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STUDY OF CONFINED REINFORCED CONCRETE BEAMS UNDER FLEXURAL LOADING

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ABSTRACT

In this paper a study on improvement of the ductility of the conctre is presented. The ductility of the concrete is generally improved by providing steel or any other suitable fibers or by providing stirrups and such a concrete is called as confined concrete. The spacing limitations of stirrups limit the confinement in regular reinforced concrete beams. In the present study an attempt has been made by addition of steel fibers in critical zones in the beam section. Over dosage of fibers in concrete leads to segregation or balling effect. To overcome this difficulty along with fibers a wire mesh is used in the flexure zone of beams. The size of the beam is 2000mmx120mmx200mm.Test results show that, confinement of concrete with the combination of wire mesh and steel fibers improves the cracking, ultimate loads and stiffness of the beam as well as the ductility of the composite.

Keywords: Beam, Ductility, Flexure, Steel Fibers and Wire Mesh

1.0 Introduction

The development of high strength concrete has been taken place in the last thirty years or so. Due to industrial demand the development of high strength concrete have improved rapidly because the industrial demand of new features in concrete members with serious advantages such as increased capacity and stiffness. The benefit of increased compressive strength is to lower volumes and produce smaller designs in terms of design prospective, thus allowing its immediate application into design. The brittle nature of high strength concrete is a major obstacle in its widespread use, as any benefits in terms of reduced member size are negated by the need for increased factor of safety to prevent brittle failure. The confining reinforcement increases ductility and compressive strength of concrete under compression by resisting lateral expansion due to Poisson’s effect upon loading. The behaviour of confined concrete depends on the effectiveness of the confinement. There is no confining effect after loading, until a particular lateral stress due to Poisson’s effect is reached and then the confinement commences. Confinement does not increase strength or ductility initially, but when the axial stress is about 60% of the maximum cylinder strength, the concrete is effectively confined .Under loading, the micro cracks present in concrete propagate and open up, and owing to the effect of stress concentration and also additional cracks is the main cause of inelastic deformations of concrete. It has been recognized that the addition of small, closely spaced and uniformly dispersed fibers to concrete would act as crack arrester and would substantially improve its static and dynamic properties. This type of concrete is known as Fiber Reinforced Concrete. Some of the fibers that can be used are Steel fibers, Glass fibers, Recron3s, nylons, coir glass and carbon. Each type of fiber has its characteristic properties and limitations. Fiber reinforced concrete is composite obtained by a single type (steel or glass fiber) or a blend (steel+ glass fibers) of fibers to the concrete mix. Steel fibers are in used reinforced concrete adding mechanical properties that can be used for structural design purpose.

2.0 Literature Review

Bentur.A [1] reported on the treatment of alkali resistant glass fibers with silica fume and show the effectiveness in improving durability performance of alkali resistant glass fiber reinforced cement composites (GFRC). Jyoti Narwal. et al [4] thirteen specimens of series (SV1, SVF1, SVF2 and SVF3) with different aspect ratio of fibres were tested. Finally, thirteen specimens of series (SV1, SVF1, SVF2 and SVF3) with volume fractions of 0.5%, 1.0%, 1.5% and 2% steel fibres were cast and tested. The results obtained from the investigation indicated that addition of steel fibres in the concrete mix improved structural performance of beam measured in terms of ultimate load carrying capacity, stiffness, crack width, deflection. Li.V.C., Backer, etal[5]; presented the some of the improvements in toughness and ductility of normal and high strength concrete due to synthetic fiber reinforcement. Examples of improvements in the ultimate shear strength of longitudinally reinforced beams without shear stirrups and the flexural strength and energy capacity of un-reinforced beams, which are a direct result of synthetic fiber reinforcement, are mentioned. Rao. T.C. et al [6, 7, 8]; investigated on the behavioural aspects of solid and voided plate and channel beam elements under shear and flexural loading. From the test results it is observed that the intentionally created voids (to reduce self weight) shown their influence on pre-cracking stage than post-cracking stage. A good agreement has been achieved between the test results and proposed empirical equations.

3.0 Experimental Investigation

3.1 Materials

Cement: 53-grade conforming to IS 12269

Fine Aggregate: River sand passing through 2.36mm sieve is used

Coarse Aggregate: Passing through 20mm sieve and retained on 12.5mm sieve is used

Fibers: Steel fibers with aspect ratio 50

Wire mesh: 22 gauge hexagonal wire mesh

Tensile Reinforcement: 20mm diameter

Hanger bars: 6mm diameter

Mineral admixture: Silica fume

Super plasticizer: CONPLAST SP430.

