ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 9, Issue, 11, pp.60405-60408, November, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

EXPERIMENTAL DETERMINATION OF MODULUS OF ELASTICITY FOR FIBER REINFORCED CONCRETE

[*,1]Kiran. T., [2]Srinivas, H. R., [3]Showkath Ali Khan Zai, [4]Guruswamy. J, [5]Dr. Sadath Ali Khan Zai, [6]Dr. Nagaraja, P. S. and [7]Dr. Shashishankar, A.

[1, 2] Research Scholar, Department of Civil Engineering, UVCE, Bangalore University, Bangalore
[3] Research Scholar, Department of Civil Engineering, Jain University, Bangalore and Head of Department- Civil Engineering, Islamiah Institute of Technology, Bangalore
[4] Research Scholar, Department of Civil Engineering, Jain University, Bangalore and Lecturer, Department of Civil Engineering, PVP Polytechnic, Bangalore
[5,6] Department of Civil Engineering, UVCE, Bangalore University, Bangalore
[7] Head of Department - Civil Engineering, AMC Engineering College, Bangalore

ARTICLE INFO

Article History:
Received 19th August, 2017
Received in revised form
26th September, 2017
Accepted 28th October, 2017
Published online 30th November, 2017

Key words:
Modulus of elasticity,
Fiber reinforced concrete,
M60 grade, Extensometer,
Stress-strain curve,
Steel fibers,
Polypropylene fibers,
Carbon fibers.

ABSTRACT

The modulus of elasticity of concrete is a very important parameter, reflecting the ability of concrete to deform elastically and avoiding excessive deformation providing satisfactory serviceability. In order to utilize the full compressive strength of concrete, the structure using high strength concrete tend to be slimmer and requires a higher elastic modulus to maintain its stiffness with ductility aspects. The ductile properties of High Strength Concrete are mostly dependent on proportions of ingredients used and can be enhanced by addition of fibers. This paper present a detailed experimental investigation carried out at the department of civil engineering laboratory, Bangalore University, Bangalore as per Indian Standards using standard cylindrical specimens tested with extensometer having 150 mm gauge length under uni-axial compression. M60 grade of concrete matrix is integrated with Steel fibers (SF), Polypropylene fibers (PF), carbon fibers (CF), PF+SF, PF+CF, CF+SF, PF+CF+SF to obtain modulus of elasticity of concrete for above modified fiber reinforced concrete and the results shows 3.48, 3.84, 3.87, 3.89, 3.88, 3.79, 3.91, 4.35 value for modulus of elasticity respectively and same is validated analytically. The Modulus of Elasticity of fiber reinforced Concrete for combination of M60+SF+PF+CF is found to be higher as compared to other fiber reinforced concrete matrices.

Citation: Kiran. T., Srinivas, H. R., Showkath Ali Khan Zai *et al.* 2017. "Experimental determination of modulus of elasticity for fiber reinforced concrete", *International Journal of Current Research*, 9, (11), 60405-60408.

INTRODUCTION

Concrete is most widely used construction material in the world due to its ability to get cast in any form and shape. It also replaces old construction materials such as brick and stone masonry. The strength and durability of concrete can be changed by making appropriate changes in its ingredients like cementatious material, aggregate and water and by adding some special ingredients. Hence concrete is very well suitable for a wide range of applications. Though Concrete is most commonly used structural material, it has some deficiencies such as Low tensile strength, Low post cracking capacity, Brittleness and low ductility, Limited fatigue life, Incapable of accommodating large deformations and Low impact strength. In plain concrete and similar brittle material, structural cracks (Micro cracks) develop during loading, drying shrinkage or other causes of volumetric changes. The width of these initial cracks seldom exceeds a few microns. When loaded these micro cracks propagate and open up and due to stress concentration, additional micro cracks are formed. The micro cracks are the main cause for elastic deformation in concrete. Fiber reinforced Cement and concrete were developed to overcome these problems. Modulus of elasticity of concrete is the ratio of stress to strain of the concrete under the application of loads. Considering the stress-strain curve of the first cycle, the modulus could be defined as the initial tangent modulus, secant modulus, tangent modulus or chord modulus. In Stress-strain Plot of Concrete, at stress below 30% of ultimate strength, the transition zone cracks remain stable. The stress-strain plot remains linear. At stress between 30% and 50% of ultimate strength, the transition zone micro cracks begin to increase in length, width and numbers. The stress-strain plot

****Corresponding author:*** **Kiran, T.**
Research Scholar, Department of Civil Engineering, UVCE, Bangalore University, Bangalore

becomes non-linear. At 50 to 60% of the ultimate stress, cracks begin to form in the matrix. With further increase to about 75% of the ultimate stress, the cracks in the transition become unstable, and crack propagation in the matrix will increase. At 75 to 80% of the ultimate stress, the stress reaches a critical stress level for spontaneous crack growth under a sustained stress. Cracks propagate rapidly in both the matrix and the transition zone. Failure occurs when the cracks join together and become continuous. Thus modulus of elasticity based on the slope of the limit joining origin to any point on stress-strain curve, at which the deformation are to be calculated can be effectively used, this modulus is termed as Secant Modulus of Elasticity. Moisture condition, Aggregate properties, Cement matrix, Transition zone are the factors that affects modulus of Elasticity.

