BEHAVIOUR OF FIBRE REINFORCED CONCRETE UNDER CYCLIC AND FATIGUE LOADING

by

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.. Fibre reinforced concrete

CERTIFICATE

This is to certify that the thesis entitled "**Behaviour of Fibre Reinforced Concrete Under Cyclic and Fatigue Loading**" being submitted by **Mr. Vinod Kumar Jain** to the Indian Institute of Technology, Delhi for the award of the degree of Doctor of Philosophy in Civil Engineering, is a record of bonafide research work carried out by him. **Mr. Vinod Kumar Jain** has worked under my guidance and supervision and has fulfilled the requirements for the submission of this thesis, which to my knowledge, has reached the requisite standard.

The matter embodied in this thesis has not been submitted to any other University or Institute for the award of any degree or diploma.

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(Vinod Kumar Jain)

ABSTRACT

In this study, an experimental investigation was conducted to study the behaviour of Steel Fibre Reinforced Concrete (SFRC) under cyclic compressive, fatigue compressive and cyclic flexural loading. Six grades of SFRC consisting of two aspect ratios of 60 and 100, three percentages (0.5, 1, 1.5) of fibres with diameter 0.5mm and length 30 and 50mm were used. The study conducted in three phases. A brief review is described as follows :

In phase I of the study, 72 SFRC cylinder specimens having 150mm diameter and 300mm height were tested to investigate the behaviour under cyclic compressive loading. Three types of tests were conducted for each grade of SFRC: (i) Monotonic tests where load was increased to failure; (ii) Repeated loading – unloading in which the peak of each loading cycle approximately coincided with the monotonic curve. The stress-strain hysteresis obtained in this test possessed a locus of common points, which is a point of intersection of reloading curve with the previous unloading curve; (iii) Tests consisting repeated loading-unloading in which the repeated load was applied as in the second type of test except that in each cycle, loading and unloading were repeated several times, each time the load was released when the reloading curve intersects the initial unloading curve. This point of intersection gradually descended and stabilised at a lower bound point. Such lower bound points are termed as stability points and the further cycling led to the formation of a closed hysteresis loop.

A single general mathematical expression is proposed for the envelope stress-strain curve, the locus of common points and the locus of stability points for all six grades of SFRC. It was observed that the addition of fibres has little effect (5 to 7 percent) on the compressive strength of concrete but the ductility of concrete increases significantly. The stability point curve may be used to define the permissible stress level, when reduction in strength due to effect of repeated loading has to be considered. The maximum permissible stress obtained in this investigation is based on maximum permissible plastic deformation capacity.

The energy dissipation characteristics of SFRC cylinders under cyclic compressive loading were determined. The stress-strain hysteresis obtained by performing cyclic loading was used to study the energy dissipation capacity of SFRC. The relation between energy dissipation ratio and plastic strain in the material was used to identify the point in the load history at which the process of strength deterioration begins. The stress at this stage is close in value to the peak stress of the stability point curve.

A mathematical model is proposed to obtain the stress-strain reloading and unloading curves for SFRC cylinders under cyclic compressive loading. Both reloading and unloading curves were found to depend on the plastic strain.

In phase II of the study, 54 SFRC cylinder specimens having 150mm diameter and 300mm height were tested to investigate its behaviour under repeated uniaxial compressive loading between three minimum stress and various maximum stress levels, until the strains accumulated to produce failure. The fatigue study presented in this investigation was limited to approximately upto 13500 cycles. It was found that the effect of repeated compressive loading can cause reduction in the compressive strength of SFRC as high as 28 percent of the ultimate compressive strength.

Finally in phase III of the study, 72 SFRC beam specimens having a cross section of 100mmx100mm and length of 500mm were tested under cyclic flexural loading. Three types of tests as done in phase I of the study were conducted. The envelope, common point and stability point load deflection curves were established for SFRC beams. The energy dissipation characteristics of SFRC beams were also determined. The relation between energy dissipation ratio and plastic deflection was used to identify the point in the load history at which process of strength deterioration begins.

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