INFLUENCE OF FLUCTUATIONS IN VOLUMETRIC DOSAGES OF COMPOSITE MATERIALS ON TORSIONAL RIGIDITY

[1]T.Muniraj, [2]S.Suresh Babu, [3]V.S.Satheesh
[1]P.G. Student, [2]Head of the Department, [3]Assistant Professor
[1]Department of Civil Engineering,
[1]Adhiyamaan College of Engineering, Hosur, Tamilnadu, India

Abstract*—Concrete is a composite material which consists of cement, aggregates and some other alternatives such as steel reinforcements, fly ash, fibers, etc. In a structural member, torsion is usually associated with bending moments and shear forces. In this study, the influence of fluctuations in volumetric dosages of steel fibers on torsional rigidity has studied. Also the torsional moment of the concrete beam and the angle of twist is evaluated. Fibers are most generally discontinuous, randomly distributed throughout the concrete matrices. Fibers having the aspect ratio of 60 with different volumetric ratios of 9% to 13% with the weight of concrete have been used for this investigation. The specimens were casted as slender beams with cement and fine aggregate in the ratio of 1:1. The test results shows that the volume fraction of 12% having linear changes in the torsion with respect to the angle of twist.

***Index Terms*—Steel fiber, torsional moment, angle of twist, torsional rigidity, shear stress.**

I. INTRODUCTION

Concrete is a composite material used for construction purposes, also will be provided with reinforcement in which concrete's low tensile strength and ductility are counteracted by the inclusion of reinforcement having higher tensile strength.

In a structural member torsion is usually associated with bending moments and shear forces. Torsional rigidity is the amount of resistance a cross section has against torsional deformation. It is dependent on the shape of the cross section, modulus of rigidity of the material, length of the member subjected to torsion and the support conditions.

Structural members curved in plan, members of a space frame, eccentrically loaded beams, curved box girders in bridges spandrel beams in buildings and spiral stair-cases are typical examples of the structural elements subjected to torsional moments and torsion cannot be neglected while designing such members. The behavior of concrete members in torsion is primarily governed by the tensile response of the material, particularly its tensile cracking characteristics.

The slender beams are considered in design of long span upturned roof beams or in the design of thin deep panels used as spandrel beams. The slender beam can be expressed as the beams in which the spacing of the lateral support to the compression flange or face is more than 50 times the least width of the flange or face. The slender beams are considered in design of long span upturned roof beams or in the design of thin deep panels used as spandrel beams.

On several situations beams and slabs are subjected to torsion in addition to bending moment and shear force. Loads acting normal to the plane of bending will cause bending moment and shear force. However, loads away from the plane of bending will induce torsional moment along with bending moment and shear.

Fiber reinforced concrete

Fiber reinforced concrete is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers each of which lend varying properties to the concrete. In addition the fiber-reinforced concrete changes with varying concretes, fiber materials, geometries, distribution, orientation and densities.

Fibers are usually used in concrete to control cracking due to plastic shrinkage and to drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibers produce greater impact, abrasion, and shatter resistance in concrete.

The fiber is a small piece of reinforcing material possessing certain characteristics properties. They are circular or flat. The fiber is often described by the parameter aspect ratio which is the ratio of fiber length to its diameter. The typical aspect ratio varies from 20 to 150.

Steel Fibers

Steel fibers have been used in concrete from the 19th century. Nowadays, steel fibers are manufactured from steel wire with either rough surface, hooked ends or crimped through their length. Addition of steel fibers to concrete arrests cracking caused by volume change (expansion and contraction), because of steel fibers which support concrete in all directions. A structure free from micro cracks prevents migration of water or moisture throughout the concrete. Hence this helps to prevent the corrosion of steel used for primary reinforcement of the structure. The modulus of elasticity of steel is high with respect to the modulus of elasticity of the concrete binder. Steel fiber helps in increasing flexural strength of concrete. The performance of the hardened concrete is enhanced more by fibers with a higher aspect ratio, since this improves the fiber-matrix bond. On the other hand, a high aspect ratio adversely affects the workability of the fresh mix.

