Study of Behaviour of Beams Cast With High Performance Fibre Reinforced Concrete Using Steel And Glass Fibres

Mr. Toshant P. Kapse[1], Asst. Prof. Mrs. Pallavi N. Velhal[2]
Department of Civil Engineering
[1, 2] K.J College of Engineering and Management Research,Pune, Maharashtra, India.

Abstract-*This paper present the results of an experimental study of behavior of beam cast with high performance fibre reinforced concrete. The deflection and cracking behavior of concrete structure depend on the flexural tensile strength of concrete. This paper aimed to evaluate the behavior and strength of high performance fibre reinforced concrete beam. This experimental program consist of compressive strength test, spilt tensile strength test, flexural strength test and mode of failure of beam on high performance fibre reinforced concrete. Two types of fibres were used including steel fibres and glass fibres, steel crimped fibre of length 50mm with aspect ratio 100 and glass fibre of 0.2mm diameter and 12mm length with aspect ratio 60. The studied included 0.75% steel fibre, 0.5% glass fibre by the volume of concrete. The confining fibres increases ductility and large deflection in structures provide a good warning of failure prior to complete failure of the flexure member. The behavior of tested beams was investigated with special attention to the cracking pattern and width of cracking, it is observed that due to use of fibres numbers of cracks increases, which led to the reduced width of cracks.*

Keywords*-*Aspect ratio, Shear cracks, Shear Strength, Fibre reinforced concrete, Water absorption, Specific gravity.

I. INTRODUCTION

The low tensile strength and high brittleness of high-strength concrete can be improved by adding fiber into the concrete. There are several types of fibers that can be used to improve the properties of concrete. The demand of efficiency is a dominant consideration in the application of high strength-concrete. In terms of price and high quality control, the cost in producing of high strength concrete is indeed expensive, but, in terms of increased strength, structural dimension saving, and reinforcement saving will make high-strength concrete more efficient. Plain concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. Internal micro cracks are inherently present in the concrete and its poor tensile strength is due to the propagation of such micro cracks, eventually leading to brittle fracture of the concrete. In the past, attempts have been made to impart improvement in tensile properties of concrete members by way of using conventional reinforced steel bars and also by applying restraining technique. Although both this methods provide tensile strength to the concrete members, they however, do not increase the inherent tensile strength of concrete itself.

In plain concrete and similar brittle material, structural cracks (micro-cracks) develop even before loading, particularly due to drying shrinkage or other causes of volume change. The width of this initial cracks seldom exceeds a few micron, but their two dimensions may be of higher magnitude.

When loaded, the micro cracks propagate and open up, and owing to the effects of stress concentration, additional cracks form in place of minor defects. The structural cracks proceed slowly or by tiny jumps because they are retarded by various obstacles, changes of direction in bypassing the more resistant gain in matrix. The development of such micro cracks is the main cause of inelastic deformations in concrete. It has been recognized that the addition of small, closely spaced and uniformly dispersed fibres to concrete would act as crack arrester and would substantially improve its static and dynamic properties. This type of concrete is known as Fibre reinforced concrete. Fibre reinforced concrete can be defined as a composite material consisting of mixtures of cement, mortar or concrete and discontinuous discrete, uniformly dispersed suitable fibres. Continuous meshes, woven fabrics and long wires or rods are not considered to be discrete fibres [1-4].

The primary purpose of inclusion of fibers in conventionally R.C. members is not for increasing strength. The strength can be increased more easily and economically by using steel bars placed along the direction of principal tensile stresses. The deficiencies of ordinary R.C. in the form of micro-cracks, which cannot be corrected by bar reinforcement, can be remedied to a significant extent by using fiber reinforcement. Addition of randomly oriented fibers in plain concrete mixes help to bridge and arrest the cracks formed in the brittle concrete under applied stresses, and enhances the ductility and energy absorption properties of the composite [2].

II. OBJECT OF STUDY

The main objective of this research is to study the behaviour of beam using fibre reinforced concrete on the shear behaviour of R.C. beams.This experimental program was carried out in the present work to investigate the strength of concrete taking into consideration the level of compressive strength of concrete, spitting tensile strength concrete, beam mode of failure and its cracking pattern.

III. MATERIALS

Cement and aggregates

Ordinary Portland cement with specific 3.15 was used. The initial and final setting time were found as 140 min and 255 min respectively. Grade 1 loose fly ash was use with specific gravity 2.2. Fine aggregate used is zone 1 crush sand with fineness modulus, specific gravity and water absorption were found as 3.5, 2.66 and 2.5% respectively. Crushed Basalt of nominal size of 10 mm and 20 mm was used as coarse aggregate. The specific gravity of 10 mm and 20 mm coarse aggregate is found to be 2.92 and 2.95 respectively. The coarse aggregates have water absorption of 1.01% in SSD condition.