Literature review

Cement mortar and cement concrete undergoes significant changes when admixtures and fibers are used in concrete resulting in changes in structural properties. Thus, behavior of RCC structural members after being added with fibers is upgraded. When fibers are added to concrete, it effects the Modulus of Elasticity of concrete. In the recent years much of the research is emphasized on the effects caused by use of any one type and combination of fiber on Strength Properties and Modulus of Elasticity. The AADHTO specification (Section 8.7.1) and ACI 318 Building Code (Section 8.5) suggest the same prediction equations for determination of modulus of Elasticity, given in Eq. (1) and Eq. (2)

$E_c = 4700\sqrt{f_c}$(Mpa)- (1)

For normal-density concrete

$E_c = 3320\sqrt{f_c} + 6900$(Mpa) $(w^{1.5})$– (2)

For 21 Mpa< f_c < 83 Mpa

Where, E_c = Modulus of Elasticity, Mpa; w = Density of concrete, kg/m^3; f_c= compressive strength of concrete at 28 days, Mpa. (Xiaoming *et al*., 2001)

An another method based on the BS 8110 method was introduced previously to assist engineers in predicting design values of Modulus of Elasticity of concrete (E). The design formula is in the form

E (Gpa) = $K_o + \alpha f_{cu}$ (Mpa) – (3)

Where K_o and α are factors related to the stiffness of aggregates and aggregate-matrix interaction and f_{cu} is the compressive strength of concrete (Alexander *et al*., 1995). From the critical literature review, the concrete with addition of steel fiber demonstrated the highest compressive and modulus of elasticity value, Mohamed *et al*. (2015). Notable change in Modulus of Elasticity was reported with the addition of polypropylene fibers, was increased by 11% as compared to that of Conventional concrete, Divya S Dharan, *et al*. (2016). The tensile, compressive, and flexural strengths and flexural toughness were increased by latex addition for any fiber type which indeed affected the Modulus of Elasticity (Bertil Persson *et al*. (2003). Carbon fibers gave mortar of higher tensile strength, higher flexural strength than polyethylene fibers at the same volume fraction, very few studies have been used two different types of fibers in concrete matrix at a time. But no attempt has been made to use three different fibers in a single concrete matrix. Hence an attempt has been made to select the best combination of fibers such as steel fibers, polypropylene fibers and carbon fibers and same is to be optimized to obtain maximum modulus of elasticity of fiber reinforced concrete.

Experimental programme

Material

In this present investigation Ordinary Portland Cement of 53 Grade has been used. Tests on cement were conducted in accordance with the Indian standards confirming to IS-12269:1987. Manufactured sand passing through 4.75 mm sieve and entirely retained on 150-micron sieve having specific gravity 2.63, water absorption 2% and fineness modulus 2.29, zone II.Coarse aggregates passing through 12.5 mm sieve and retained on 10 mm sieve having specific gravity of 2.63.Tests on fine aggregate and coarse aggregate were conducted in accordance with IS: 650-1966, IS: 2386-1968, IS 383-1970 were used. Silica fume and Ground granulated blast furnace (GGBS) has been used as mineral admixtures. The dosage of Silica fume was 10% and GGBS was 20 % was optimized for total cementations material. 0.6 % by weight of cementations material Glenium - Ace 31 as Chemical Admixtures (Super plasticizer) to impart additional workability. 0.65% of Crimped steel fiber (SF) having Aspect ratio (L/D) =50, Polypropylene fibers (PF) having length of 12mm, 900gm per volume of concrete and 0.5% of Carbon fiber (CF) (6 mm length) with respect to total volume of concrete were added. Potable water was used for casting and curing. The mix proportion for M60 grade of concrete is arrived after the trail mixes as 1: 0.137: 0.251: 0.957: 2.46: 0.386(Cement: SF: GGBS: FA: CA: Water). To this mix proportion steel fiber, polypropylene fibers, carbon fibers are added after adjusting water cement ratio to the required workability of 90 mm slump.

