TORSIONAL BEHAVIOUR OF REINFORCED CONCRETE 'L' BEAM

Nagendra Prasad.N[1], Naresh kumar.Y[2]
1PG Students, Department of Civil Engineering, Sathyabama University, Chennai – 600 119, Tamil Nadu, India.
2Professor, Department of Civil Engineering, Sathyabama University, Chennai – 600 119, Tamil Nadu, India.

Abstract: Many structural elements in building and bridge construction are subjected to significant torsional moments that affect the design. In this paper, the behaviour and performance of reinforced concrete 'L' shaped beam subjected to pure torsion is presented. The beams are provide with reinforcement to resist bending moment and without torsional moment resisting reinforcement. The torsional strength is related to the amounts of transverse and longitudinal reinforcement and to the concrete strength. The beams are reinforced with three varies type, a normal under reinforced beam and beams with 30% less reinforcement in longitudinal and transverse direction. This torsional test is based on the strength of membrane elements subjected to pure shear that was also applied to beams subjected to combined shearing forces, bending moments, and axial loads. The ultimate strength and crack patterns of the beams where predicted.

Keywords: 'L' beam, transverse reinforcement, longitudinal reinforcement.

1. Introduction:

If external loads act far away from the vertical plane of bending, the beam is subjected to twisting about its longitudinal axis, known as torsion, in addition to the shearing force and bending moment. Torsion on structural elements may be classified into two types; statically determinate, and statically indeterminate. In figures 1.1 are several examples of beams subjected to torsion are shown. In these figures, torsion results from either supporting a slab or a beam on one side only, or supporting loads that act far away transverse to the longitudinal axis of the beam. Shear stresses due to torsion create diagonal tension stresses that produce diagonal cracking. If the member is not adequately reinforced for torsion, a sudden brittle failure can occur. Since shear and moment usually develop simultaneously with torsion, a reasonable design should logically account for the interaction of these forces. However, variable cracking, the inelastic behaviour of concrete, and the intricate state of stress created by the interaction of shear, moment, and torsion make an exact analysis unfeasible. The current torsion design approach assumes no interaction between flexure, shear and torsion. Reinforcement for each of these forces is designed separately and then combined. In figure 1.1 are Reinforced concrete members subjected to torsion, (a) spandrel beam (b) and (c) loads act away from the vertical plane of bending (d) curved beam (e) circular beam. Principal Stresses Due to Torsion, Shear, and Moment, if a beam is subjected to torsion, shear, and bending, the two shearing stresses add on one side face and counteract each other on the opposite face. Therefore, inclined cracks start at the face where the shear stresses add and extend across the extreme tension fiber. If the bending moment is large, the crack will extend almost vertically across the back face. The Compressive stresses at the bottom of the cantilever beam prevent the cracks from extending all way down the full height of the front and back faces.

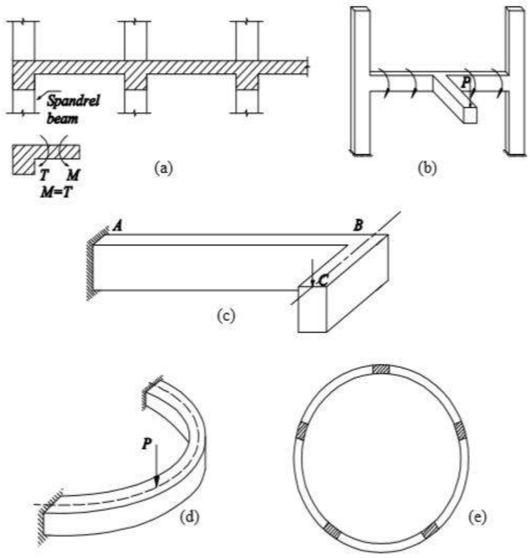


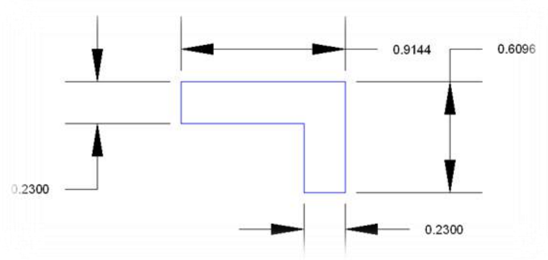
Fig 1 : Typical cross section of torsional moments

2. Objective:

The paper's goal is to investigate the torsional moments induced in the beams, the angle of twist produced in the beams due to applied torque, the shear crack patterns of the beams and also to study the behaviour of all the beams under torsion in ANSYS software. The main aim of the is to study the responsibilities of the longitudinal and transverse reinforcement in the beams under torsional loading conditions.

