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Experimental Study of Shear Strength and Behavior of RC Deep Beams after Replacement of Shear Reinforcement by 0.2% Steel and 0.1% Polypropylene Fibers

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Abstract: *Concrete is acknowledged to be a relatively brittle material when subjected to normal stresses and impact loads, where tensile strength is only approximately one tenth of its compressive strength. As a result for these characteristics, concrete member could not support such loads and stresses that usually take place, majority on concrete beams and slabs. Historically, concrete member reinforced with continuous reinforcing bars to withstand tensile stresses and compensate for the lack of ductility and strength. Furthermore, steel reinforcement adopted to overcome high potentially tensile stresses and shear stresses at critical location in concrete member. Fibrous concrete can be mixed by vibration, whirling, press moulding, dehydration, press moulding with dehydration and densification in a magnetic field shear is generally brittle in nature in contrast to the ductile behavior and progressive flexural failure with large number of cracks observed in normal beams. The stresses in isotropic homogeneous deep beams before cracking can be determined using finite element analysis or image elastic model studies. It is found that the smaller the span/depth ratio (i.e. less than 2.5), the more pronounced the deviation of the stress pattern from that of Bernoulli and Navier.*

Keywords: Energy management system**,** Active power filters (APF), Power Quality (PQ), distributed system

I. INTRODUCTION

Beams with large depths in relation to spans are called Deep Beams. In IS 456(2000) Cl.29, a simply supported beam is defined as deep when the ratio of its effective span L to overall depth D is less than 2. Continuous beams are considered as deep when the ratio of L/D is less than 2.5. The effective span is defined as the Centre-to-Centre distance between the supports or 1.15 times the clear span whichever is less.

The behavior of deep beams is significantly different from that of beams of more normal proportions, requiring special consideration in analysis, design and detailing of reinforcement. Because of their proportions, they are likely to have strength controlled by shear.

II. TYPES OF DEEP BEAMS

Deep beams may be classified to be of the following types:

2.1 Simply Supported

A deep beam is simply supported when it is supported at its ends such that translational displacement is not possible, but rotation is possible.

2.2 Continuous Beam

Continuous deep beam, which is supported at several support along the length of beam. (Figure 1.2)

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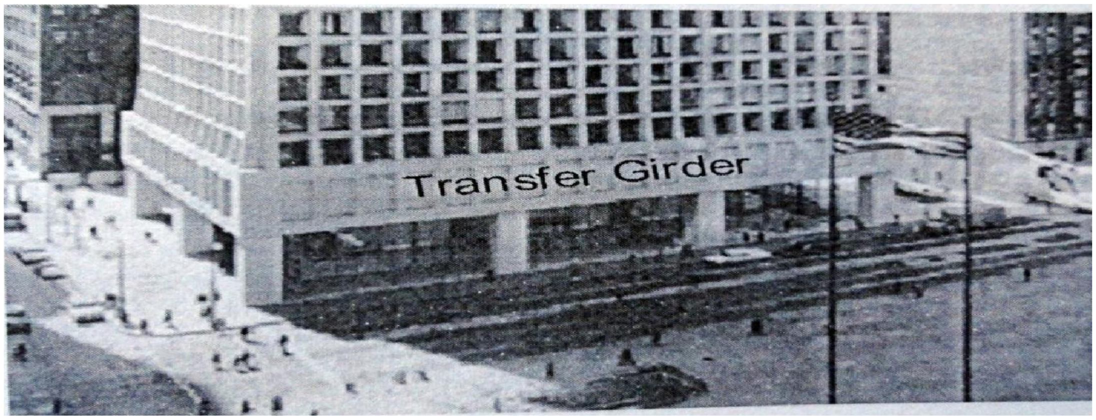

Figure 1.2: Deep beam, Brunswick Building, Chicago: picture courtesy of (Columbia.edu)

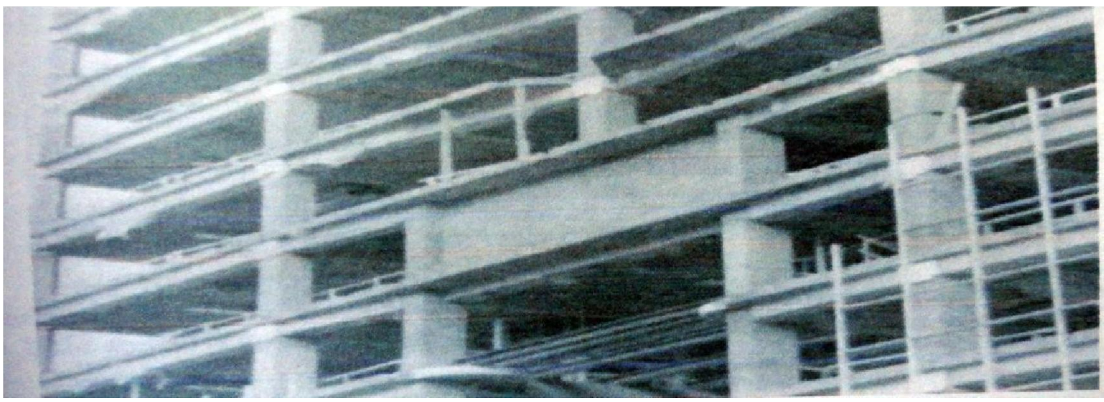

Figure 1.3: Single Span Deep beam: picture courtesy of (MacGregor & Wight, 2005)

