CHAPTER - 1

INTRODUCTION

1.1 Occurrence of Torsion

Torsion is frequently encountered in reinforced concrete structures originating mainly from the monolithic character of reinforced concrete construction. In most cases it occurs as a secondary effect, very often in combination with bending moment and shearing force. A spandrel beam, an edge beam of a shell, an element in a grid structure, a member of a stiff-jointed space frame, a cantilever balcony beam and interconnected girders are all subjected to torsion in addition to bending moment and shearing force because of their typical location in structures. Torsion may also result from the loading pattern as in the case of the continuous beam-slab construction subjected to unsymmetrical loading on the slab spans. A load not passing through the shear centre of a beam also produces torsion in the beam.

In the cases of a spiral staircase, a beam curved in plan and an edge beam, sometimes called a spandrel beam, torsion may also be the primary effect and govern the design.

1.2 Design for Torsion

The torsional behaviour of reinforced concrete structural members is not yet completely understood. Study (1)*

*Parenthesised Superscript numbers indicate the serial number of references listed at the end of the Thesis.

of various national codes reveal that code provisions for torsion in most of the cases are arbitrary and based on varying concepts. Only recently some codes[2,3] have incorporated relatively more scientific methods for torsion design on the basis of research findings so far available.

1.3 Importance of Investigation

A survey of structures conducted by the Portland cement Association for the ACI Committee 438 revealed evidences of structural distress due to improper consideration for torsion in a number of cases. This together with the refinement of the present-day design methods and reduction of safety margin emphasizes the importance of thorough investigation of the torsion problem and provision for torsion in design. Even though there are reports of earlier research work [4-11], organised investigation considering practical aspect of the torsion problem started since the early fifties and as a result a few theories have evolved. The information available at present is not so meagre as it was before fifties, but still there are gaps in the knowledge on torsional behaviour and further research works are needed to fill up the gaps.

The spandrel beams are essentially L-beams subjected to combined bending, shear and torsion created mainly due to distributed loads. Such loads, unlike the concentrated loads,

produce varying shear and varying torsion along the length. The support conditions of a beam again induce typical combinations of three types of actions along a beam. A simply supported beam with proper restraint against torsion and supporting an eccentric load distributed uniformly is subjected to maximum twisting moment and maximum transverse shear with zero bending moment at support sections, whereas at the middle of the beam where the bending moment is maximum, the shear force and twisting moment are zero. A continuous beam or a beam restrained at ends supporting uniformly distributed eccentric load is subjected to maximum value of each of torsion, shear and bending moment at the interior support sections whereas at the point of contraflexure the beam section is subjected to combined torsion and shear only. Thus combinations of the three may also involve variations of the relative individual effects.

Most of the previous research works in this field of combined loading dealt with rectangular beams subjected to combined bending, shear and torsion created by concentrated load. Investigations on L-beams under combined bending, shear and torsion created by uniformly distributed loads are very meagre. Some of the few available reports of research in this respect are due to Victor and Ferguson[12] and Rajagopalan and Ferguson[13]. Victor and Ferguson[12] reported test

results of twenty-one semicontinuous T-beams without stirrups and observed that the torsional strength of such beams under distributed loading was larger than that in case of concentrated loading. Rajagopalan and Ferguson[13] reported test results of nine semicontinuous L-beams with stirrups subjected to combined bending, shear and torsion due to distributed loads. Their results also showed 30% increase in strength. As their findings were based on limited test data, they suggested further extensive research in this direction. The present research is intended to add some more information in respect of the effect of combined loading in the form of distributed loading.

1.4 Object and Scope of the Present Research

The object of the present investigation is to study the behaviour of semicontinuous spandrel beams of L-section with and without stirrups under combined bending, torsion and shear produced by concentrated and distributed loads. This problem involves a large number of variables like shape of the section, various arrangements of reinforcements, relative magnitudes of bending, shear and torsion and their gradients. To understand the effect of combined actions of bending, shear and torsion, it is necessary to know the effect of their individual actions, since the combined effect will result from modification of individual effects due to interactions. The knowledge of the behaviour

of rectangular beams also will help in understanding the effect of flanged sections like L or T. Similarly the effect of reinforcement and its various arrangements will be understood in the light of the behaviour of plain concrete beams. Thus the problem starts from the consideration of behaviour of plain concrete rectangular members under pure torsion. As regards the behaviour of reinforced concrete beams under flexure and transverse shear, the magnitude of information is quite large and some theories have already been formulated. In studying the effect of combined loading in L-section, the behaviour of rectangular beams with various arrangement of reinforcement under pure torsion has to be considered. The determination of balanced condition when both longitudinal and transverse reinforcements yield and concrete crushes under pure torsion is an important factor from the point of view of ultimate strength as well as economy. Various proportions of longitudinal and transverse reinforcements and their distribution also may affect the ultimate strength.

In consideration of the above the present study has been divided into the following three classifications :

(i) Review of the previous research works.

(ii) Analysis of existing available data and development of a generalised theory and

(iii) Testing and evaluation of test results for combined effect of bending, shear and torsion due to distributed loads in semi-continuous spandrel beams of L-section.