Test Specimens

In the present experimental investigation, eight different Concrete matrix mix integrated with fibers were used and for each mix, three cubes and three Cylinders comprising a total of 24 cubes and 24 cylinders were casted and tested at 28days curing. The details of description are shown in Table 1.

Casting the Specimens

In casting of specimen, Weigh batching is used for the experimental study. The coarse aggregate, fine aggregate, cement, silica fume, GGBS, fibers, Super plasticizer and water are mixed as per design mix proportion. The assembled mould was filled with the cement concrete mix in 3 layers and compacted using table vibrator and needle vibrator. The cubes and cylinders were removed from the moulds after 24 hours of casting and cured for 28 days.

Experimental methodology

Procedure

The Modulus of Elasticity for Concrete can be determined in laboratory as follows:

The modulus of Elasticity is determined by loading a capped cylindrical specimen subjected to uni-axial compression and measuring deformation across a gauge length of 150mm using

Table 1. Details of number of specimens

S.No	Description (Concrete Matrices)	Number of concrete Cubes	Number of concrete Cylinders
1	Control Specimen CS: (M60)	3	3
2	M60 + Polypropylene fiber (M60 + PF)	3	3
3	M60 + Steel fiber (M60 + SF)	3	3
4	M60 + Carbon fiber (M60 + CF)	3	3
5	M60 + Polypropylene fiber + Steel fiber (M60+PF+SF)	3	3
6	M60 + Polypropylene fiber + Carbon fiber (M60+PF+CF)	3	3
7	M60 +Carbon fiber +Steel fiber (M60+CF+SF)	3	3
8	M60 + Polypropylene fiber + Carbon fiber + Steel fiber (M60+PF+CF+SF)	3	3

Table 2. Modulus of Elasticity

S.No.	Description (Concrete Matrices)	Experimental Modulus of Elasticity (N/mm^2)	[2]Theoretical Modulus of Elasticity (N/mm^2) E= $(3320\sqrt{f_c} + 6900)\, w^{1.5}$	E/T ratio
1	Control Specimen CS: (M60)	3.48×10^4	3.94×10^4	0.88
2	M60 + Polypropylene fiber (M60 + PF)	3.79×10^4	4.03×10^4	0.93
3	M60 + Steel fiber (M60 + SF)	3.87×10^4	4.05×10^4	0.94
4	M60 + Carbon fiber (M60 + CF)	3.82×10^4	4.07×10^4	0.95
5	M60 + Polypropylene fiber + Steel fiber (M60+PF+SF)	3.88×10^4	4.05×10^4	0.95
6	M60 + Polypropylene fiber + Carbon fiber (M60+PF+CF)	3.84×10^4	4.03×10^4	0.95
7	M60 +Carbon fiber +Steel fiber (M60+CF+SF)	3.91×10^4	4.14×10^4	0.94
8	M60+ Polypropylene fiber+ Carbon fiber + Steel fiber (M60+PF+CF+SF)	4.3×10^4	4.23×10^4	1.01

extensometer mounted on the cylinder parallel to its axis as shown in Figure 1. Load the cylinder at the rate of 14 N/mm^2 per minute and at regular interval of loading record the extensometer reading. Then the specimen is subjected to a number of loading and unloading cycles to a stress level equal to 1/3rd of the ultimate cube strength of concrete or at least the loading and unloading is repeated for 3 minimum cycle until the deformation observation should not differ more than 5 % and calculate the stress-strain for each cylinder and plot the stress-strain curves. Then secant modulus is determined by the slope of each cycle i.e., tan θ = stress/strain at 30% of cube strength. The average value from 3 cycle gives the true value of modulus of elasticity of concrete i.e., secant modulus of elasticity.

Fig.1. Measuring Strain in CTM Using Extensometer

RESULTS AND DISCUSSION

Stress-Strain curves for concrete

It is observed from the stress strain curve, the slope of curve at secant modulus of elasticity obtained for CS (M60) is 3.48 x 10^4, M60 +PF is$3.79 \times 10^4 N/mm^2$, M60+SF is $3.87 \times 10^4 N/mm^2$, M60+CF is $3.82 \times 10^4 N/mm^2$, M60+PF+SF is $3.88 \times 10^4 N/mm^2$, M60+PF+CF is $3.84 \times 10^4 N/mm^2$, M60+CF+SF is 3.91x $10^4 N/mm^2$, M60+PF+CF+SF is $4.3 \times 10^4 N/mm^2$ as shown in figure no.3 and the values determined theoretical and analytically are tabulated in Table no.2.

