix proportioning. To beat this problem, accelerated curing method is determined. Accelerated curing method gives the compressive strength values in 24 hours later casting. Because this method fastens the hydration process of cement due to this the strength attains very quickly as compared to normal curing. There are two methods for accelerated curing i.e. warm water method and boiling water method. In this research work boiling water method is used.

Both the nature of cement and curing method influence the relation among the 28 days curing and accelerated curing compressive strength. The accelerated strength improvement capacity is more for ordinary Portland cement as compared to trass cement. The Performance of concrete made with low early strength cement rise when the curing temperature is raised [1]. With the help of accelerated compressive strength values of concrete, 28 days strength values can be predicted [2]. The relation among the accelerated strength and 28 days strength in fly ash concrete can be defined by a power equation, the constants of which depend on the type of fly ash and the age of concrete. The constants of the suggested power equation do not alter under different accelerated conditions [3]. The compressive strength achieved by using accelerated curing method is more when compared to compressive strength achieved by normal curing [4].The curing is more time-consuming work in construction. Accelerated curing give a high strength value and reduce the time period of curing [5].

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II. RESEARCH SIGNIFICANCE

According to IS: 9013-1978, there is a relationship between compressive strength results of 28 days normally cured concrete and accelerated curing concrete for plain concrete. There is no such relationship for concrete made with admixtures like fly ash, GGBS, silica fume. The main aim of this research is to develop that type of relationship for fly ash and silica fume concrete to help the future mix designers.

III. MATERIALS AND PROPERTIES

Materials used for experimental work

1. Cement
2. Fly ash
3. Silica fume
4. Fine aggregate
5. Coarse aggregate (10mm, 20mm)
6. Super plasticizer
7. Water

The chemical properties of cement, fly ash, silica fume are shown in Table I, II, III. The physical properties of cement, fly ash, silica fume, coarse and fine aggregates are shown in Table IV.

Table I: Chemical properties of cement

Chemical properties of cement	%
SiO_2	20.3
Al_2O_3	4.60
Fe_2O_3	3.40
CaO	63.9
MgO	1.91
SO_3	2.86

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Loss of ignition	2.24
Insoluble residue	0.38

Table II: Chemical properties of Fly ash

Chemical properties of Fly ash	%
SiO_2	57.60
(Al_2 O_3)	21.90
(Fe_2O_3)	2.70
(CaO)	7.80
(MgO)	1.68
(SO_3)	0.41
(Na_2O)	1.05
Loss of ignition	7.05

Table III: Chemical properties of Silica fume

Chemical properties of Silica fume	%
SiO_2	96.9%
Al_2O_3	0.20%
Fe_2O_3	0.20%
CaO	0.30%
K_2O	0.30%
Na_2O	0.20%
MgO	0.20%
SO_3	0.10%
Loss of ignition	2.17%

Table IV: Physical properties of materials

Material	Specific gravity
Cement	3.15
Fly ash	2.2
Silica fume	2.24
Coarse aggregate	2.8
Fine aggregate	2.65

IV. MIX PROPORTION

In this research work, fly ash is used with different percentages of replacements in different water cement ratios. The replacement level of fly ash in 0.3 water cement ratio is 70%, 60% and 50%. The level of replacements of fly ash in 0.4 water cement ratio is 60%, 50% and 40%. In 0.5 water cement ratio the fly ash replacement percentage is 50%, 40%, and 30%. Additionally 5% of silica fume and 0.3% of super plasticizer is added to every mix. Water (140kg/m^3) is kept constant for every mix. For each mix 9 cubes were casted among them 3 cubes are used for accelerated curing, 3 cubes are used for 28 days curing and 3 cubes are used for 90 days curing. The dimension of the cube is 150mmx150mmx150mm.

V. EXPERIMENTAL PROCEDURE

A. Boiling water method

The casted cubes have to leave in an uninterrupted position without any free vibration at a normal temperature for 24 hours from the time of addition of water to the cement. The specimens shall then be gently immersed in a curing tank and maintain totally immersed in a water for a period of 3.5hours ±5 minutes. The temperature of water in the curing tank shall be at boiling (1000c) at sea level. The temperature of water shall not drop more than 30c after the specimen is dropped and the temperature shall return to boiling in 15 minutes. After the curing of 3.5hours ±5 minutes in the curing tank the specimen shall be removed from boiling water and the specimens were cooled by immersing in cool water for 2 hours. After 2 hours the specimens removed from the cool water and conduct the compressive strength test for the results [7].