2.3 Applications of Deep Beam

Deep beam has its useful applications in following cases:

- Water tanks (side walls): R.C.C side walls of water tank may act as deep beams.
- Pile Caps: Pile caps can also act as deep beams in case of smaller spans.
- Raft Foundations: Raft foundation may contain deep beams in some cases.
- Bunkers & Silos: Beams of these structures may act as deep beam.
- Shear Walls: R.C.C shear walls may act as deep beam.

2.4 Objectives

The main objective of this investigation is to conduct an experimental study on strength & behavior of deep beams. The detailed analysis has been carried out using the finite strip method. The study also aimed at testing validity and usefulness of IS 456-2000.

The objectives of the experimental investigation can be listed as follows:

1. To observe and explain the deflection, cracking and failure modes of fibre reinforced deep beams subjected to two points loading.
2. To check whether 0.5% steel fibre is sufficient for complete replacement of conventional shear reinforcement in R.C. deep beams.

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III. REVIEW OF LITERATURE

A.K. Sachan, C.V.S. Kameswara Rao studied *"behavior of fibre reinforced concrete deep beams"*. This paper describes an experimental investigation to study the strength and behavior of steel fibre reinforced concrete deep beams. In total 14 beams were tested. The effects of fibre content, percentage reinforcement and type of loading were studied. The ultimate load-carrying capacities, mode of failure and load-deflection behavior are reported. A simple model is proposed to predict the load-carrying capacity of the beams.

T.M. Roberts, N.L. Ho studied *"shear failure of deep fibre reinforced concrete beams"*. The results of a number of tests on deep fibre reinforced concrete beams are presented. The beams contained conventional tensile steel reinforcement but different percentages of steel fibre in place of conventional shear reinforcement. All beams were simply supported and loaded to failure by a central load distributed through two bearing plates. The results confirm that steel fibres can prevent shear failure in deep beams, and indicate the various modes of fibre of deep beams.

IV. METHODOLOGY

This chapter demonstrate the detailed experimental program of this investigation .It includes materials and fibres used detailed methodology of experimental program, mix proportions specimen details, reinforcement detailing and test set up. In this experimental investigation, the physical properties such as aspect ratio, specific gravity, water absorption, density and ultimate strength are studied.

4.1 Fibre

Diameter of fibre was measured and it was 0.6 mm. The specific gravity was determined based on the method specified in IS: 2386 (Part III). Five gram of fibre samples was accurately weighed in an electronic balance of accuracy 0.001 gm.

Table: Properties of Fibres

Properties of Fibres	Values
Length	50mm
Diameter /Equivalent Diameter (mm)	1mm
Aspect Ratio	50
Specific gravity	7.85
Water Absorption (%)	0.0
Density in Kg/m^3	7850