3. Beam Design:

The Beam A is designed as per IS 456 : 2000 as a cantilever beam to resist the design bending moment of 106.68kN-m.Beam B is reduced with 30% less longitudinal reinforcement and Beam C with 30% less shear reinforcement. The beams are designed with the material strength of M30 Grade concrete and 415 Grade steel.



All the dimensions are in meter

Beam A reinforcement detail

Beam B reinforcement detail

Beam C reinforcement detail

Fig 2 : size of beam and reinforcement details

I. REINFORCEMENT DETAILS OF BEAMS

	BEAM A	BEAM B	BEAM C
MAIN REINFRORCEMENT	7 NOS OF 16mm DIA BAR	5 NOS OF 16mm DIA BAR	7 NOS OF 16mm DIA BAR
SHEAR REINFORCEMENT	2 LEGGED 8MM DIA STIRRUPS SPACING @ 65mm C/C	2 LEGGED 8MM DIA STIRRUPS SPACING @ 65mm C/C	2 LEGGED 8MM DIA STIRRUPS SPACING @ 85mm C/C

4. Torsional test on Beam: All the three casted beams are tested by creating a torsional moment in the beam by inducing eccentric point loads on the beam. The beam is arranged in such a way that one end of the beam is fixed with the special arrangement and extended part is left free end. So as it behaves as a cantilever beam. Proving rings and dial gauges are attached with beam to measure the applied load and the displacement correspondingly.

Fig 3: Experimental setup

5. Crack patterns in beams: The beams are tested under a torsional moments so we achieved a shear crack patterns in the beams and its in 45degree angle.

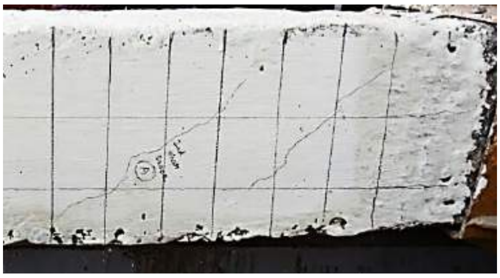


Fig 3: Experimental setup

II. OBSERVED VALUES BEAM A

ECCENTRIC LOAD (kN-m)	TORSIONAL MOMENT (kN-m)	ANGLE OF TWIST	
		RADIANS	DEGREE
5	3.048	0.0996	5° 42′ 23.97
10	6.096	0.1445	8° 16′ 25.26
15	9.144	0.2142	12° 16′ 21.92
20	12.192	0.2491	14°16′ 20.56
25	15.24	0.3089	17° 41′ 55.2
30	18.288	0.3537	20° 15′ 55.86
35	21.336	0.4085	23° 24′ 19.17
40	24.384	0.4484	25° 41′ 29.14
45	27.432	0.5132	29° 24′ 15.1
50	30.48	0.563	32° 15′ 27.09
55	33.528	0.5978	34° 15′ 5.1

