S Y N O P S I S

The present period in the history of structural engineering can rightly be called a transition from elastic to ultimate load design procedures. Research workers all over the world are engaged in establishing the behaviour of structural members at ultimate loads and in evolving rational and simplified design methods. Design codes of several countries are being revised to include the ultimate load design methods as an alternative to the existing conventional elastic design procedures. Though the illogical nature of the elastic methods of design is now well understood, the complete replacement of the time-honoured elastic approach by ultimate load procedures calls for a considerable further study of all primary and secondary aspects of design. The introduction of the plastic design methods coupled with the use of higher strength concretes, has necessitated the consideration of stiffness requirements of flexural members, the hitherto usually neglected and unimportant aspects of reinforced concrete design. Thus, new clauses controlling the stiffness of members are introduced in several national Codes of Practice, simultaneously with the inclusion of inelastic methods of design. Though remarkable success has been achieved by the recent researches all over the world in evolving basically sound principles regarding the strength in bending, the shear failure of beams is still a riddle to a large extent. The Codes of Practice could not provide a rational method for shear design, alternative to the existing

conventional method based on elastic theory. Furthermore, the theory of inelastic design of statically indeterminate structures is based on the phenomenon of 'redistribution of moments',rendered possible owing to the 'rotation capacity' of the plastic hinges, resulting in the formation of collapse mechanisms. In this thesis, the investigations of deflections, rotation capacities, ultimate shear and flexural strengths made on simple and two-span continous rectangular reinforced concrete beams are presented.

The first part of the thesis deals with the deflections and rotation capacities of reinforced concrete beams. The problem of deflections and rotation capacities would be easier in the case of a homogeneous material, such as steel, and a cross-section presenting ~~the same~~ the same elasto-plastic properties for tension and compression. In a complex material such as reinforced concrete, the problem becomes more difficult. The stiffness of a reinforced concrete beam depends upon numerous factors which influence the values of the modulus of elasticity and the second moment of area of the cross-section separately and combinedly. Such factors are too numerous to be represented by parameters within the framework of a complete theory. Only the principal factors are taken into account, these being described by an equation with a single parameter wherein the causes of variation in the stiffness of reinforced concrete beams are treated summarily.

The second part of the thesis deals with the ultimate shear strength of reinforced concrete beams. Expressions for the shear strength of beams with and without web reinforcement for different values of the effective shear span-depth ratios have been developed. These expressions for predicting the ultimate strength in shear are based on Seth's failure criterion, first applied to concrete by Sen. A unique feature of Sen's theory is the suggested method of successive approximation to evaluate the ultimate strength in shear for larger effective shear span-depth ratios from the expressions derived. The expressions for the ultimate flexural strength of beams have also been developed on the same basic assumptions in respect of the stress-strain curve for concrete. Having thus been in a position to estimate the flexural and shear strengths, the web reinforcement can be varied suitably to evolve an economical design.

The proposed theories of strength and stiffness were verified experimentally by conducting tests on 15 simple and 46 two-span continuous rectangular reinforced concrete beams with web reinforcement. The variables included in the investigation were the size of the specimen, the percentage of longitudinal and web reinforcement, and the load configuration. The computed deflections were found to compare well with the actual deflections upto 80% to 90% of the failure load. It was found that continuous beams with normal percentagesof steel exhibited a rotation capacity sufficient for the development of crushing moments at all critical sections. The test results agreed fairly well with the ultimate loads in all cases.