An experimental investigation on dynamic modulus of elasticity of fly ash based steel fiber reinforced concrete

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ABSTRACT

Utilization of fly ash in concrete improves strength. Tenacity and ductility beahviour improves concrete durability properties. Hence, this paper mainly focuses on use of fly ash (FA) and steel fiber in concrete. FA content used was 0%, 10%, 20% and 30% in mass basis, and steel fiber (SF) content was 0%, 0.5%, 1.0% and 2.0% by volume basis. Dynamic Modulus of elasticity (Ed) was determined for fly ash based fiber reinforced concrete using NDT equipment.

KEY WORDS: Concrete; Fly ash; Steel fiber; Dynamic Modulus of elasticity, Compressive strength.

1. INTRODUCTION

FA and sludge collected from various industries is a major task in day today life which becomes a great environmental problem. FA found to have numerous advantages for use in concrete industry. Blending concrete with fly ash increases workability and ultimate strength and reduces permeability, bleeding and heat of hydration. However, the use of FA in concrete reduces the early strength. Fly ash from different thermal power plants has different characteristics. FA in concrete leads to early-age strength loss, to compensate the loss fibers of varying percentage were are used. Static flexural strength, impact strength, tensile strength, ductility and flexural toughness considerably improve due to the presence of fibers. Following are the types of fibers used in concrete: steel fibers, glass fibers, ceramic fibers etc. SFRC is used in most of the civil engineering infrastructure. Aspect ratio used varies between 50 and 100. The volume fraction between 0.5% and 2.5% by volume of concrete was found to be appropriate. Strength and Durability of FRC governs by the material and geometry of fiber. Also, on the way the fiber inclusions get distributed in the concrete matrix. Further, fiber orientation and fiber concentration also influence the recital of fiber-reinforced concrete. The research work mainly focuses on study of compressive strength and Ed of FA based fiber reinforced concrete.

2. EXPERIMENTAL INVESTIGATION

Test materials:

Cement: Cement of OPC 53 grade was used. The specific gravity (SG) of the cement was 3.15. Initial setting time of cement and final setting time of cement were found to be 140 minutes and 245 minutes respectively.

Fly ash: Fly ash used was obtained from Mettur-Thermal power station located in Salem District, Tamil Nadu. The SG of the FA was found to be 2.5

Aggregate: In this work, aggregates of size 20 mm and 12 mm were used. The SG of coarse aggregate was found to be 2.78 and its water absorption was 0.5%. The SG of fine aggregate was 2.60 and its water absorption was 1.02%.

Fiber reinforcement: Steel fiber was used in this work and its tensile strength was 1098 Mpa. The properties of steel fiber was given in Table 1.

Table.1. Properties of Fiber

Fiber type	Length (mm)	Diameter (mm)	Tensile strength (Mpa)
Steel fiber (SF)	50	1	1098

Mixture composition and preparation: Indian Standard code (IS) 10262-2009 was used to design for mix proportion for M20 grade of concrete. FA concretes containing 10%, 20% and 30% were used as cement replacement in mass basis. Steel fibers of 0.5%, 1.0% and 2.0% were added by volume of concrete. For mixing the fiber-reinforced concrete the following steps involved, first, the coarse aggregate and fine aggregate were placed in a concrete mixer and dry mixed for 1 min. then the cement and fiber were spread and dry mixed for 1 min. Finally water was added and mixed for approximately 2 min. Then mixed composition was placed into specimens mold and vibrated simultaneously. After casting, the specimens were allowed to stand for 24 h in laboratory before demolding. The specimens were stored in water at 23 ± 2 °C until testing days.

Testing method:

Compressive Strength tests: Compressive strength of the concrete specimens (100mm x 100mm x 100mm) was determined according to the IS: 516: 1959 (Reaffirm date: October, 2013). The bearing surfaces of the machine were wiped clean and the concrete cube specimen was placed in the machine in such a manner that the load was applied on the opposite sides of the cubes as cast, and not on the top and bottom faces. The load was applied at a rate of approximately 14 N/mm^2/min without any shock until the specimen failed. The failure load was recorded. Load by cross sectional area will give the compressive strength of the specimen.

