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Effect of Size of Specimen on Compressive Strength of Fly Ash Concrete

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Abstract: Concrete, one of the maximum consumed and extensively used, as a principal construction material in the world with a vital role in the construction field due to its abundant advantages such as strength, durability, easy of fabrication, non- combustibility properties, it possesses over other construction materials. During recent years due to its added advantages over standard concrete, the use of high strength concrete for construction has become common, especially for multistoried structures, bridges and high rise buildings etc. As the cost of concrete is high and in of view of economy, now a day's fly ash is being used in construction replacing by mass of cement. The characteristic compressive strength of concrete is being used in design of structures, use of this value is a problem since the control specimen sizes and shapes are varying from country to country. In India, the characteristic compressive strength is usually measured based on 150 mm cubes, whereas the ACI code of practice specifies the design compressive strength based on the standard 150 x300 mm cylinder in the design of reinforced structures. In this context the size and shape of concrete is an important parameter for the compressive strength, which necessitates the study of effect of size and shape of the specimen. Hence in this study different sizes and shape of specimens are prepared cured and tested in compression at an age of 7, 28, 56 and 91 days.

Keywords: Compressive strength, fly ash, high strength concrete, cement.

1.0 INTRODUCTION

Concrete has been the leading, extensively used construction material as its ingredients are easily available, manufacturing cost of it is less and also durable over other construction material. Cement is one of the chief ingredients, also responsible for strength of concrete and globally the demand for cement is increasing year by year due to increase in utility of cement for the development of infrastructure, Recently concrete is utilized to build special structures and applied for special purposes which further lead to the development of other concretes such as high performance concrete, ultra high strength concrete, self compacting concrete pozzolanic concrete like pulverized fuel ash concrete, fly ash concrete, silica fume concrete, GGBS concrete etc. It is necessary to know the effect of size and shape of the specimen on compressive strength as it is the important parameter.

1.1 Previous studies: Krishna Rao, M., V. et al. [1], studied the compressive strength on different sizes of cubes cylinders and prisms with plain concrete and adding fibres of 1 kg/m^3. It was reported that the increase in compressive strength is more in 100 mm cubes as compared to 150 mm cubes; 100 mm diameter cylinders have high compressive strength than 150 mm diameter cylinders, the same trend observed for specimen with fibers. Benjamin Graybeal and Marshall Davis, [2], studied the compressive strength of an ultra-high-performance fiber-reinforced concrete (UHPFRC) in the range from 80 to 200 MPa on 76, 102 mm cylinders and 70.7, 100 mm cube specimens. The 76 mm cylinder as well as the 70.7 and 102 mm. cubes was found to be acceptable alternatives to the standard 102 mm cylinder specimen. The 70.7 mm cube specimen is recommended. LEUNG & K.S. Ho. (SPR 3/96), [3], examined the compressive strengths of the 100 mm and 150mm cubes and the results in accordance with the criterion specified in Clause 16.61(3) of the General specification for Civil Engineering Works (Hong Kong Government,i992). From the results it was concluded that the 28-day strength of 100 mm cubes is on average about 5% more than that of the 150mm cubes made from the same batch of concrete.

Mohammed Karem Abd and Zuhair Dhaher Habeeb [4] investigated the influence of size and shape of specimens on compressive strength of NC high strength concrete, SCC of strength 100 MPa by testing different sizes of cubes, cylinders compression. It was concluded that large size cube and cylinder specimens have less strength over small ones. The compressive strength decreased as the shape and size increased.

2.0 EXPERIMENTAL PROGRAM

2.1 Mix Proportions: In present experimental investigation, four different concrete mixes with varying fly ash content 30, 40 and 50% by weight of cement and one mix without fly ash are selected. The mix proportion for the study is 1:1.39: 3.43 (cementetious material: fine aggregate: coarse aggregate) arrived after casting of several trial mixes as per guide lines of IS 456-2000 [6] and IS 10262-2009 [7]. The ordinary Portland cement of

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53 grade conforming to IS 12269 [8], fine aggregate conforming to zone-II, coarse aggregate as per IS: 383 [9], code provisions, fly ash of class F from N.T.P.C. thermal plant at Visakhapatnam are used for present study.