Preparation of Reinforcement Mesh

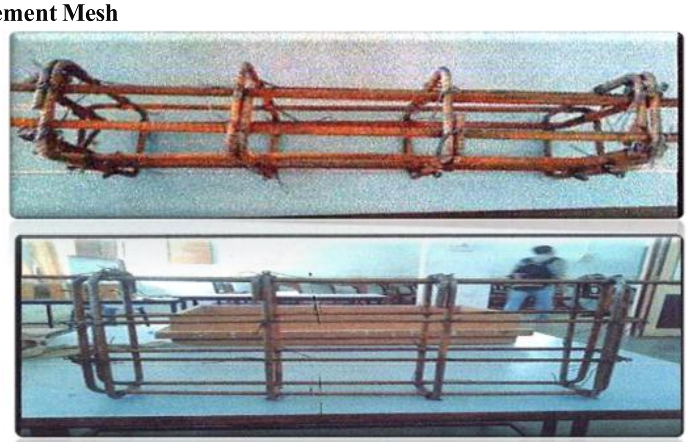

Fig-1.4. Preparation of Reinforcement Mesh

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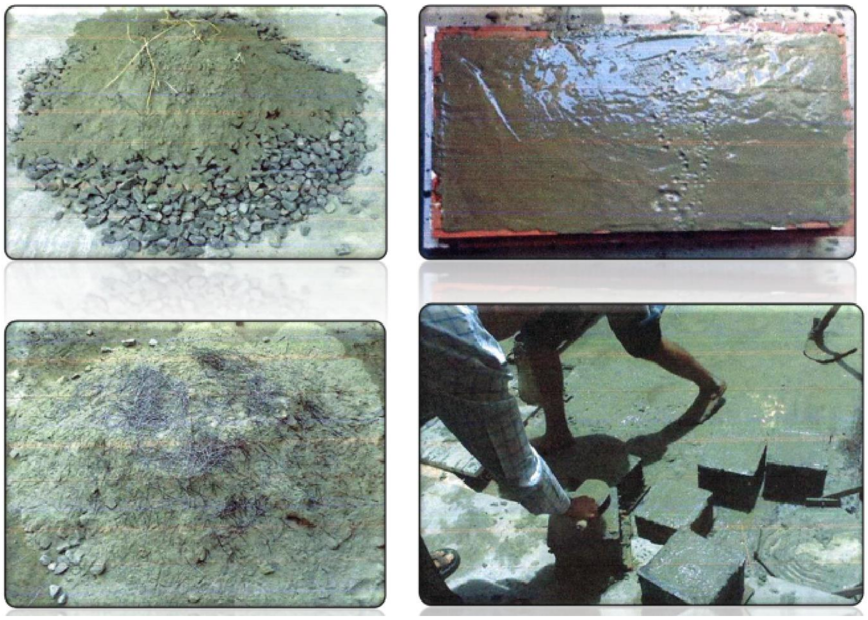

Fig 1.5 Casting Work

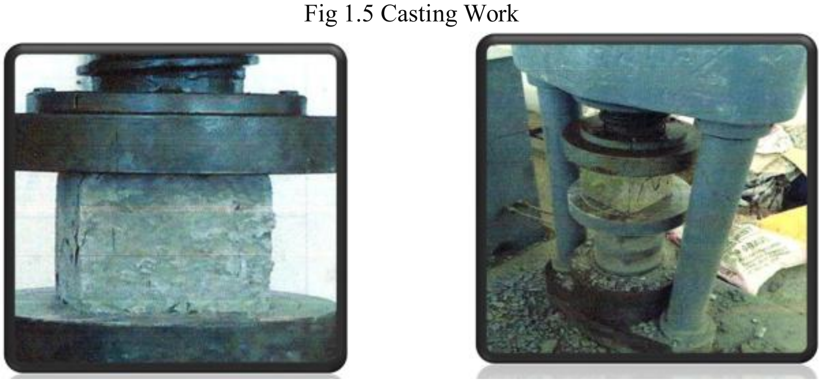

Fig 1.6 Testing of Cubes

V. RESULTS AND DISCUSSIONS

Cubes with Fibre

Sr. No.	No. of Days Cured	Dimension	Load (Tonnes)	Strength (N/mm^2)	Average Strength (N/mm^2)
1	28	151x150x155	103	45.474	**43.35**
2	28	156x152x151	110	47.296	
3	28	152x150x154	85	37.28	

Cubes without Fibre

Sr. No.	No. of Days Cured	Dimension	Load (Tonnes)	Strength (N/mm^2)	Average Strength (N/mm^2)
1	28	150x151x152.5	53	23.39	24.69
2	28	152.5x152x154	51	22	
3	28	152.1x151x150	65	28.697	

VI. SUMMARY

From the study carried out on RC Deep beams it has been clearly seen deep beams with fibre can be a resist shear as well as cracking and deflection. Load carrying capacity also gets increased as we move towards the fibre reinforced deep beams.

VII. CONCLUSION

1. All the tested deep beams has significantly low deflection at failure, failure was due to the diagonal cracking of deep beam, it implies that failure is due to shear rather than flexural deflection.
2. Due to high tensile strength of hook end steel fibre, initial cracks were developed after sufficient interval of time. Initial crack on conventionally designed deep beam was appeared at 163.33 kN load, whereas initial crack on deep beam with 50% shear reinforcement and 0.5% steel fibre appeared at 216.67 kN (32.66% more than that for conventional deep beam), deep beam with 0% shear reinforcement and 0.5% steel fibre 213.33 kN (30.61% more than that for conventional deep beam). It implies that due to addition of 0.5% hook end steel fibre, better interlocking between fibre and concrete, so deep beam sustain more initial load. Hook end steel fibre increase ductility of deep beam.
3. In type II deep beam, By adding hook end steel fibre to the extent of 0.5%, complete shear reinforcement can be replaced without compromising its strength. Which in turn facilitate in good compaction of concrete.
4. In type II deep beam, Conventional shear reinforcement can be replaced totally by providing hook end steel fibres.
5. If the fibre is 0.5% the flexural strength is found to increase nominally by average of 16.50%.
6. In type II deep beam, Complete replacement of shear reinforcement is achieved by adding 0.5% steel fibre, cost increase by 31% due to that strength increases by 16.50%.

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