CHAPTER-1

INTRODUCTION

1.1 General

Beams in general are classified as shallow beams, moderate deep beams, and deep beams according to their span to depth ratios. Beams whose depths are comparable to their spans may be described as deep beams. There is a distinct change in behaviour of deep beams and moderate deep beams because of the presence of local lateral normal forces in addition to usual bending moments and shear forces. This is not true for shallow beams. There is gradual transition from shallow beam behaviour to deep beam behaviour. See **Fig.1.1**. The transition range appears to be between span to depth ratios of 2.0 to 6.0. Such beams are defined as moderate deep beams.

In construction, deep beams are widely used in water tanks,underground bunkers, silos, nuclear reactors, etc., where walls act as vertical beams spanning between column supports. Sometimes pile caps are also designed as deep beams. Deep beams and moderate deep beams occur frequently in modern buildings such as departmental stores, hotels and theatres where it is desired to have the lower floor completely free of columns. In reinforced concrete hipped plate construction, the supporting diaphrams often behave as deep beams.

There is no clear demarcation as to just what constitutes a deep beam and a moderate deep beam. The American Concrete Institute Building Code, ACI : 318-1989 (5)* refers to deep beams as those with span to depth ratios less than 2.5 for continous beams and 1.25 for simply supported beams. According to Europeen Concrete Committee as well as Indian

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* **Numbers in parentheses refer to the references in the Bibliography.**

Standard Code IS:456-1978 (76) the beams with span to depth ratios less than 2.5 for continuous span and less than 2.0 for simply supported span are considered as deep beams.

There is no clear cut demarcation for their boundaries. The boundaries are difficult to define because of different transition zones of behaviour which depends on concrete strength, span to depth ratio, shear span to depth ratio, percentage of longitudinal and web reinforcement as well as loading configuration. However, according to all the codes they can be classified as under :

$L/D \geq 6.0$ Shallow beams

$2 < L/D < 6.0$ Moderate deep beams

$0.5 < L/D < 2.0$ Deep beams

Considerable efforts are still being made in every part of the world to develop new composite construction material. Fibre reinforced concrete is one of the most promising materials. Ordinary concrete with the addition of discontinuous, discrete, randomely oriented fibres of short length and small diameter is known as fibre reinforced concrete. In recent times, different types of fibres are used to produce a concrete of superior properties and performance. Mainly four types of fibres (steel, glass, carbon and polypropylene) are currently being investigated in fibre reinforced concrete matrix. Due to low effectiveness and poor alkaline resistance, use of other fibres has been almost ruled out; The steel fibre reinforced concrete has been the subject of extensive investigations in the recent time. Steel fibres in concrete improves post cracking performance. It helps in controlling crack propagation, reduction in crack width, and imparts ductility to concrete. Due to pulling out of fibres, it absorbs lot of energy. Hence, toughness and impact resistance are increased considerably. The fibre reinforced concrete has found many intresting field applications such as bridge-decks, highways, pavements for airfields, slope stabilizing in mining and tunnelling, industrial flooring, etc. The application of fibres to reinforced concrete structural members would be one of the major areas of use in structural engineering. Thus, fibre reinforced concrete has got an exciting future in construction in days ahead.

1.2 Object and Scope

In a report on the "Research Needs in Structural Engineering for the Decade 1966-1975" published by American Society of Civil Engineers (33) the committee on research concluded that knowledge concerning the behaviour and strength of reinforced concrete members under combined bending and shear was still grossly inadequate. Recently ACI - ASCE Committee 426-1973 (8) published a revised report for the shear provision in building codes in which it has been mentioned that they are inadequate for designing deep beams and moderate deep beams. The recommendations contained in ACI Committee 544-1973 (6) are also inadequate for deep beams and moderate deep beams.

Reinforced concrete deep beams and moderate deep beams have many useful applications, particularly in tall buildings, foundations and offshore structures. However, their design is not covered adequately by national codes of practice. For example the current British Code BS 8110-1985 explicitly states that "For design of deep beams reference should be made to specialist literature". Similarly, the draft Eurocode EC/2-1987 (31) states that "it does not apply, however, to deep beams and moderate deep beams ... " and instead refers readers to the CEB-FIP model code-1990. Currently, the main design documents are the American Building Code ACI 318-89, the Candian Code CAN-A23.3-M84-1987 (25), the CEB-FIP model code-1990 (32) and the CIRIA Guide 2-1987 (34). Of these, the CIRIA Guide gives the most comperhensive recommendations for design of deep beams.

The main aim of this investigation is to examine the possibility and potential use of fibres, in zones of concrete members upto half depth and full depth for optimization of fibres with desired performance along with cost effectiveness. In this study, observations were taken for the first cracking load, crack patterns, deflections, modes of failure and ultimate load along with the measurement of maximum crack widths with their locations. Design using steel fibre reinforced concrete is a topic not yet covered by any code of practice. Indeed research in this field has been carried out on a wide scale, making it possible now to postulate design equations based on available data.