Study of Literatures

- RC beams buckle elastically do not undergo diagonal tension cracking before buckling. Therefore, uncracked torsional rigidity, which considers the entire concrete beam as a solid and homogeneous body and neglects the contribution of reinforcement, reflects the rigidity of an RC beam at buckling.
- The increase of compressive strength of concrete increases the pre-cracking torsional stiffness remarkably and marginally increases the ultimate torsional capacity.
- The beams with increasing span to depth ratio have reduced torsional strength [2].

- Increased resistance to twist can be obtained by reducing the spacing of the transverse reinforcement of the beam.
- The maximum torsional strength for beams without stirrups is 2.03MPa and for beams with stirrups is 3.24MPa [8].

II. METHODOLOGY

The concrete mix was made as dry with PPC and fine aggregate (River Sand). The materials were properly mixed in the dry condition and different volume of fibers were taken in terms of weight with respect to the weight of concrete as 9%, 10%, 11%, 12% and 13%. The water cement ratio of 0.4 was used to prepare the concrete mix. Totally 12 number of specimens were casted and cured for 28 days. After the curing period the specimens were subjected to testing using torsion tester to find the loading capacity of the specimen with respect to the angle of twist.

III. EXPERIMENTAL PROGRAM

A. Materials

1. Cement

   Cement is one of the binding material of concrete used as a proportion for casting of beam specimen. Portland Pozzolona Cement of ACC plus 53 grade was used. Specific gravity - 3.15, Initial setting time - 35 minutes, Final setting time - 585 minutes.
2. Fine Aggregate

   Locally available river sand was used as fine aggregate which passes through 4.75mm. The specific gravity of the fine aggregate is 2.67. The fineness modulus of aggregate was 2.62.
3. Steel Fiber

   Crimped steel fibers of 30mm length, 0.5mm diameter with an aspect ratio of 60 was used. Material type – Low carbon drawn wire, Tensile strength-1050Mpa.

B. Testing Procedure

Concrete beam specimen of size 400mm x 30mm x 40mm was casted in the mix proportion of 1:1. The beams were tested after curing of 28 days for determining the torsional resistance with respect to the each applied angle of twist. From the above data the torque, modulus of rigidity and shear stress were calculated using the following formula

1. Torque, T = Load x Length of the specimen
2. Modulus of Rigidity, $G = \frac{TL}{J\varphi}$

   T- Torque in N-m, L- Length of the specimen in mm, J- Polar moment of Inertia in mm^4, φ- Angle of Twist in radians
3. Shear stress, $\tau = \frac{3T}{bt^2}$

   b- Width of the beam in mm (largest size of cross section), t- Thickness of beam in mm

IV. RESULTS

Table 1 Overall test results of the beam

Volume fraction in %	Cracking Torque in kN-m	Ultimate Torque in kN-m	Modulus of Rigidity in N/mm^2	Shear Stress in N/mm^2
9	19.42	21.77	924.29	1.81
10	22.36	24.5	104087	2.04
11	24.13	24.91	1057.52	2.07
12	25.30	25.702	1090.83	2.14
13	24.91	25.50	1082.50	2.12

These linear curve for 12% volume fraction in the graph shows that the increasing volume of fibers resulting in increased torsional strength and shear stress. After achieving the ultimate strength the torsional strength reduces slowly. The graphical representation of the test results were shown below (Fig.1,2,3).