Admixture

High range water reducing super plasticizer is used to obtain constant slump of 140 mm for concrete mix, 1% admixture is used by the mass of cement for concrete production.

Steel and glass fibre

Crimped steel fibres shown in Fig. 1, of length 50 mm of equivalent diameter 0.5 mm leading to an aspect ratio of 100 and the glass fibres shown in Fig.2, of length 12 mm was use. The young's modulus of steel fibres was found to be 2×105 MPa. The density of steel fibre was found to be 78500 N/m3.

Fig. 1. Crimped steel fibres

Fig. 2. Glass fibers

Mix proportion

Mix design shown in Table I, was done as per IS 10262. The super plasticizer dosage was adopted as 1% by mass of cementitious material.

Table I Mix Proportion M40

Material	Design Material Quantity
Cement	390 kg
Fly ash	40 kg
Coarse aggregate: 10 mm	400 kg
Coarse aggregate: 20 mm	777 kg
Fine aggregate	769 kg
Water	163.4 kg
Admixture	4.3

IV. EXPERIMENTAL PROCEDURE AND RESULTS

An experimental program including the testing of 150 mm cube at 7 days and 28 days to obtain the compressive strength of concrete. Cylindrical specimen were tested at 7 days and 28 days to obtain the spilt tensile strength of concrete. Beam specimen were tested at 28 days to obtain flexural strength, beam deflection and cracking pattern of beam.

Compressive strength test

The following results shows by adding .075% crimped steel fibre to the concrete the compressive strength of concrete increases by 4.8% at 28 days, while by using 0.5% glass fibre the compressive strength is increase by 10.33% at 28 days. Results shows that by using accelerating admixture to the concrete the compressive strength of concrete at early age that is at 7 days is significantly increases.

Concrete cube tested on compressive testing machine of capacity 2000 KN the speed of loading was 5.2 MPa/Sec.

Splitting tensile test

By adding 0.75% crimped steel fibre to the concrete the splitting tensile strength of concrete increases by 8.17% at 28 days, while by using 0.5% glass fibre the splitting tensile strength is increase by 10.53% at 28 days.

Cylinder specimen tested on compressive testing machine of capacity 2000 KN.

Analysis of Beam Specimen

To achieve the main aim of the current study, an experimental program including nine beams of size (150 x 150 x 700 mm) reinforced with two bars of 10 mm diameter at bottom and nominal bar of 8 mm diameter at top, stirrups provided at 150 mm spacing center to center. The rebars has a yield stress of 550 MPa. In this paper cracking pattern and mode of failure is discussed.

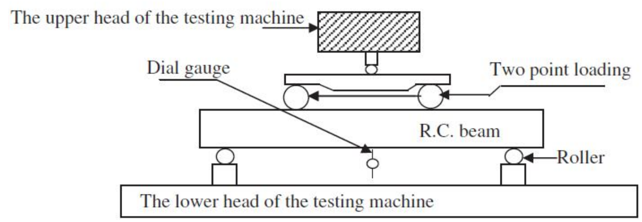

Fig 5 Test set-up and instrumentation

Fig. 6. Test set-up of the tested beam

Cracks pattern and failure mode for all tested beams with and without fibres are shown in Fig. 8, all beams failed in shear failure. The failure of tested beams without fibres (B1NF) showed a brittle failure mode compared to specimen with glass fibre (B2GF) and steel fibre (B3SF). Moreover, steel fibre showed more brittleness as compared to glass fibre. The cracks pattern for all the beams at failure were almost the same. In shear zone of beam one or two major cracks together with some secondary cracks formed. The major cracks propagated from the support to the point of loading. The cracks patterns of the beam with glass fibre were characterized closer and thinner cracks as compared to steel fibre and without fibre beams. The beams with steel fibre were smaller cracks as compared to without fibre beam.

Fig. 7. The crack pattern and failure modes of the tested specimen

V. CONCLUSIONS

The study presents the results of an experimental investigation on fibre reinforced concrete and behaviour of beam using steel and glass fibre. The following main conclusions can be drawn.

- The steel fibre reinforced concrete with crimped steel fibre of 50mm length with aspect ratio 100 increased compressive strength by 4.8% and splitting tensile strength by 8.17% as compared to plain concrete (reference mix).
- The glass fibre reinforced concrete with glass fibre of 12mm length with aspect ratio 60 increased compressive strength by 10.33% and splitting tensile strength by 10.53% as compared to plain concrete (reference mix).
- By using glass fibre the failure mode becomes more ductile as compared to without fibre mix concrete.
- The failure mode becomes more ductile by using fibre reinforced concrete than without fibre concrete.
- In fibre reinforced concrete beam the number of the observed cracks increased and its width decreased as compared to without fibre concrete mix.
- The application of the used Glass and Steel fibers, which is the environment waste, could contribute to the preservation of environment.

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