All appropriate engineering parameters of steel fibre reinforced concrete which can be incorporated in the analysis of structureal response of beams have been explored.

Expression of ultimate flexural moment for steel fibre reinforced concrete deep beams and moderate deep beams have been derived on the pattern of assumed stress distribution. To reflect analytically the role of fibres in such beams, the concept of strain enhancement factor is used. This factor is obtained from direct tension test along with suitable parameters.

Based on the test results of these investigations, equations are developed to find the strength of steel fibre reinforced concrete deep beams and moderate deep beams considering splitting strength of elliptical section whose major axis lies on a line joining the load and the supports, together with the resistance offered by reinforcing steel and the resistance offered by steel fibre reinforced concrete.

The ultimate loads of the test beams are presented to show the reliability of the analysis and the method adopted. Based on the results presented in this study, design recommendations are made which can be incorporated in the code of practice for fibre reinforced concrete members.

1.3 Notation

The letter symbols used in this study are defined where they first appear in the text. For convenience, frequently used symbols are listed in **Appendix-A**.

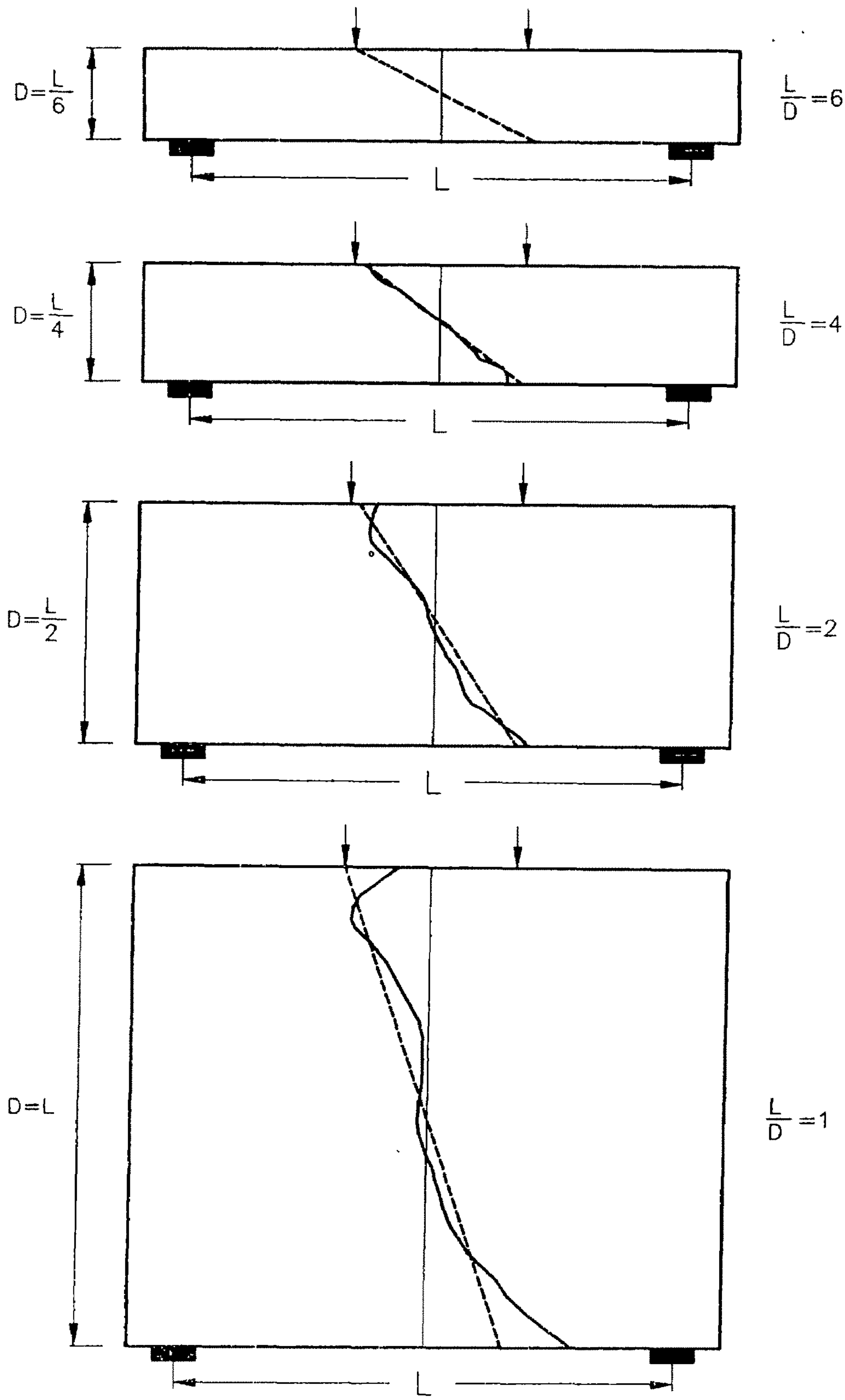

Fig.1.1THEORETICAL MAXIMUM BENDING STREES DISTRUBUTION FOR VARYING L/D RATIO AT MID SPAN