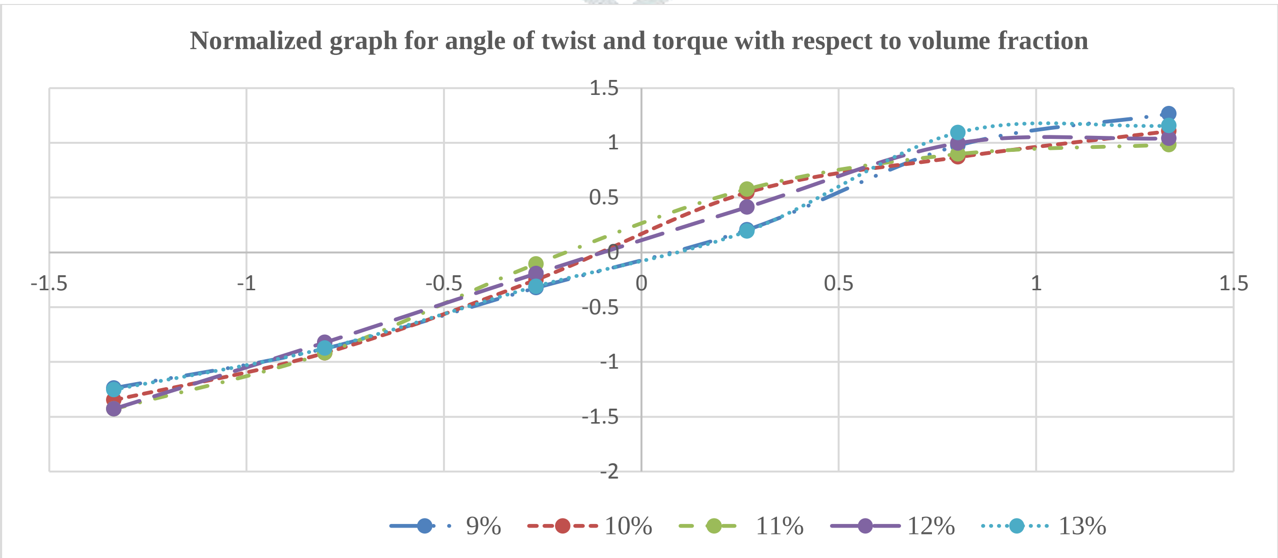


Figure 1 : Normalized graph for angle of twist and torque with respect to volume fraction