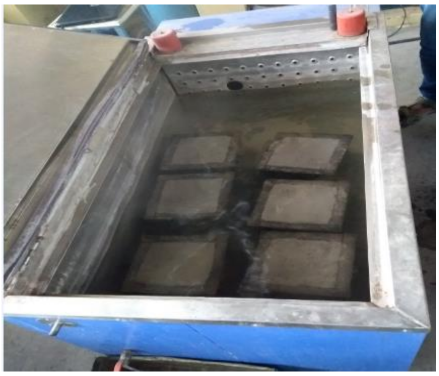

Fig. 1: Accelerated curing tank

B. Normal water curing

The cubes which were casted shall be in an uninterrupted position without any free vibration at a normal temperature for 24 hours from the time of addition of water to the cement. Remove the specimen from the mould and those specimens gently lowered in to a curing tank and keep them totally immersed in water for a period of 28 days, 90 days. After the completion of the curing period remove the specimens from the curing tank and conduct the compressive strength test for the results.

VI. RESULTS AND DISCUSSIONS

The compressive strength values of 28 days normal curing and accelerated curing strength of plain concrete, 0.3w/c, 0.4w/c and 0.5w/c fly ash and silica fume concrete is represented in Fig. 1, 2, 3, 4 respectively.

The compressive strength values of 90 days normal curing and accelerated curing strength of plain concrete, 0.3w/c, 0.4w/c and 0.5w/c fly ash and silica fume concrete is represented in Fig. 6, 7, 8, 9 respectively.

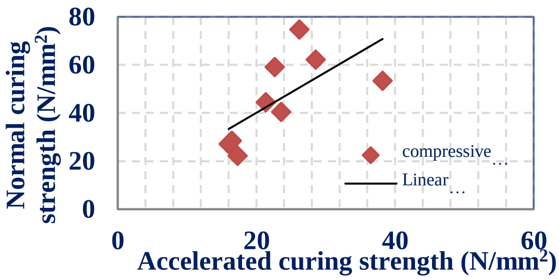

Fig. 2: Comparison of regression lines relating ACS and 28 days NCS of plain concrete

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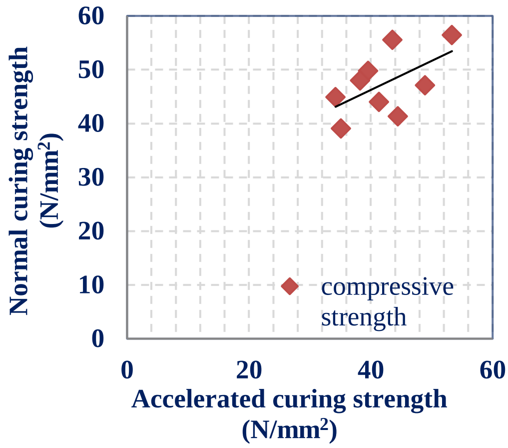

Fig. 3: Comparison of regression lines relating ACS and 28 days NCS of 0.3w/c FA+SF concrete

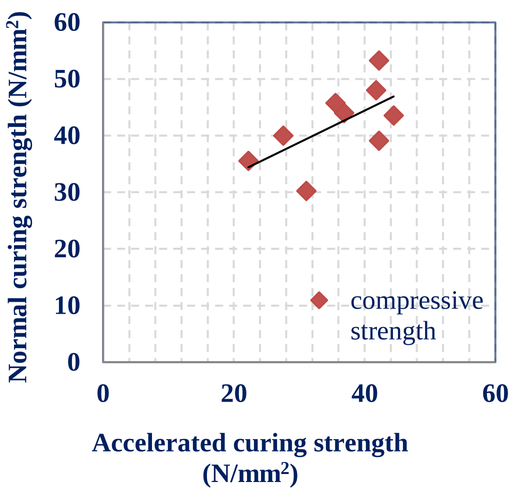

Fig. 4: Comparison of regression lines relating ACS and 28 days NCS of 0.4w/c FA+SF concrete