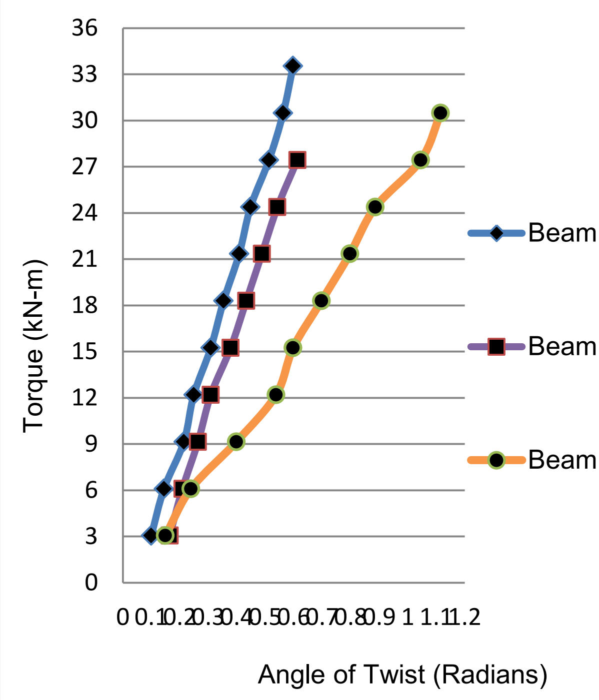
III. OBSERVED VALUES BEAM B

ECCENTRIC LOAD (kN-m)	TORSIONAL MOMENT (kN-m)	ANGLE OF TWIST	
		RADIANS	DEGREE
5	3.048	0.1644	9° 25′ 29.93
10	6.096	0.2093	12° 00′ 33.1
15	9.144	0.2641	15° 7′ 54.54
20	12.192	0.3089	17° 41′ 55.2
25	15.24	0.3786	21° 41′ 31.86
30	18.288	0.4334	24° 49′ 55.17
35	21.336	0.4882	27° 58′ 18.48
40	24.384	0.543	31° 6′ 41.79
45	27.432	0.6128	35° 6′ 39.07

IV. OBSERVED VALUES BEAM C

ECCENTRIC LOAD (kN-m)	TORSIONAL MOMENT (kN-m)	ANGLE OF TWIST	
		RADIANS	DEGREE
5	3.048	0.1495	8°33′ 56.59
10	6.096	0.2391	13°41′ 57.92
15	9.144	0.3986	22°50′ 17.15
20	12.192	0.538	30° 49′ 30.47
25	15.24	0.5978	34°15′ 5.1
30	18.288	0.6975	39°57′ 49.7
35	21.336	0.7971	45°40′ 13.68
40	24.384	0.8868	50°48′ 35.68
45	27.432	1.0462	59°56′ 34.24
50	30.48	1.1159	63°56′ 10.9

V. GRAPH COMPARING ALL THE THREE BEAMS BETWEEN TORQUE VS ANGLE OF TWIST:



6. ANSYS modelling and deflection of beams: The beams which are experimentally tested are feeded in ANSYS software and its modalled, meshed, applied load, assigned support and the corresponding deflection are founded.