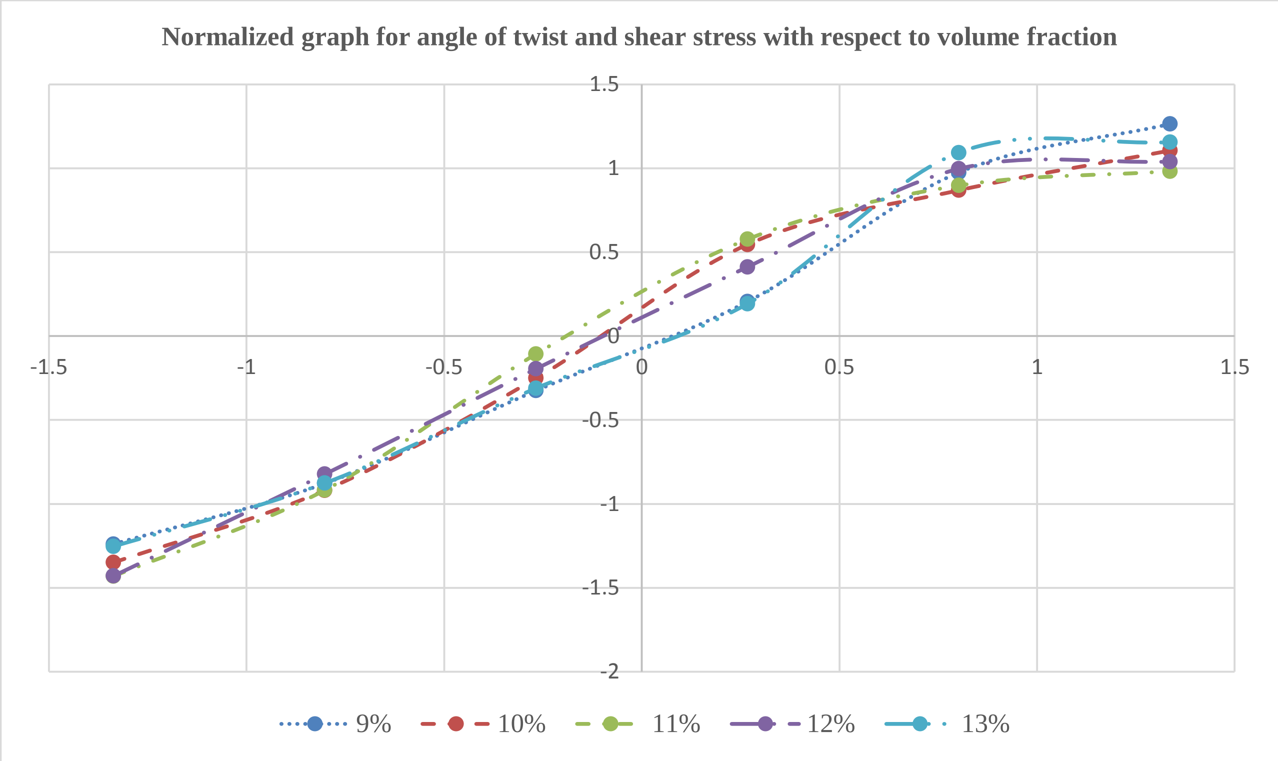


Figure 2 : Normalized graph for angle of twist and shear stress with respect to volume fraction