2.2 Method of casting testing

The concrete cubes of 100, 150 mm and cylinders of 150 mm diameter and 300 mm height are prepared for studying the response of different concrete mixes of 0, 30, 40 and 50% fly ash at different ages of 7, 28, 56 and 91 days. The specimens are demoulded after 24 hours from time of casting and placed in potable water for curing. After the stipulated period is completed the specimens are removed from water allowed to dry naturally in air and tested in 3000 kN compression testing machine in compression as per IS 516-1959 (reaffirmed 1999) [10], guidelines. Casting of 100 mm cubes and testing of specimen are shown in Fig.1 and Fig.2.

Fig.1 Cubes of 100mm under casting

Fig.2 Testing of 100mm cube under compression

3.0 RESULTS AND DISCUSSIONS

3.1 Introduction:

The results from experimental investigations on compressive strength for both M30 and M60 grades of concrete are presented. Cubes of 150 mm, 100 mm and cylinders of 150 mm with 0, 30, 40 and 50% fly ash of M 60 grade concrete are tested in compression to study the effect of size at an age of 7, 28, 56 and 91 days at room temperature. The results of tests on different sizes of specimens are shown graphically in Fig.3.3 to 3.10, the specimens with fly ash concrete follow similar trend of specimens with conventional concreteat room temperature.

3.2 Standard concrete: Referring to the Fig.3, the values of compressive strength of conventional standard concrete cube of 100 mm at an age of 7, 28, 56 and 91 days are 44.5, 46.7, 53.2 and 55.7 respectively, while the corresponding values for cube of 150 mm are 42.6, 44.1, 49.7 and 52.4. At the same time the corresponding values for 150 mm cylinder are 21.9, 33.4, 38.5and 42.4. Similarly from the Fig.4, the values of compressive strength for concrete replacing cement with 30% fly ash for 100 mm cube are 42.7, 45.2, 47.5 and 54.5 respectively, while the corresponding values for 150 mm cube are 40.2, 43.2, 45.1 and 50.9 respectively. At the same time the values for 150 mm cylinder are 20.9, 25.8, 35.1 and 40.7. Referred to the Fig.5, the values of compressive strength for concrete replacing cement with 40% fly ash for 100 mm cube are 41, 43.3, 46.3 and 55.6 respectively, while the corresponding values for 150 mm cube are 39.2, 41, 44.5 and 48.9. At the same time the values of compressive strength for 150 mm cylinder are 19.2, 25.3, 31.9 and 37.2. In the same way referring the Fig.6 the values of compressive strength of standard concrete with replacing cement by 50% fly ash for 100 mm cube are 37.5, 42.2, 44.3 and 47 respectively, where as the values of 150 mm cube are 35.9, 40.5, 42.2 and 45.1. At the same time the values for 150 mm cylinder are 19.4, 23.5, 25.5 and 29.1.

3.3 High strength concrete:

Referring to the Fig.7, the values of compressive strength of conventional high strength concrete cube of 100 mm at an age of 7, 28, 56 and 91 days are 61.3, 66.8, 71.1 and 76.4 respectively, while the corresponding values for cube of 150 mm are 58.5, 64.2, 67 and 72.2. At the same time the corresponding values for 150 mm cylinder are 32.4, 36.842.4 and 46. Similarly from the Fig.8, the values of compressive strength for concrete replacing cement with 30% fly ash for 100 mm cube are 59.7, 64.5, 67.7 and 72.7 respectively, while the corresponding values for 150 mm cube are 57.6, 62.2, 65.5 and 67.7 respectively. At the same time the values for 150 mm cylinder are 29.4, 35.3, 41.3 and 45.1. Referred to the Fig.3.9, the values of compressive strength for concrete replacing cement with 40% fly ash for 100 mm cube are 57.3, 60.7, 65 and 66.2 respectively, while the corresponding values for 150 mm cube are 45.2, 48, 53.5 and 59.1.

At the same time the values of compressive strength for 150 mm cylinder are 26.2, 33, 38.9 and 43.6. In the same way referring the Fig.10 the values of compressive strength of high strength concrete with replacing cement by 50% fly ash for 100 mm cube are 54.7, 56, 57 and 58.3 respectively, where as the values of 150 mm cube are 44.1, 45.6, 51.7 and 55. At the same time the values for 150 mm cylinder are 24, 28.5, 36 and 42.6.

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From the results it is observed that small size specimens show higher strength over large specimens, the reason being in small size sections voids are less and resisting more load. And we have a relation,

Stress = force/area.