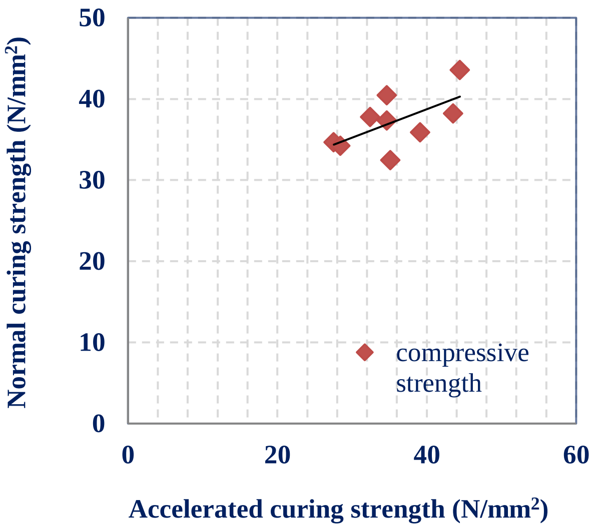

Fig. 5: Comparison of regression lines relating ACS and 28 days NCS of 0.5w/c FA+SF concrete

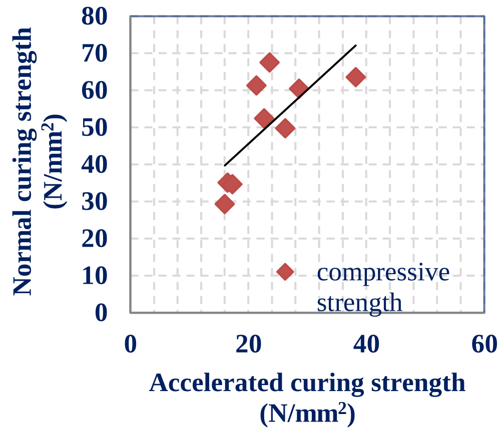

Fig. 6: Comparison of regression lines relating ACS and 90 days NCS of plain concrete

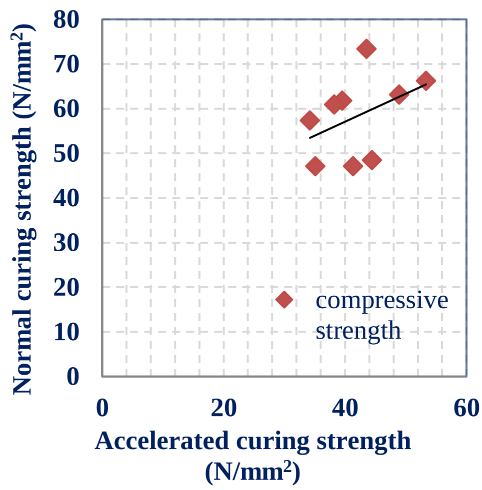

Fig. 7: Comparison of regression lines relating ACS and 90 days NCS of 0.3w/c FA+SF concrete

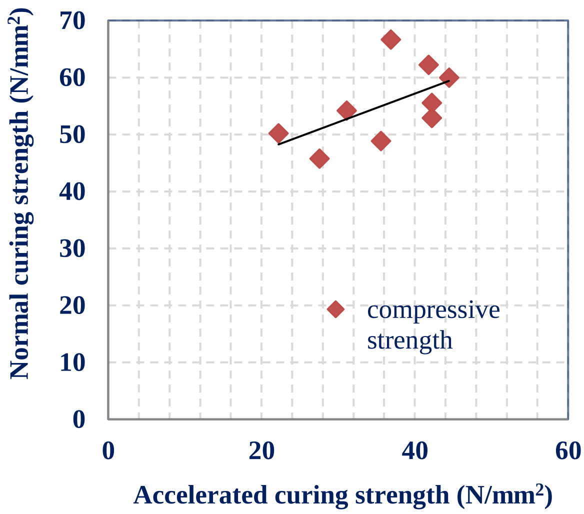

Fig. 8: Comparison of regression lines relating ACS and 90 days NCS of 0.4w/c FA+SF concrete