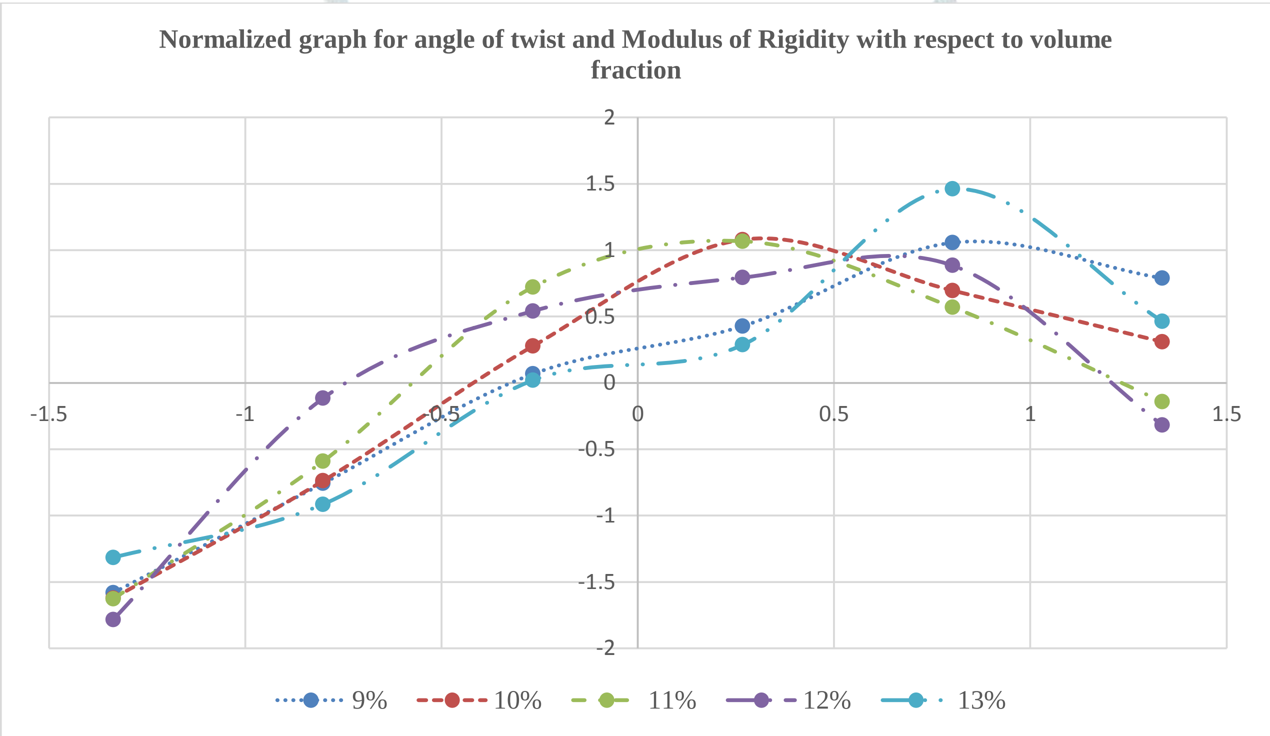
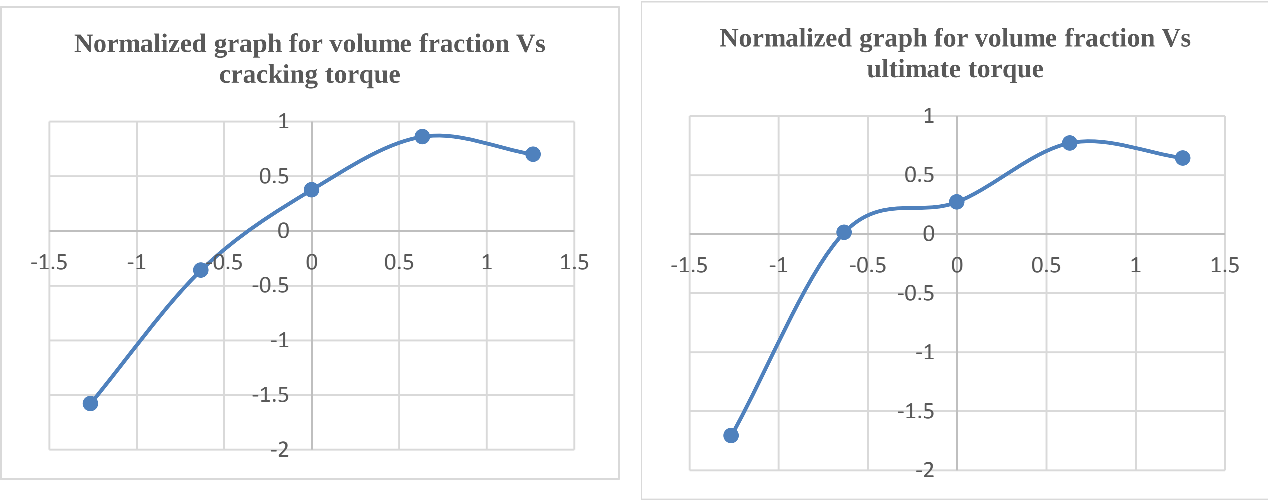


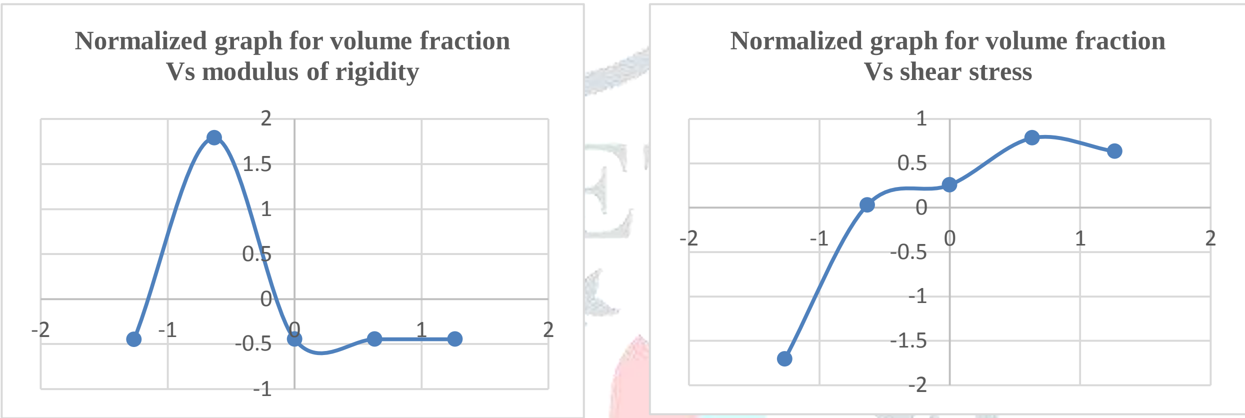
Figure 3 : Normalized graph for angle of twist and Modulus of Rigidity with respect to volume fraction