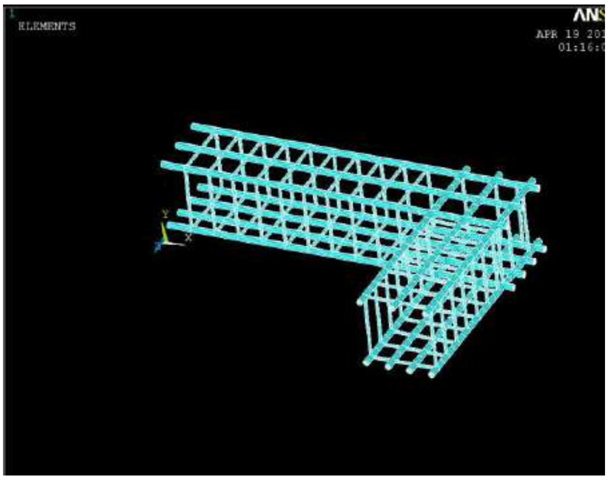


Fig 4: Modelled reinforcement of beam A

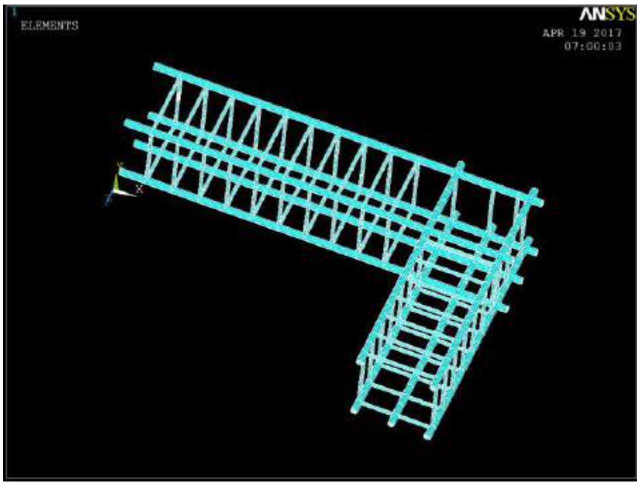


Fig 5: Modelled reinforcement of beam B

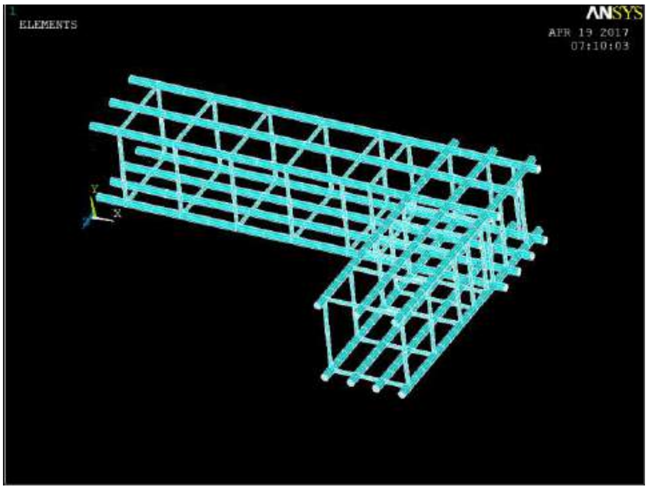


Fig 6: Modelled reinforcement of beam C

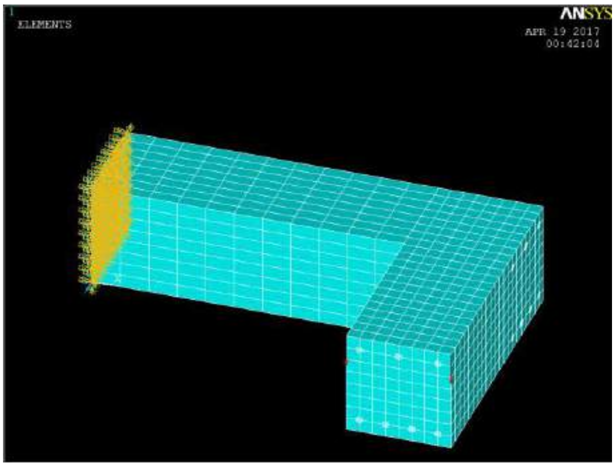


Fig 7: Meshed Modal with reinforcement of beam

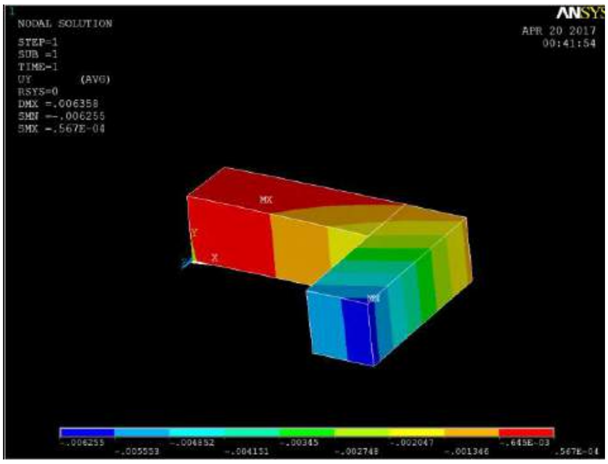
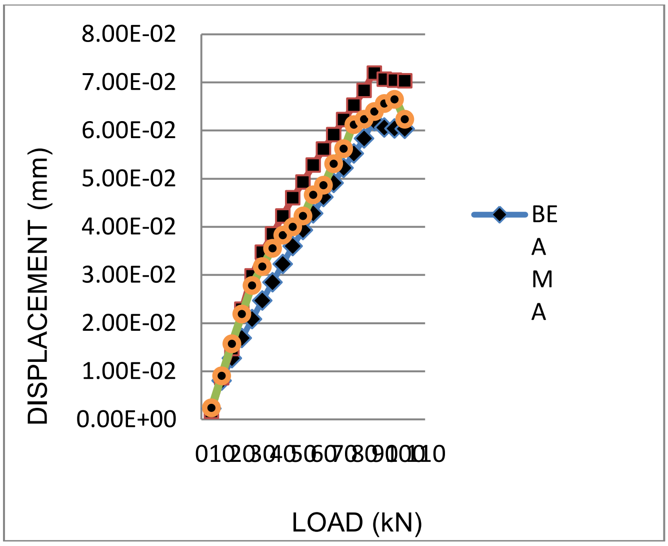


