SYNOPSIS

STRUCTURAL RESPONSE OF PARTIALLY STEEL FIBRE REINFORCED CONCRETE DEEP BEAMS

INTRODUCTION AND BRIEF SURVEY

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 are described as 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. Looking to the wide use of deep beams and moderate deep beams in construction, an attempt is made through this study to know the effect of inclusion of steel fibres in conventional reinforced concrete deep beams and moderate deep beams on their flexural and shear behaviour.

Ordinary concrete with the addition of discontinous, discrete randomely oriented fibres of short length and small diameter is known as fibre reinforced concrete. This is a new composite material. Among different types of organic and metallic fibres, steel fibres are most widely used. The steel fibre reinforced concrete has been the subject of extensive investigations all over the world including India. Use of steel fibres in conventional reinforced concrete deep beams has attracted the attention of the structural engineers. Publication of results of few investigators in this area highlights the significant improvement of the service load performance with reduction in deflection and crack width.

A critical review of the existing literature has revealed that the presence of steel fibres changes the brittle failure to ductile failure by imparting ductility. Increase in ultimate load capacity is significant. Deflection and crack control are the two limit state parameters in the design codes of most of the countries. Current design philosophy of limit state design highlights to predict these two parameters in terms of fibre parameters and properties of the cross sections.

The problem of determining the elastic stress distribution in reinforced concrete deep beams has been investigated by a number of investigators, namely F. Dischinger, Li Chow, Winter and Conway. Investigations considering non-linear stress distribution were carried out by P. J. Robins, F. K. Kong, R. H. Evans, G. R. Sharp, V. Ramkrishnan and Y. Ananthanarayan, Michael D. Kotsovos, K. N. Smith and A. S. Vantsiotis, K. H. Tan and M. A. Mansur, N. E. Shanmugan, B. P. Hughes, R. N. Swamy, H. W. Reinhardt, and others. However, these results cannot be applied directly to steel fibre reinforced concrete deep beams because of non-homogenity and inelastic behaviour of concrete.

A survey of published literature shows that very less experimental work has been conducted on partially fibre reinforced concrete deep beams and moderate deep beams. It was, therefore, decided to study experimentally the behaviour of such beams and develop equations for first cracking load, ultimate load for flexure and shear capacity of such beam, taking effect of fibres in full depth and partial depth and also to observe the deflection, crack patterns and maximum crack widths with its locations and modes of failure.

Some of the investigators have highlighted the performance of partial steel fibre reinforced concrete shallow beams indicating the improvement of service load. H. V. Dwarakanath and T.S.Nagaraj, P.Sabhapati and H.Achyutha, T.M. Roberts and N.L.Ho, V.S.Parameshwaran and K.Rajagopalan have stated that the presence of fibres can be utilised effectively by taking partially fibre reinforced section over a fully fibre reinforced section. In the analysis of partially steel fibre reinforced concrete deep beams and moderate deep beams, the possibility of using fibres for a certain depth has been examined in detail. This mode of using fibres is regarded as partially fibre reinforced concrete members.

An engineering parameter for tensile strain enhancement has been identified for designing such beams. In the analysis of conventionally reinforced fully fibrous and partially fibrous deep beams, and moderate deep beams, the effect of the presence of fibres on the structural response has been explored in the present investigations.

EXPERIMENTATION

The test specimen consist of forty beams of five series under two point loads having span to depth (L/D) ratios ranging from 1 to 6 and shear span to depth (a/D) ratios ranging from 0.33 to 2.0. Depth of the beams varied from 100 mm to 600 mm for constant span of 600 mm. The width of all the beams was kept as 75 mm. All beams were provided with plain round mild steel bars on tension side with full depth steel fibre and partial depth steel fibre reinforced concrete sections. Observations were taken for first cracking load, crack patterns, deflection, modes of failure and ultimate load alongwith measurements of maximum crack widths and their locations. Strain gauges were used to measure strains at different points of beams.

ANALYSIS

Expressions for the ultimate flexural moment for steel fibre reinforced concrete deep beams and moderate deep beams have been derived on the assumed stress distribution namely $\sigma = A \in +B \in^2$. Tension in the concrete is also considered. 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.

Based on the test results of these investigations, equations given by ACI-318-89 Building code(5) for estimating maximum crack width of reinforced concrete flexural member was modified using statistical analysis of the data of present investigation. The degree of agrement seen confirms the validity of the proposed modification for estimation of fibre contribution.

The ultimate loads given by the proposed formulas shows good aggrement with the test results of the fibre reinforced concrete deep beams and moderate deep beams.