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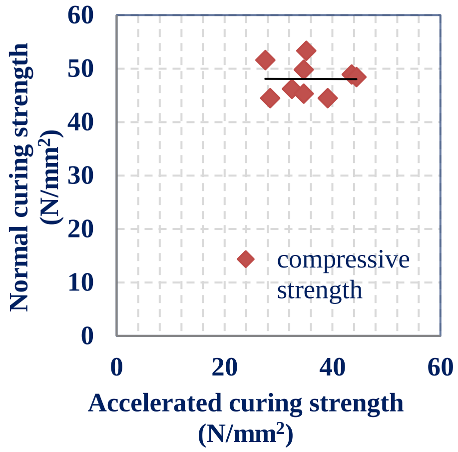

Fig. 9: Comparison of regression lines relating ACS and 90 days NCS of 0.5w/c FA+SF concrete

Regression analysis were carried out and obtain a relationship between normal 28 days and 90 days curing strength and accelerated curing strength for plain concrete and fly ash + silica fume concrete irrespective of water cement ratio is shown in Fig. 10,11 respectively.

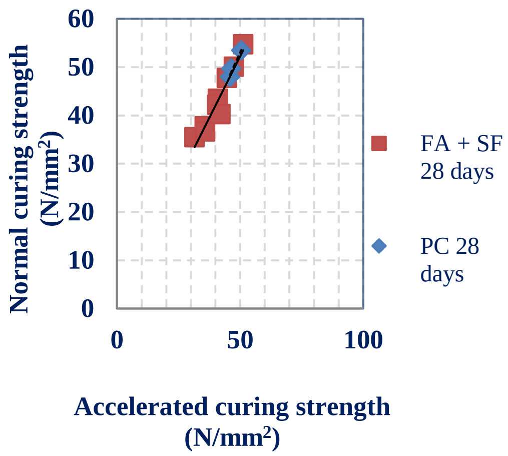

Fig. 10: Relationship between ACS and NCS of plain and FA+SF concrete at the age of 28 days

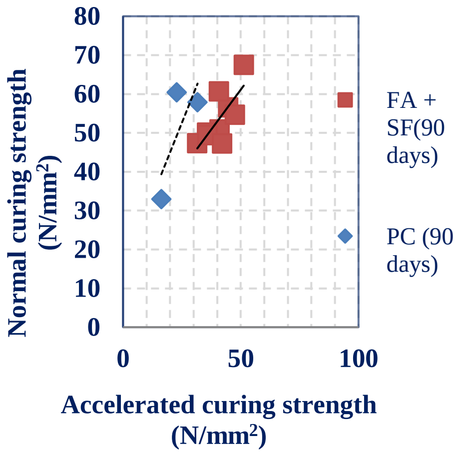

Fig. 11: Relationship between ACS and NCS of plain and FA+SF concrete at the age of 90 days

Through regression analysis regression equation is generated and the equations are given below

For plain concrete the equation is

$$Y = 1.108\, x - 2.3809 \qquad \text{Eq. (1)}$$

For fly ash and silica fume concrete the equation is

$$Y = 1.017\, x + 1.3674 \qquad \text{Eq. (2)}$$

For plain concrete the equation is

$$Y = 1.5152\, x + 14.73 \text{ -------- Eq. (3)}$$

For fly ash and silica fume concrete the equation is

$$Y = 0.8185\, x + 20.201 \text{ -------- Eq. (4)}$$

By using equations1 and 2, the prediction of 28 days compressive strength is possible. By using the equations 3and 4, the prediction of 90 days compressive strength is possible. The graph for predicted compressive strength values and experimental 28 days, 90 days compressive strength values of plain concrete and fly ash and silica fume concrete in Fig. 12,13,14 and 15 respectively.

In Fig. 12 and 14, the numbers 1, 2 and 3 indicates 0.3, 0.4, 0.5 water cement ratios.

In Fig. 13 and 15, on x-axis the numbers 1, 2 and 3 represents 70%, 60% and 50% replacements of fly ash in 0.3W/C ratio of cement. The numbers 4, 5 and 6 represents 60%, 50% and 40% cement replacements of fly ash in 0.4W/C ratio and the numbers 7, 8 and 9 represents 50%, 40% and 30% cement replacements of fly ash in 0.5W/C.