Fig 8: Deflection of beam A



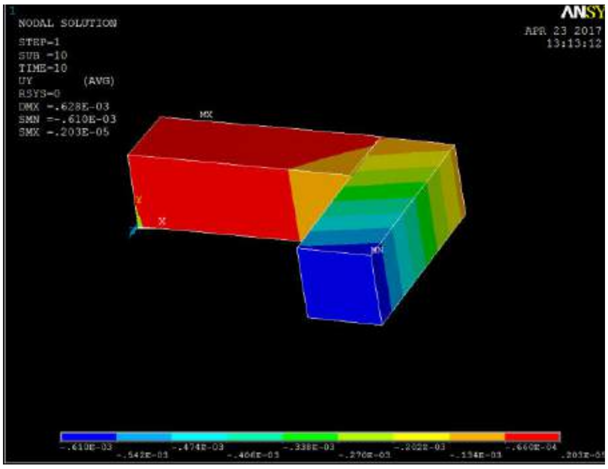


Fig 9: Deflection of beam B

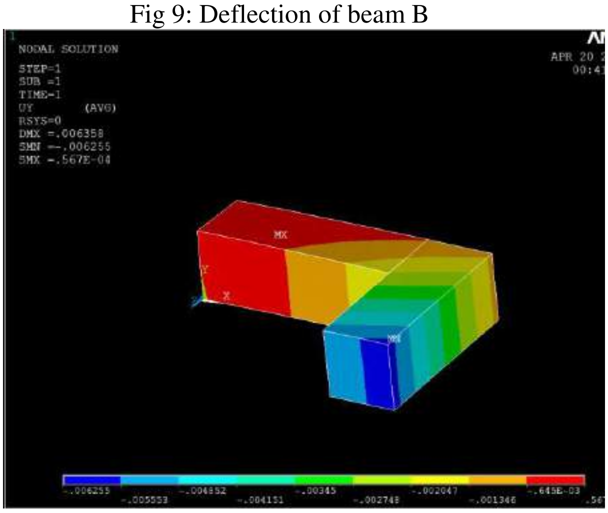


Fig 10: Deflection of beam C

VI. GRAPH COMPARING ALL THE THREE BEAMS BETWEEN TORQUE VS ANGLE OF TWIST:

CONCLUSION: The crack pattern and the behaviour of 'L' shaped RC Beam has learnt. Beam A is designed to carry a design bending moment of 106.68kN-m and but when it subject to torsion it can resist only a 33.528kN-m torsional moment. Whereas, beam B and beam C are provided with the 30% less reinforcement than beam A, so beam B and beam C fails early than beam A with the torsional moment of 27.432kN-m and 30.48kN-m correspondingly.As of from my work, when we are comparing beam 'B', 'C' with the beam 'A' it shows that :

a) Beam 'B' is subject to torque it has possess a less twisting in the beam but whereas Beam 'C' possess more twisting against torsion as shown in figure 5.13 .
b) Beam 'B' possess a less resistance torque than beam A, because the beam is provided with less longitudinal reinforcement, when it subject to torsional moment, the beam possess bending crack.
c) Beam 'C' fails early than Beam 'A' but it reached a resistance near to, it's safer than Beam 'B'

REFERENCES:

1) Chalioris.C.E., "Experimental study of the torsion of reinforced concrete members", Structural Engineering & Mechanics, Vol. 23(6), 2006, pp. 713-737.

2) Hsu.T.T.C. and Mattock, A. H., "A Torsion Test Rig", Journal of the PCA Research and Development Laboratories, Vol. 7, 1965, pp. 2-9.

3) Hsu.T.T.C., "Ultimate Torque of Reinforced Rectangular Beams", American Society of Civil Engineers, Vol. 94(S1'2), 1968, pp.485-510.

4) Khaldoun Rahal, "Torsional strength of reinforced concrete beams", Canadian Journal of civil engineering vol.27, October 2000, pp.445-453.

5) Kuang Fang.J and Jyh-Kun Shiau, "Torsional behavior of NSC and HSC concrete beams", ACI Structural Journal, Vol.101, May-June 2004, pp. 304-313.

6) Koutchoukali.N and Belarbi, "Torsion of High-Strength Reinforced Concrete Beams and Minimum Reinforcement Requirements". Structural Journal of the American Concrete Institute, Vol. 98, 2001, pp. 462-469.

7) Lessig.N.N., "Determination of Load Carrying Capacity of Reinforced Concrete Element with Rectangular Cross-section Subjected to Flexure with Torsion", Concrete and Reinforced Concrete Institute Moscow, 1959, pp. 5-28.

8) McMuUen.A.E. and Warwaruk, J., "Concrete Beams in Bending, Torsion and Shear", American Society of Civil Engineers, Vol.96(ST5), 1970, pp.885-903.

9) Mirza.M.S. and McCutcheon, J.P., "Behaviour of Reinforced Concrete Beam under Combined Bending, Shear and Torsion", American Concrete Institute Journal, Vol. 66(5), 1969, pp.421-427.