An Experimental Study On Combined Flexural And Torsional Behaviour Of RC Beams

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Abstract –*When the load was acting away from the resultant force from the shear center axis, combined action of bending and torsions occurs . The present investigation aims to study the combined action of flexure and torsion for which two beams are casted. The test set up is specially fabricated for applying combined torsion and bending. For the study, Crack pattern , load- deflection characteristics, torque-twist response have been taken of those specimens.*

KeyWords: **flexure, torsion, rcbeams, deflection, torsional crack**

1.INTRODUCTION

The Reinforced Concrete elements which are subjected to torsional loading in addition to flexure and shear includes the following:
a)peripheral beams in each floor of multi-storied buildings
b) ring beams at the bottom of circular tanks
c)edge beams of shell roof,
d)beams supporting canopy slabs
e) helical staircases
In reinforced concrete design, depending on the load transfer mechanism the torsion is classified as 'equilibrium torsion and compatibility torsion. In beams supporting lateral overhanging projections due to eccentricity in the loading, equilibrium torsion occurs. Torsion is induced in a structural member by rotations (twists) applied at one or more points along the length of the member in case of compatibility torsion. Statically indeterminate twisting moments are generally formulated and their analysis necessarily involves compatibility conditions. Therefore it is named compatibility torsion. The structural elements which are subjected to torsion show cracks if they are not designed properly. Beam subjected to transverse loading with the resultant force passing through the longitudinal shear centre axis, the beam bends and no torsion will occur. The beam is subjected to not only bending but also twisting when the resultant acts away from the shear centre axis. Practically, in RC construction, torsion occurs as a secondary effect of bending. Members subject to combined bending and torsion should be designed in the same way as sections subject to combined bending and shear. The section should be able to resist the bending moment, and if the torsional resistance of the section is inadequate, additional torsional shear reinforcement should be introduced.

2. OBJECTIVES OF PRESENT STUDY

- To study the combined flexural and torsional behaviour of RC beams

3. EXPERIMENTAL PROGRAM

3.1 TEST PROGRAM

The test program is so devised so as to study the combined flexural and torsional behaviour of RC beams. The test program consists of:

1. First is the determination of basic properties of constituent materials namely cement, fine and coarse aggregates and steel bars as per relevant Indian standard specifications and designing the relevant concrete mix proportions.

2. Casting of 2 RC beams with rectangular shape of dimensions 230 mm x 300 mm and length of 2000 mm using M 25 grade concrete.

The details of the test program are discussed in subsequent sub-sections.

3.2 MATERIALS USED

Cement, fine aggregates, coarse aggregates, reinforcing bars and water are used in casting of beams. The specifications and properties of these materials are as under:

3.2.1 Cement

Ordinary portland cement of Dalmia make from a single lot is used for the study. The physical properties of cement as obtained from various tests are listed in Table 3.1.All the tests are carried out in accordance with procedure laid down in IS 4031:1988, valid for portland cements.

Table-1:Properties of Cement

Sl. No	Properties	Results
1	Specfic gravity	3.2
2	Standard consistency	29%
3	Initial setting time	35 min
4	Final setting time	6 hours
5	Fineness of cement	9%
6	Soundness of cement	< 10 mm

3.2.2 Fine Aggregates

Locally available sand is used as fine aggregates both in the preparation of cement mortar as well as for the concrete mix. The physical properties and sieve analysis results of sand are shown in Tables 2.

Table-2: properties of sand

Properties of sand	Values
Specific gravity	2.67
Fineness Modulus	5.43

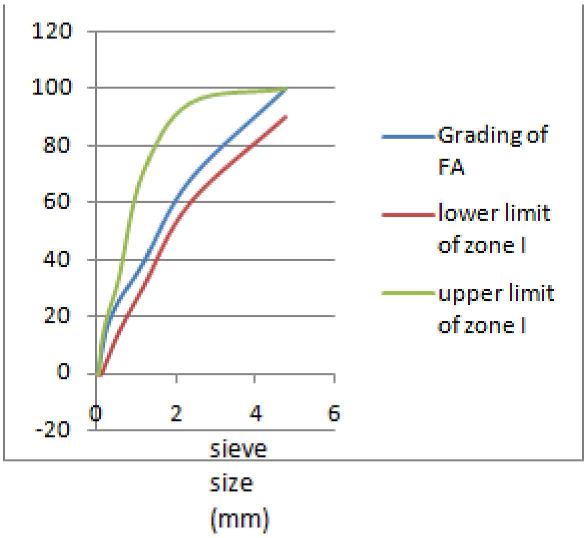

Chart-1:sieve analysis of FA

3.2.3 Coarse aggregate

Crushed stone aggregates (locally available) of 20 mm is used through-out the experimental study. The physical properties and sieve analysis results of coarse aggregates is given in Tables 3 .