The experimental work is composed of casting and testing of (3 series i.e HB, HBSF-1 and HBSF) 6 under reinforced beams of size 2000mm x120mm x200mm. For this, wooden moulds of required shape and size are prepared. As main reinforcement, 2-12mm diameter bars are provided in the tension zone, 6mm diameter bars are used as hanger bars and also for vertical stirrups as shear reinforcement. The stirrups are provided at a spacing of 300mmc/c. The six beams are divided into three series, as HB, HBSF-1and HBSF series. The 'HB' series indicates the under reinforced beams cast only with tension reinforcement along with 6mm diameter bars vertical stirrups provided at a spacing of 300mmc/c. The 'HBSF-1' is the second series in which the beams are cast with tension reinforcement, vertical stirrups and also 1% steel fibers are added in the flexure zone(in between the load points). The quantity of steel fibers(1%) by weight of cement are calculated and then added to the concrete mix. This mix is used only in the flexure zone of beam section. The third series is HBSF' series, in which the beams are cast with steel fibers and G.I wire mesh. One layer of G.I.hexagonal wire mesh is wrapped around the reinforcement section in the flexure zone to provide lateral confinement to the concrete in addition to vertical stirrups. The mix proportion adopted in this work is 1: 1.472: 3.043 with water cement ratio 0.33. Compressive strength and split tensile strength of concrete is found to be 56.6Mpa and 5Mpa respectively. The beams are tested on universal testing machine of 40Ton capacity. The load is transferred as two

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point symmetrical load through a rigid steel girder as shown in fig (1) with flexure span of 400mm. The span of the beam (between the supports) is 1800mm.

4.0 Test Results and Discussions

In the test programme, all the beams cast as under reinforced sections. The term under reinforced means that the unconfined reinforced concrete sections is designed to fail in tension only. The behaviour of control beams is similar to the behaviour of fibrous confined reinforced concrete beams up to 65 to 70 percent of the ultimate load of corresponding confined fiber reinforced concrete beams.

The visible cracks developed approximately at 60 to 70 percent of ultimate load of each beam. The first flexural crack formed outside the fiber zone. The visible cracks propagated into the compression zone slowly, indicating the upward movement of the neutral axis towards the compression zone. The crack pattern along the length of the beam indicates that, the presence of fibers with higher specific surface factor arrested the propagation of cracks. The strain distribution along the depth of the units was linear up to the cracking load in all the members i.e., (control, steel fibrous and confined steel fiber reinforced concrete beams).

4.1 Behaviour Under Flexural Loading

The salient features of the test results were shown in the table 1. The strain distribution along the depth of the units is linear up to the cracking load in all the members(i.e., control beams and fibrous confined reinforced concrete beams).the load deflection curves of the all specimens have indicated linear behaviour up to about cracking load. After the cracking, the load deflection curves deviated from linearity and become non-linear, as the applied approaches to ultimate load, several new cracks were formed at finite spacing. The specimen is then maintained approximately, the same load level with the increasing deflection. But the cracks continued to penetrate deep into the top layers of specimens. At this stage no crushing of the concrete was observed on the compression zone. Further increase in deflection is associated with a drop in the applied load.

The typical crack patterns of the specimens at ultimate load are shown in fig.2.The crack width at this cracking stage is very less due to the presence of fibers and confinement with the mesh reinforcement. The improvement in flexural strength at ultimate stage is due to the fact that the mesh wires participate in the load sharing better in the post cracking stage rather than in the pre cracking stage.

4.2 Load Deflection Response

Load-Deflection response of the tested fibrous confined reinforced concrete beams presented in Fig 3& 4. From these figures it is clear that the deflections of fibrous confined reinforced concrete beams are less compared to the deflection of control beams at the same load level. The reason for this behaviour may be due to the active participation of the reinforcement in the post cracking stage of the beam. The improvement in cracking load is of about 42% in fibrous confined reinforced concrete beams compared to control beams. This is due to presence of fibers in flexure zone. Similarly the improvement in the ultimate load is of about 24% in fibrous confined reinforced concrete beams compared to control beams. Cracking load of the members is taken as the load corresponding to the visible crack formed in the member. Crack width of around 0.50mm is noticed at the ultimate load level of the fibrous confined reinforced concrete beams whereas crack width of around 1.1mm is noticed at the ultimate load level of the control beams.

5.0 Conclusions

1. The provision of confinement by means of steel fibers and wire mesh wrapping in the flexure zone of RC beam improves the flexural strength and stiffness.
2. Reinforcing the concrete beams(HBSF-1) with steel fibers in the flexure zone alone improves cracking and ultimate load about 20% & 9% respectively compared to control beams (HB).
3. The improvement of cracking and ultimate loads in confined with steel fibres and wires mesh reinforced concrete beams(HBSF) is of about 43% & 24% and 19%and 13% respectively compared to control(HB) and steel fibrous reinforced concrete beams(HBSF-1).

6.0 References

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