CHAPTER-I

INTRODUCTION

1.1 General:

The presence of torsion in combination with bending and shear is a common enough feature in modern concrete structures. In the past, torsion in the presence of other actions was either not generally taken into account in the design, or it was assumed that its effect vis-a-vis other forces was of a minor nature and could be taken care of by the then large factors of safety used in flexural design. Also, attempts were sometimes made to arrange the members in a structure in such a way as to keep the torsional moment to the minimum. This imposed an undesirable restraint on the designer. To maintain the continuity and the aesthetic beauty in bold and complicated forms of modern structures, occurrence of considerable torsion along with bending and shear often becomes unavoidable. With the increase in the knowledge of concrete properties, quality control and design sophistication, the factors of sefety for flexural design has been considerably reduced, so that significant torsional moments can no longer be neglected in design. Explicit design for torsion has further been necessary with increasing use of structures incorporating members subject to torsional moments of the same order of magnitude as the flexural moments. Bridges and girders curved in plan, beams from which other beams or slabs cantilever, skew slabs, modern staircases, members meeting at a point, etc., are some of the instances where torsion becomes one of the primary actions for design consideration.

Although research on torsional behaviour of concrete was taken up almost at the beginning of the present century, it is only in the last 15 years or so, that the problem has drawn intensive attention of a large number of research workers all over the world. Prior to Nylander's published work in 1945 (16), the limited available studies on torsion of structural concrete were confined to plain and reinforced concrete beams subjected to pure torsion only. The more practical case of torsion combined with bending and shear remained almost neglected. Even after two decades since Nylander's work only two other researchers, Lessig and Yudin, have considered the problem of combined bending, torsion and shear in reinforced concrete beams. A review of past research (Chapter-II) indicates that there is considerable lack of information, theoretical as well as experimental, on the behaviour and ultimate strength of beams with longitudinal and transverse steel under simultaneous actions of torsion, bending and shear. As a result of which, code provisions for torsion in the various national codes are somewhat inconclusive in nature, in some aspects arbitrary, and between different codes show divergence of views.

All previous investigators except Hsu (46,48) assumed the concrete in a reinforced beam to be either fully effective or totally ineffective in resisting ultimate torsional moments. It was Hsu who showed that contribution of concrete to the ultimate resisting torque was present, but to a limited extent of about 40% corresponding to that of a plain concrete beam. Known theories in combined torsion have not taken this fact into account and are based on either of the previous concepts of concrete contribution. It was also experimentally shown by Hsu that, depending upon the percentages of longitudinal and transverse steel, and the strength of concrete, a beam under pure torsion would be designated as underreinforced, partially overreinforced, or completely overreinforced. An underreinforced beam was defined as one in which both the longitudinal and transverse steel yielded before final failure of the beam. In a partially overreinforced beam either the longitudinal steel or the transverse steel remained unyielded at failure; while in an overreinforced beam none of the types of steel yielded. It can be argued that such situations also exist in reinforced beams subjected to any combination of torsion, bending and shear. Even for the simple case of pure torsion, available expressions differentiating underreinforced, partially overreinforced, and completely overreinforced beams cannot be considered as quite satisfactory. Existing research concerns mainly the underreinforced beams. No investigation so far is known to have been made for overreinforced beams. As regards combined loading, torsion and flexural shear give rise to like and unlike shear stresses in opposite faces of an uncracked beam. Their interaction in the post-cracking condition of a reinforced beam is yet to be established.