Table-3: Properties of CA

Properties of coarse aggregate	Values
Specific gravity	2.73
Water absorption	0.94%
Bulk density	1.5g/cm3
Porosity	0.443

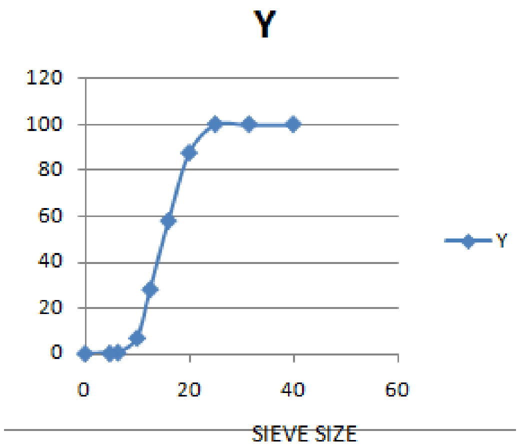

Chart-2: sieve analysis of CA

3.2.4 Water

Fresh and clean water is used for casting and curing the specimens. The water is relatively free from organic matter, silt, oil, sugar, chloride and acidic material as per requirements of indian standard.

3.2.5 Reinforcing steel

HYSD steel of grade Fe-500 of 16mm, 10mm diameters and mild steel of 8mm diameters are used in the experimental program. 16mm diameter bars are used as tension reinforcement and 10mm diameter bars are used as compression steel. 8mm diameter bars are used as stirrups.

3.2.6 Concrete Mix

M25 grade concrete mix is designed as per IS code design procedure using the properties of materials as discussed above and presented in Tables 3.1 to 3.6. The water cement ratio achieved in the design is 0.38. The mix proportion of material came out to be 1: 1.57: 2.94 (cement: sand: coarse aggregate) and compressive strength of materials after 28 days is 32.65N/mm^2.

3.3 DESIGN OF BEAM

To study the proposed behaviour, 2 beam specimens are cast using M-25 grade concrete and Fe-500 grade steel. The beam has dimensions 230 mm x 300 mm in all test specimens and length of 2000 mm.The reinforcement consisted of 2 no's of 16 mm diameter bars in tension zone and 2 no's of 10 mm diameter in the compression zone. The RCC beam is designed using limit state method considering it to be an under-reinforced section. The reinforcement detailing is shown below:

- Bottom reinforcement:2 nos 16mm dia
- Stirrup : 8mm dia @ 300mm spacing

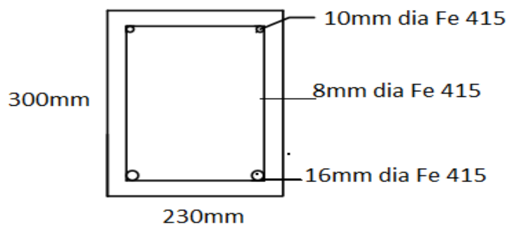

Fig-1: Reinforcement details of specimen

3.3 CASTING OF BEAM

A wooden mould is made of dimensions 230mm x 300 mm for the beam and of length 2000mm. The steel mould is shown in the Figure 3.5. Cover blocks of 20 mm are placed under the reinforcement to provide uniform cover. Coarse aggregates, fine aggregates, cement and water are mixed manually as per the proportions of design mix.

After placing the desired reinforcement, concrete is poured in the mould and vibrations are given to the mould with the help of needle vibrator, so that the mix gets compacted. The vibration is done until the mould is completely filled and there is no gap left. The wooden formworks are then removed from the mould after 24 hours. After de-moulding the beams are cured for 28 days in water.