Let us consider two cubes of 150mm and 100 mm, .apply same amount of force ,say 1kN on each cube, then the stresses induced in cube of 150mm cube= 0.0444 N/mm^2, the stress induced in 100 mm cube = 0.1 N/mm^2 100 mm cube is having high stress means high internal resistance, means resistance to failure. So it is having more compressive strength than 150 mm cube and similarly for the cylinder.

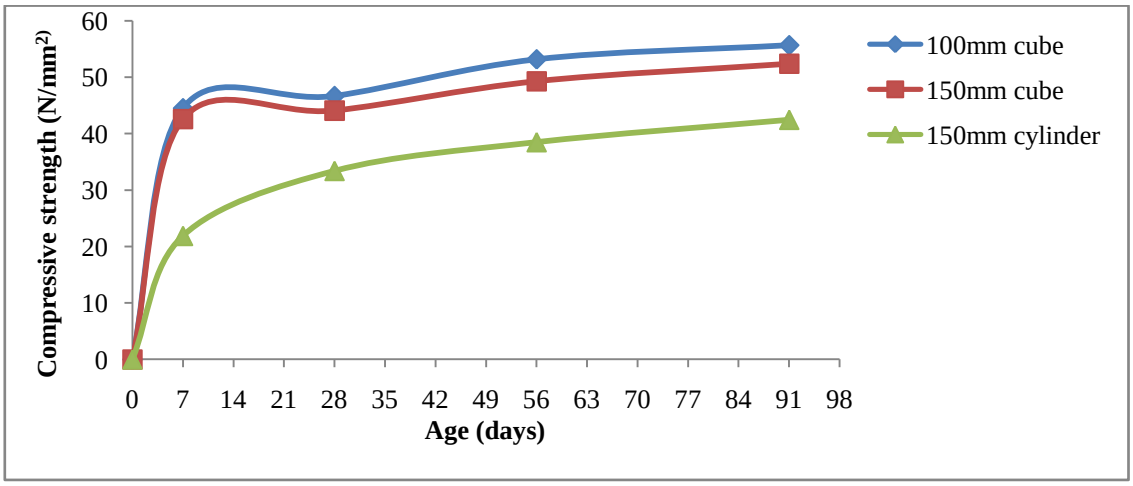

Fig.3 Variation of compressive strength with age for M30 grade concrete with 0% fly ash

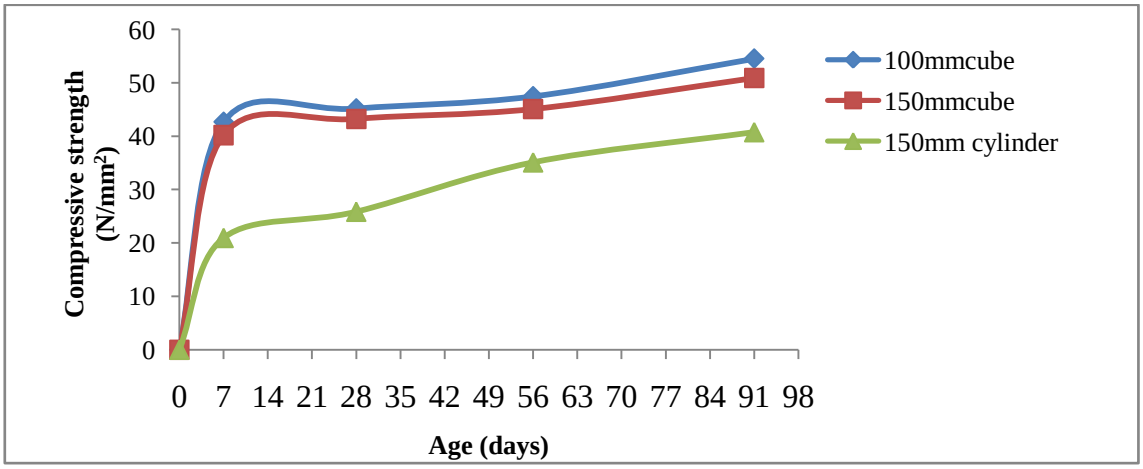

Fig.4 Variation of compressive strength with age for M30 grade concrete with 30% fly ash