Dynamic modulus of elasticity (E_d): E_d of cylindrical concrete specimens was determined using Non-Destructive testing equipment (NDT). Cylinders of dimensions 300 mm (height) and 150 mm (diameter) were used. Two transducers on either side of the specimen were placed to get the frequency of the specimen. Concrete member were subjected to longitudinal vibration at their natural frequency to find dynamic modulus.

Dynamic modulus can be calculated by using the relationship: $E_d = Kn^2L^2\rho$

Where, K is a constant, n is the resonant frequency, L is the length of the specimen, and ρ is the density of concrete.

Table.2. Test variables

Fly ash content (%)	Fiber type	water / cement + fly ash ratio
0	0%SF	0.45
	0.5%SF	
	1%SF	
	2%SF	
10	0%SF	0.46
	0.5%SF	
	1%SF	
	2%SF	
20	0%SF	0.47
	0.5%SF	
	1%SF	
	2%SF	
30	0%SF	0.50
	0.5%SF	
	1%SF	
	2%SF	

3. RESULTS AND GRAPHS

Effect of fly ash and steel fiber on Compressive Strength and Dynamic modulus of elasticity: Table 3 shows results of compressive strength. Figure 1 shows graphical pattern of compressive strength. For a FA content of 0% for varying fiber content compressive strength decreased upon increase of steel fiber. When FA content increased from 10% to 20% compressive strength increases with increase of steel fiber content. When FA content increases from 20% to 30% there is a slight reduction in strength irrespective of fiber content. Results on E_d were shown in Table 3. Result shows that for 0% FA content upon increase of steel fiber there is a marginal increase in dynamic modulus. For 10% FA content it has been observed that dynamic modulus increases when fiber content increases. When FA content increased from 20% to 30% modulus value increase for a 1% SF. This may be due the stiffness of the paste matrix. Figure 2 shows the testing of specimen for finding dynamic modulus. Figure 3 shows graphical pattern of E_d of varying fly ash content.

Table.3. Compressive strength and Dynamic Modulus of elasticity

Series	Specimen Details	Compressive strength (N/mm^2)	Dynamic Elastic modulus (GPa)
		28 days	28 days
A	0% 0%	36.20	13.96
	0% 0.5%	33.67	16.80
	0% 1%	35.50	12.94
	0% 2%	32.56	16.49
B	10% 0%	32.33	15.60
	10% 0.5%	35.34	13.40
	10% 1%	39.76	17.18
	10% 2%	32.99	15.45
C	20% 0%	36.10	16.95
	20% 0.5%	37.86	16.57
	20% 1%	38.90	15.75
	20% 2%	37.40	15.60
D	30% 0%	32.40	17.73
	30% 0.5%	31.50	17.18
	30% 1%	32.60	15.67
	30% 2%	33.60	15.97

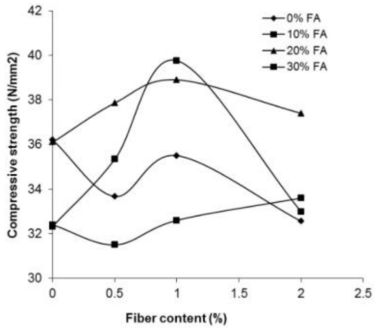

Fig.1. Compressive strength of concrete

Fig.2. Testing of specimen using NDT

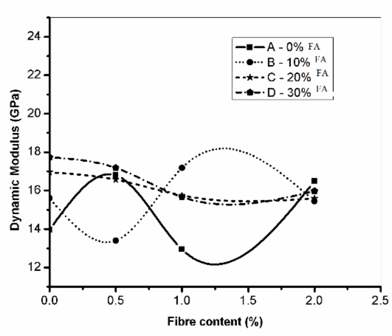

Fig.3. Dynamic modulus of elasticity

4. CONCLUSION

The conclusions were made from this study:

a) When compressive strength of FA based FRC were compared to conventional concrete 20% FA concrete gives better result.
b) Therefore 20% addition of FA concrete seems to be optimum value for getting better strength of concrete.
c) Dynamic modulus of elasiticity of concrete increses when FA content increases.

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