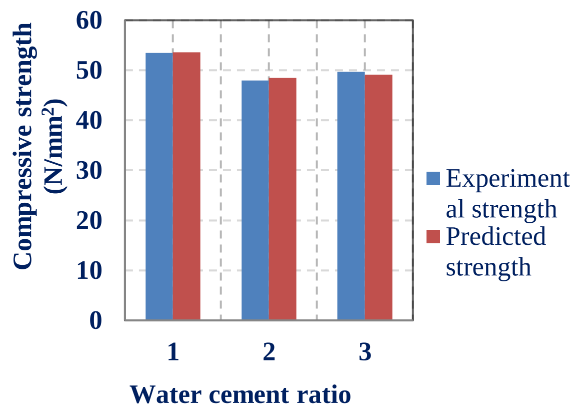

Fig. 12: Graph of 28 days experimental strength and predicted strength for plain concrete

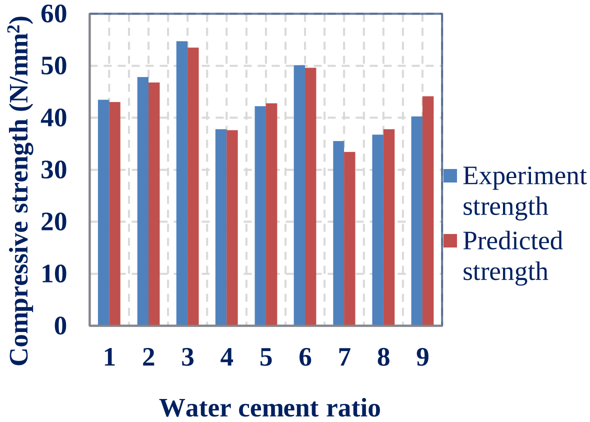

Fig. 13: Graph of 28 days experimental strength and predicted strength for fly ash and silica fume concrete

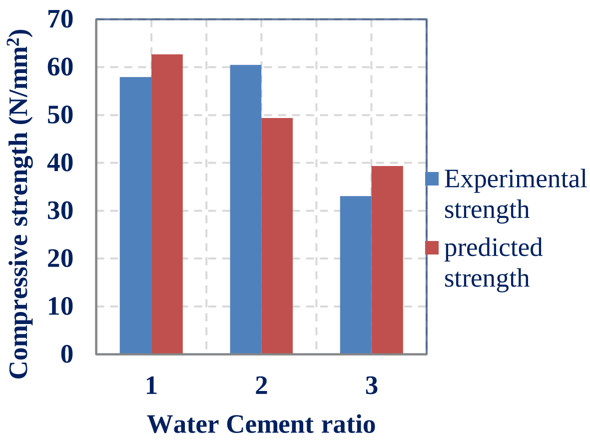

Fig. 14: Graph of 90 days experimental strength and predicted strength for plain concrete

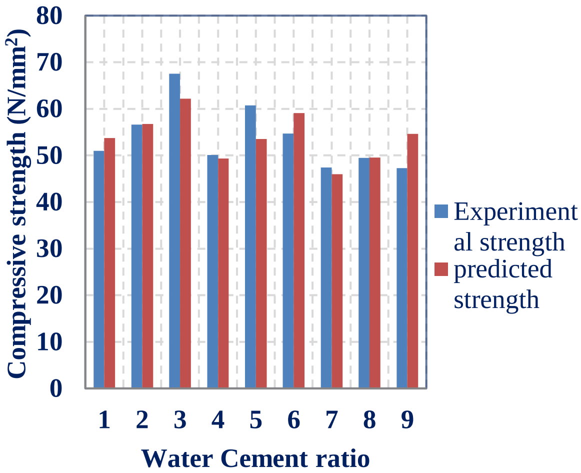

Fig. 15: Graph of 90 days experimental strength and predicted strength for fly ash and silica fume concrete

VII. CONCLUSION

1. Among all the percentages of replacements 50% replacement of cement with fly ash gives better strength irrespective of water cement ratio.
2. If the replacement level of cement with fly ash is more than 50% then the strength of concrete decreases.
3. Fly ash slowly attains strength because of this reason 90 days compressive strength value is very high compared to 28 days compressive strength values.
4. The predicted compressive strength is very near to experimental 28 days compressive strength value. So this method of curing is very useful in the construction area where time is very less to complete the work.
5. The accuracy of 90 days predicted compressive strength value is less compared to 28 days accuracy.

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