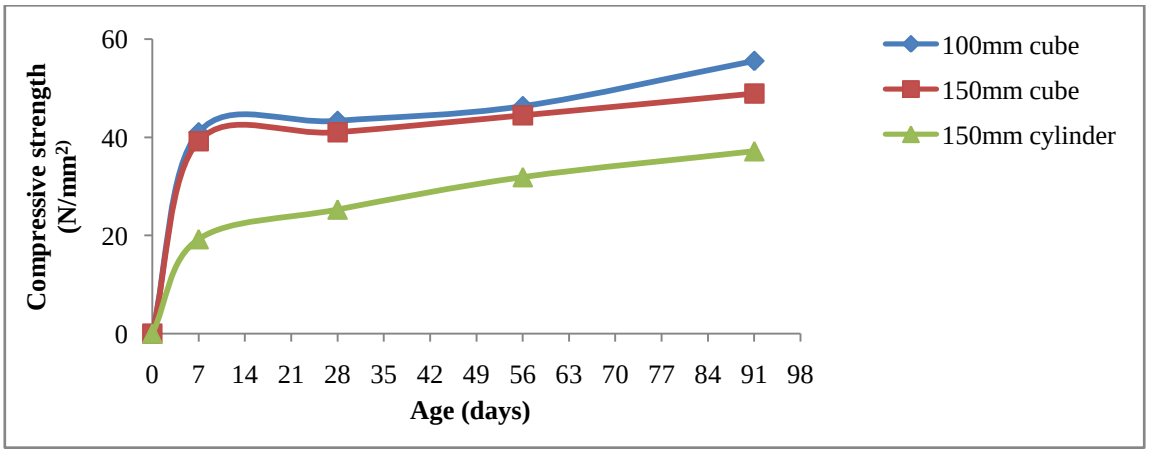

Fig.5 Variation of compressive strength with age for M30 grade concrete with 40% fly ash

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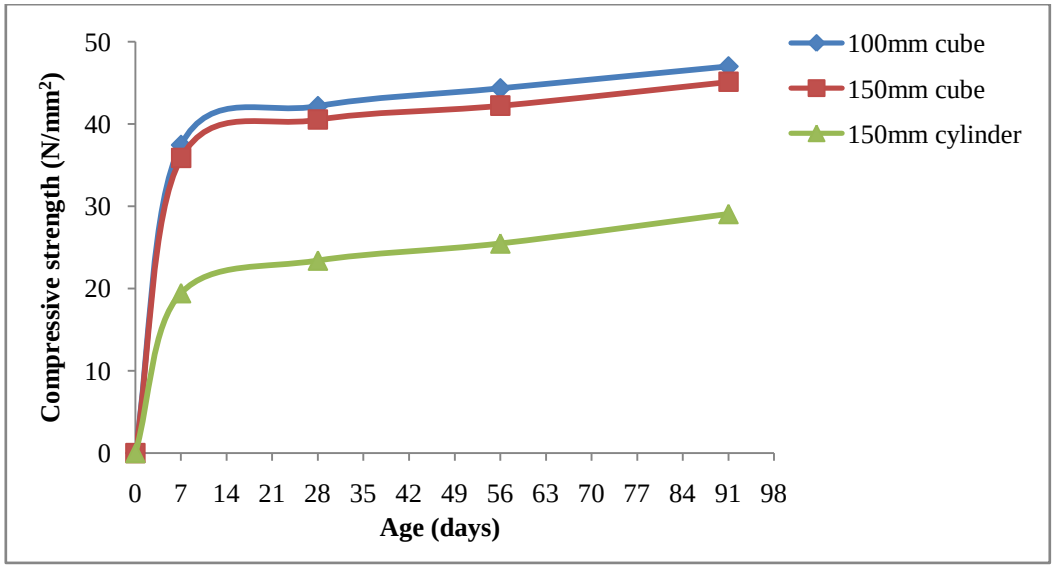

Fig.6 Variation of compressive strength with age for M30 grade concrete with 50% fly ash

