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Comparison of Flexural Behaviour ECC & SFRCC

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Abstract

Engineered Cementitious Composite (ECC) is high performance fibre reinforced cementitious composite, which has high ductility and is also known as bendable concrete as it has a strain capacity in the range of 3–7% compared to 0.01% for ordinary concrete. It's mainly due to presence fibres called Poly Vinyl Alcohol (PVA) fibres and absence of coarse aggregates. ECC also incorporates fly ash in order to reduce cement content. Cost of ECC is high as PVA fibre is bit pricey. And also specially designed PVA fibre used in ECC is not available in India. Both factors calls for a study replacing PVA fibre with another cheaper and commonly used fibre, i.e., steel fibre. This paper aims to study the flexural behaviour of ECC and also the use of Steel fibre, instead of PVA fibre in ECC, in same mix to form Steel Fibre Reinforced Cementitious Concrete (SFRCC), which can be used instead of ECC. Both are called a cementitious composite, rather than concrete, as coarse aggregate is absent in it.

Keywords: Engineered Cementitious Composite (ECC), Bendable Concrete, Steel Fibre Reinforced Cementitious Concrete (SFRCC).

Introduction

The idea of using discrete fibres to reinforce brittle materials in construction is very old. The development of Fibre Reinforced Concrete (FRC) is to offset the problems associated with plain concrete such as very low tensile strength, low ductility and little resistance to drying shrinkage cracking and even improve the ductility. Engineered Cementitious Composite is high performance fibre reinforced cementitious composites. ECC has a strain capacity of more than 3 percent and thus acts more like a ductile metal than a brittle glass like conventional concrete and so is also called bendable concrete. Unlike traditional FRC, ECC doesn't contain coarse aggregates; so is called cementitious composite rather than concrete. It incorporates fly ash and is reinforced with micromechanically designed polymer fibre, Poly-Vinyl Alcohol (PVA) fibres; with fibre volume fraction no greater than 2%. Coarse aggregates are not used, since it affects the property of ECC, which is formation of micro cracks with large deflection. Higher cost & low availability of PVA fibre in India calls for need of use cheaper & easily available steel fibre instead of PVA. Flexural Behaviour of ECC and Steel Fibre Reinforced Cementitious Composite (SFRCC) is explained in this paper.

Methodology

In the present research, experimental investigations were conducted for assessing the flexural strength of cementitious composites provided with PVA fibre & Steel fibre to form ECC & SFRCC respectively. Type of PVA fibre used was PVA REC15. (Fig. 1) Its diameter is 0.040mm & length is 8mm and has a minimum tensile strength of 1100 MPa. Mild steel hooked end fibre was used in SFRCC. (Fig. 2) Its diameter is 0.7mm & length 35mm with tensile strength of 1110 MPa. 53 grade OPC Cement & Class F fly ash was used. M-Sand was used as fine aggregate. Super-plasticiser named conflo

LN was used to improve workability. A mix ratio of Cement: Fly Ash: Sand=1:0.8:1.2 was used, with water by binder (cement + fly ash) ratio=0.33 and super-plasticiser by binder ratio=0.6%; taken after literature survey. Fibre volume fraction was also kept constant at 2% for both. (Explained in table 1) Totally 6 beam specimens, 3 each of ECC & SFRCC, of size 500 x 100 x 100 mm were used for the research. The mix was prepared and evenly filled in the moulds. The beams were then tested under two point loading test after 28 days water curing. (Fig 4)

Fig. 1 PVA REC 15 Fibre

Fig. 2 Mild Steel Hooked End Fibre

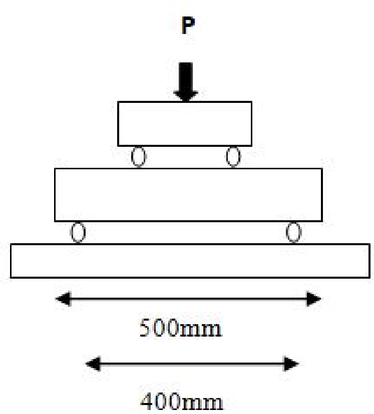

Fig. 3 Schematic Setup for Testing

Fig. 4 Experimental Setup for Testing

Table 1 Mix Ratio

Material	**Cement**	**Fly Ash**	**Sand**	**Water** [w/(c+fa)]	**PVA Fibre**	**Steel Fibre**
Weight (kg/m³)	690.1	552.1	828.1	409.93	26	157
Ratio	1	0.8	1.2	0.33	2%	2%

Results

Both beams showed flexural failure without any collapse. The ultimate loading carrying capacity of ECC beam was obtained as 15 kN and the ultimate load carrying capacity of SFRCC beam was obtained as 19 kN. Crack width was more visible for SFRCC beams compared to ECC beams, indicating that SFRCC had higher crack width and crack propagation than ECC.

Discussion

SFRCC beams showed much higher load carrying capacity when compared to ECC beams. Flexural strength for ECC beams and SFRCC beams was found to be 7.5 N/mm^2 and 9.5 N/mm^2 respectively. i.e, Flexural strength of SFRCC is 1.3 times that of ECC. But, it should be noted that, mass of Steel fibre in SFRCC is 6 times that of PVA in ECC.

Crack width and crack propagation was higher for SFRCC compared to ECC beams. It means that PVA fibre have more crack arresting property than Steel fibre. Absence of coarse aggregate inhibited sudden collapse at failure in both types of beams.

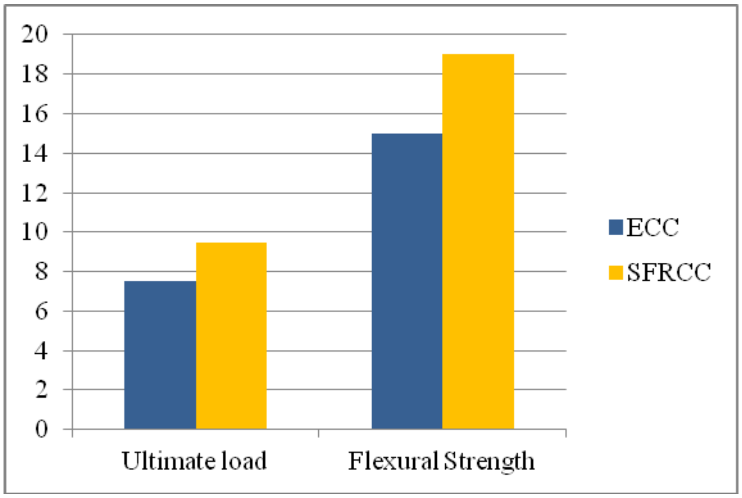

Fig. 5 Ultimate Load and Flexural Strength

Conclusions

The research work included the testing of ECC & SFRCC beams, each having a span of 500 mm. Flexural strength comparisons between ECC beam and SFRCC beams casted for the present investigation is illustrated as follows:

a) SFRCC beams showed much higher load carrying capacity than ECC beams. i.e., SFRCC had higher flexural strength than ECC.

b) Ultimate load and flexural strength of SFRCC is 30 % higher than ECC

c) Mass of Steel fibre in SFRCC is 6 times that of PVA in ECC, due to the fact that, steel fibre has more density than PVA fibre. So in a way, ECC is still more advantageous than SFRCC.

d) ECC may seem costlier than SFRCC due to high cost of PVA fibre, but as PVA fibre mass is very much lower than Steel fibre, total cost of both are almost equal.

So, further investigations are required by taking same amount of PVA & steel fibre, by taking it as a percentage by volume of composite. And also for varying Cement to Fly Ash to Sand ratio and varying water & plasticiser ratios.

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