3.4 TEST SETUP AND INSTRUMENTATION:

Total 2 beam specimen are prepared with M25 grade concrete for identifying effective ferrocement wrapping pattern under combined torsion and bending. All beams are having 230 mm × 300 mm cross section and 2000 mm length. The beams are reinforced with 2–10 mm diameter bars in longitudinal direction and 8 mm diameter stirrups in the transverse direction spaced at 200 mm c/c

Loading frame of 50 tonne capacity is specially fabricated for applying load on beam specimens to be tested under combined action of torsion and bending. A biaxial roller support condition is provided to allow movements in both directions and lever arms are attached to specimen to give torsional moment as shown in Fig. The specimen is subjected to pure torsion when the position of lever arm coincides with support. So to apply combined torsion and bending, the lever arm should be kept away from both the support. length and position of lever arm can be adjusted to apply different combination of torsion and bending moment. Two dial gauges are used from which one is used for measuring the angle of twist and the other is placed at center to measure central displacement. Mechanical strain gauges are used to measure strain of concrete . Distance of 330 mm is kept in between center of support and lever arm for achieving bending along with torsion. The load of hydraulic jack is transferred to specimen through spreader beam resting on the end of lever arm attached to specimen. So, half of the applied load will act at the end of each lever arm. As the load at the end of lever arm is away from longitudinal axis of beam and away from support of specimen, it will give rise to combined bending and torsion.

Fig-2: Test setup

4. RESULTS AND DISCUSSIONS

4.1. Torque-Twist Response

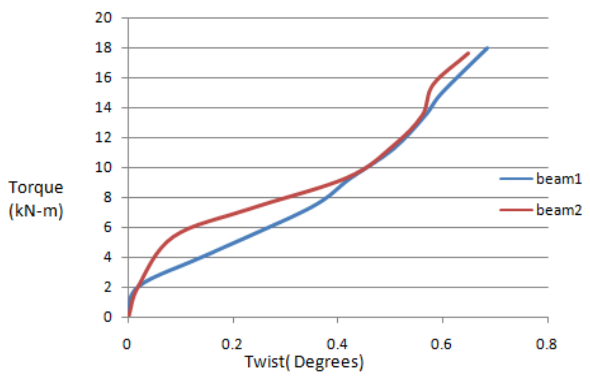

chart-3: Torque-twist response

4.2. Load- Deflection Relationship

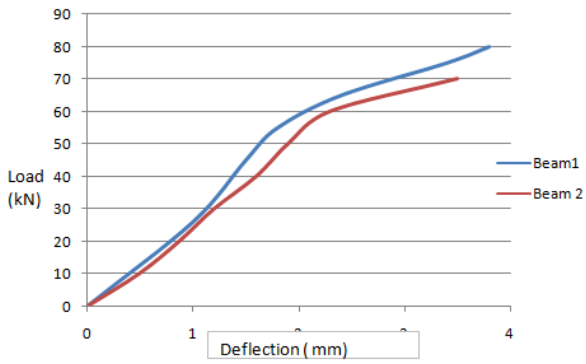

Chart-4: Load- Deflection Relationship

4.3. Load- Strain Relationship

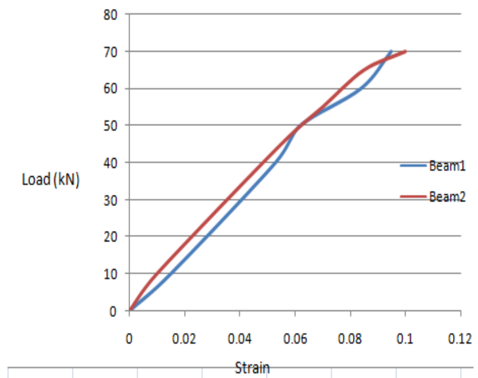

Chart-5: Load-Strain Relationship

5. CONCLUSION

The main conclusions obtained from the analysis are summarised.below:

- Combined action of flexure and torsion is observed at between the lever arm.
- The inclination of these initial cracks was nearly 45◦ to the axis of the beam.
- The cracks propagated towards the top with increasing angle of inclination and bottom faces. The beam at the ultimate stage formed a hinge along the four face, which is the compression face. This face is free from cracks.

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