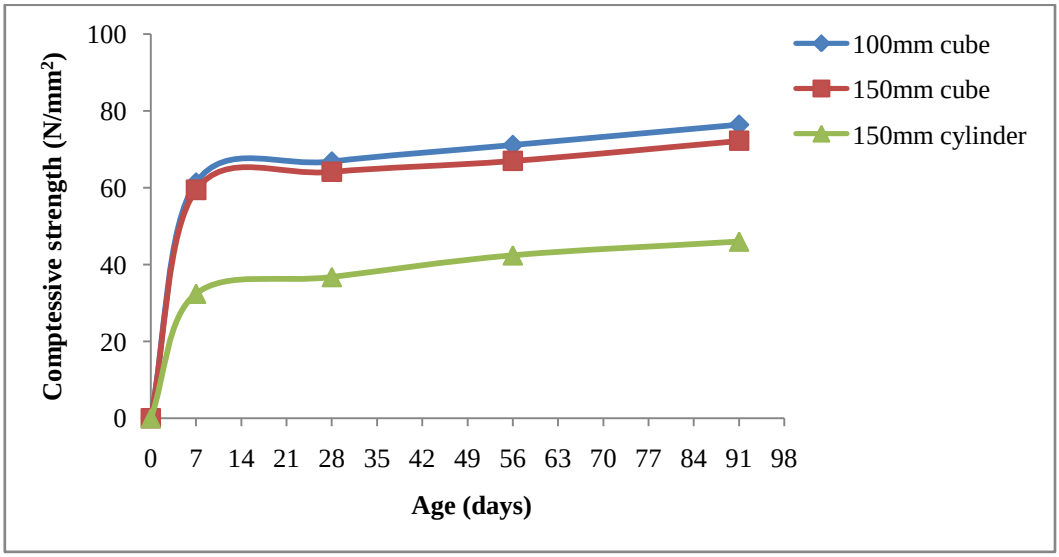

Fig. 3.7 Variation of compressive strength with age for M60 grade concrete with 0% fly ash

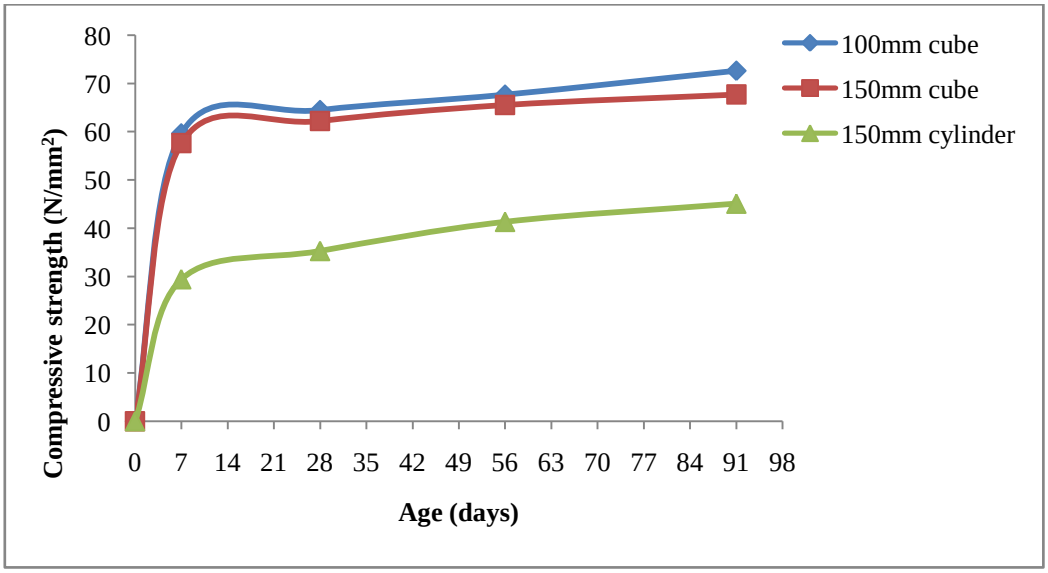

Fig.3.8 Variation of compressive strength with age for M60 grade concrete with 30% fly ash