The addition of fibers in mortar increases the cracking resistance of the beam. This is caused due to the gap reduction in between the fibers which absorbs more energy transferred from the mortar. Fibers having large capacity of absorbing tensile stress results increased ductile characteristics of the beam.



a b

Figure 4a, 4b : Normalized graph for volume fraction Vs cracking torque and ultimate torque



a b

Figure 5a, 5b : Normalized graph for volume fraction Vs modulus of rigidity and shear stress

V. CONCLUSIONS

The following conclusions were made by conduction g the above method of experimental investigation.

- The ultimate torsional strength increases with increase with the increase in volume percentage of fibers. The increasing torsional strength was observed for optimum of 12%.
- Volumetric changes of fiber in beam changes the internal stress properties of beam which results increase in torsional resistance of beam.
- Increasing limited volume of fibers shows increased crack resistance of concrete beam.
- The crack patterns are about 45º to the axis of the beam indicating occurrence of shear failure in the beam.
- After attaining the optimum torsional strength, increasing fibers further causes slight reduction in achieving the strength.
- The result shows that the torsional strength increases linearly up to a limited volume of fibers only.

REFERENCES

[1] Alfina Abdul Samad, Ramadass .S, Mervin Ealiyas Mathews, "Study of Structural Behaviour of RC Slender Beams", International Journal of Engineering Trends and Technology – Volume 39 Number 2- September 2016.

[2] C.Arvind Kumar, Madan Mohan, D.V.S.P Rajesh, Prathik Kulkarni, "Behaviour of Fibre Reinforce Concrete Beam in Pure Torsion", International Journal of Research in Engineering and Technology, Volume: 04, Issue: 05, May-2015.

[3] Atef H. Bakhsh, Faisal F Wafa, and Ali A. Akhtaruzzaman, "Torsional Behavior of Plain High-Strength Concrete Beams", ACI Structural Journal, 87-S59, September-October 1990.

[4] Constantin E. Chalioris, Chris G. Karayannis, "Experimental investigation of RC beams with rectangular spiral reinforcement in torsion", Engineering Structures 56 (2013), pp. 286–297.

[5] Fuad Okay, Serkan Engin, "Torsional behavior of steel fiber reinforced concrete beams", Construction and Building Materials 28 (2012), pp. 269–275.

[6] Hamdy M. Mohamed and Brahim Benmokrane, "Torsion Behavior of Concrete Beams Reinforced with Glass Fiber-Reinforced Polymer Bars and Stirrups", ACI Structural Journal, Volume 112, No. 5, September-October 2015.

[7] Ilker Kalkan, "Lateral Torsional Buckling of Rectangular Reinforced Concrete Beams", ACI Structural Journal, 111-S07, Jan-Feb – 2014.

[8] Kedar Kirane, Konjengbam Darunkumar Singh, and Zdene k P. Bazant, "Size Effect in Torsional Strength of Plain and Reinforced Concrete", ACI Structural Journal, 113-S107, November-December 2016.

[9] Kenichiro Nakarai, Shigemitsu Morito, Masaki Ehara, Shota Matsushita, "Shear Strength of Reinforced Concrete Beams: Concrete Volumetric Change Effects", Journal of Advanced Concrete Technology, volume-14, pp. 229-244, May 2016

[10] Khaldoun N. Rahal, "Shear Behavior of Reinforced Concrete Beams with Variable Thickness of Concrete Side Cover", ACI Structural Journal, Volume 103, No.2, March-April 2006.