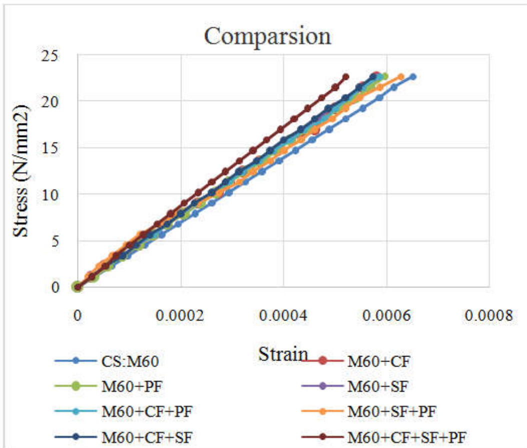

Fig.2. Stress-Strain behavior of different Concrete mix

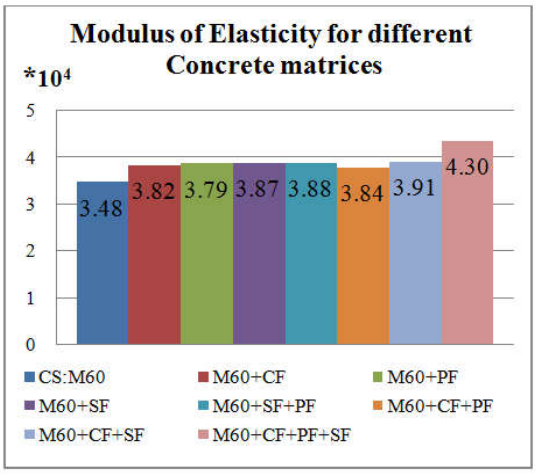

Fig.3. Modulus of Elasticity for different Concrete matrices

Conclusion

- To determine Modulus of elasticity of concrete experimentally, 30% of ultimate cube strength is considered for stress – strain curve.
- The Modulus of Elasticity of fiber reinforced concrete for Control specimen: M60 is 3.48x10^{4}N/mm^2, M60+PF is3.79x10^{4}N/mm^2, M60+SF is3.87x10^{4}N/ mm^2, M60+CF is 3.82x10^{4}N/mm^2, M60+PF+SF is 3.88x10^{4}N/mm^2, M60+PF+CF is 3.84x10^{4}N/mm^2, M60+CF+PF is 3.91x10^{4}N/mm^2 and M60+PF+CF+SF is 4.3x10^{4}N/mm^2.
- In comparison with Control specimen the percentage increase of modulus of elasticity for M60 +PF is 8.9 %, M60+SF is 11.2 %, M60+CF is 9.7 %, M60+PF+SF is 11.4%, M60+PF+CF is 10.3 %, M60+CF+SF is 12.3%. For matrix (M60+PF+CF+SF) which contains steel fibers, poly propylene fibers and carbon fibers show the highest increase of 23.5 %.

It can be concluded that steel fibers, Carbon fibers; Polypropylene fibers are viable addition in concrete which makes the transition zone stronger there by increases the Modulus of Elasticity of fiber reinforced concrete.

REFERENCES

Alexander M.G. and T.I. Milne 1995. "Influence of Cement Blend AnAggregate Type On Stress-Strain Behavior And Elastic Modulus Of Concrete" *ACI Materials Journal*, Title No. 92-M24.

Bertil Persson 2003. "Justification Of Federation International De Beton, Fib, 2000 Model For Elastic Modulus Of Normal And High Performance Concrete, HPC" Division of building materials, Lund Institute of Technology, Lund, Sweden.

Divya S Dharan and AswathyLal, 2016. "Study The Effect Of Polypropylene Fiber In Concrete" *International Research Journal of Engineering and Technology*, Volume: 03 Issue: 06

IS: 456- 2000, "Plain and reinforced concrete- code of practice (fourth revision)", Bureau of Indian Standards, New Delhi, India.

Mohamed AlfitouriMasoud, 2015. "Compressive Strengths and Modulus of Elasticity of Steel Fiber Reinforced Concrete Under Different Temperature Conditions" Postgraduate Program Department Of Civil Engineering Muhammadiyah University Surakarta.

Pu-Woei Chen and D. D. L. Chung "Study of Concretes Reinforced with Polyethylene Steel Fibers" *ACI Journals Material*

Shetty M. S., "Concrete Technology", Chand S. and Company Limited, New Delhi, 6th Edition, 2005.

Taerwe L. and A. Van Gysel, 1996. "Influence Of Steel Fibers On Design Stress-Strain Curve For High Strength Concrete" *Journal of Engineering Mechanics* /August

Xiaoming Sharon Huo, Nabil Al-Omaishi and MaherK. Tadros 2001. "Creep, Shrinkage and Modulus of Elasticity of High-Performance Concrete" *ACI Materials Journal*, Title No. 98-M47

****