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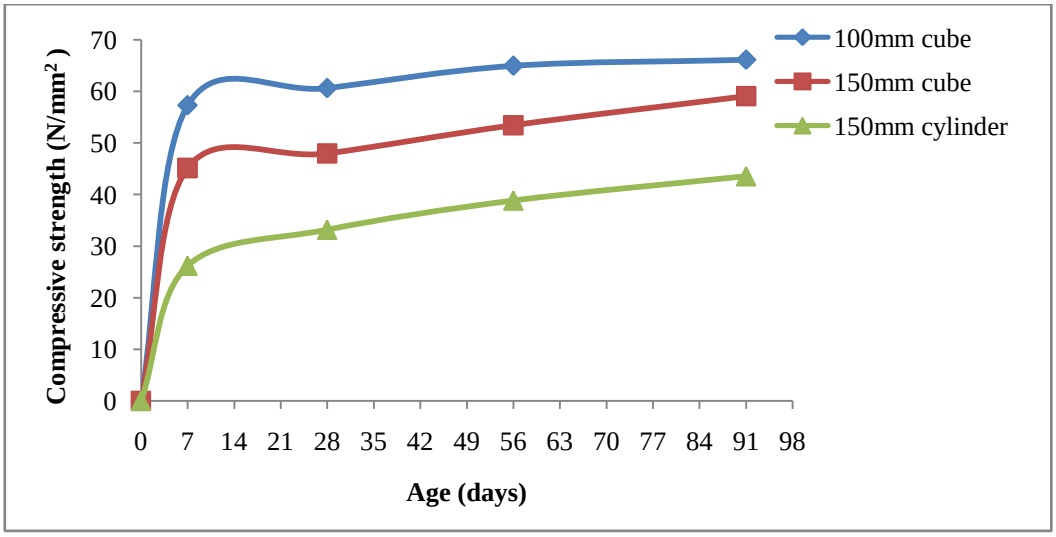

Fig.3.9 Variation of compressive strength with age for M60 grade concrete with 40% fly ash

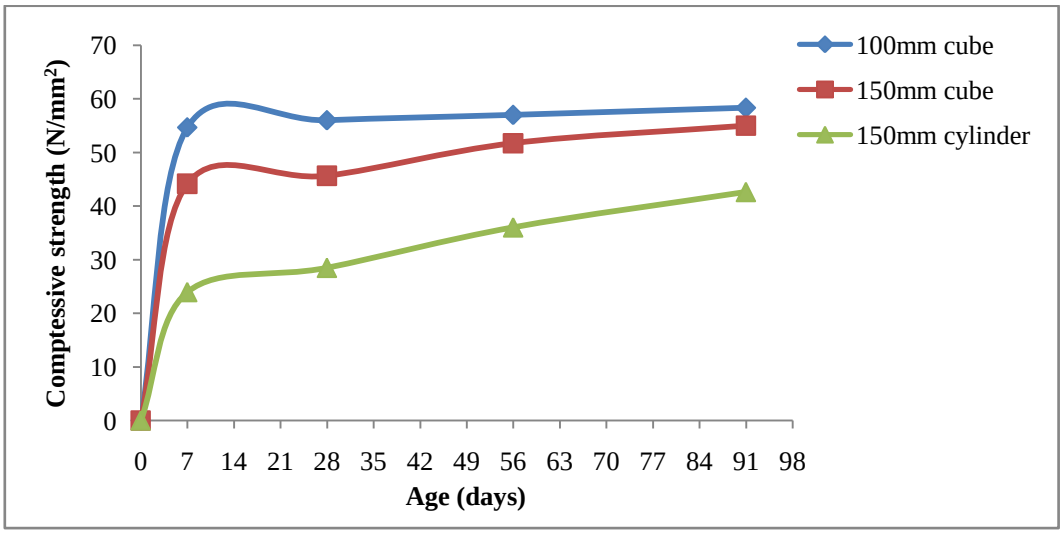

Fig.3.10 Variation of compressive strength with age for M60 grade concrete with 50% fly ash

4.0 CONCLUSION

1. Compressive strength of 100 mm cube is greater than the compressive strength of 150 mm cube prepared with conventional concrete. For specimens of conventional concrete, the compressive strength of 150 mm cylinders is less than that of both 100 mm and 150 mm cube specimens.
2. Compressive strength of conventional concrete increased with increase in the age of concrete for all sizes and shapes of specimens of the study.
3. Compressive strength of concrete with replacement of cement with fly ash decreased compared to conventional concrete.
4. Compressive strength of concrete decreased with increase in fly ash content at all ages.
5. The results of tests on compressive strength of different sizes of specimens of 150 mm cubes, 100 mm cubes and 150 mm cylinders of fly ash concrete follow similar trend of specimens with conventional concrete at room temperature.
6. The experimental results revealed that inclusion fly ash does not affect the compressive behavior of concrete.

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