[11] Prof. Kishor S. Sable, Prof. Madhuri K. Rathi, "Comparison of Normal Compacted Concrete and Self Compacted Concrete in Shear & Torsion", International Journal of Computer Technology and Electronics Engineering (IJCTEE) Volume 2, Issue 4, August 2012, pp.74-79.
[12] I-Kuang Fang and Jyh-Kun Shiau, "Torsional Behavior of Normal- and High-Strength Concrete Beams", ACI Structural Journal, 101-S31, May-June 2004.
[13] Likhil L. Raut, D. B. Kulkarni, "Torsional Strengthening of under Reinforced Concrete Beams using Crimped Steel Fiber", IJRET: International Journal of Research in Engineering and Technology, Volume: 03, Issue: 06, Jun-2014, pp. 466-471.
[14] Mohammad Rashidi and Hana Takht roozeh, "The Evaluation of Torsional Strength in Reinforced Concrete Beam", Mechanics, Materials Science & Engineering, December 2016.
[15] Muhammad I. Rjoub and Mazen A. Musmar, "Torsional Strength of Steel Fiber Reinforced Concrete", Journal of Engineering Sciences, Assiut University, Vol. 35, No.1, pp. 1-8, January 2007.
[16] Nasr-Eddine Koutchoukali and Abdeldjelil Belarbi, "Torsion of High-Strength Reinforced Concrete Beams and Minimum Reinforcement Requirement", ACI Structural Journal, 98-S44, July-August 2001.
[17] S. Pant Avinash, R. Suresh Parekar, "Steel fiber reinforced concrete beams under combined torsion-bending-shear", Journal of Civil Engineering (IEB), Volume-38(1), May-2010, pp. 31-38.
[18] K. Perumal, R. Srinivasan, "An Experimental Study on Torsional Behavior of Steel Beams Infilled with Plain Cement Concrete and Fiber Reinforced Concrete", IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 3 Issue 3, March 2016, pp. 95-100.
[19] M R Prakash, Sadanand P, Manjunath H R, Jagadeesh Kumar B G & Prabhakarar, "Cracking and Torsional Ductility Behavior Of HSC Beams", International Journal of General Engineering and Technology (IJGET) Vol. 5, Issue 1, Dec - Jan 2016; pp. 25-34.
[20] Samir A. Ashour, Tamim A. Samman, and Talal A. Radain, "Torsional Behavior of Reinforced High-Strength Concrete Deep Beams", ACI Structural Journal, 96-S117, November-December 1999.
[21] Satyajeet B. Mopari, Ajinkya D. Raut, "Experimental Study of Steel Fiber Prestressed Concrete Beam for Shear, Bending and Torsion", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), pp. 68-83, 2015.
[22] Sayed Behzad Talaeitaba, Davood Mostofinejad, "Fixed Supports in Assessment of RC Beams' Behavior under Combined Shear and Torsion", International Journal of Applied Science and Technology Vol. 1 No. 5; September 2011, pp. 119-126.
[23] Sure Naveen, Patel Asha and Jena Biswajit, "Study on Torsional Behavior of RC T- Beams Strengthened with Glass FRP", Research Journal of Recent Sciences, Vol. 4, pp. 57-64, 2015.
[24] J.Thivya, R. Malathy, D Tensing, "Behaviour of Composite Beams under Combined Bending and Torsion", International Journal of Advanced Engineering Technology, Vol. VII, Issue II, April-June 2016, pp. 563-566.
[25] Vikram Kumar, M. R. Prakash, Chinmayee & R Prabhakara, "Torsional Behaviour of Plain and Reinforced Normal Strength Concrete Beams", Imperial Journal of Interdisciplinary Research (IJIR) Vol-3, Issue-3, 2017.