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Use of Precast SIFCON Laminates for Strengthening of RC Beam

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ABSTRACT: Slurry infiltrated fibrous concrete (SIFCON) is a novel type of high performance fibre reinforced concrete made by infiltrating steel fibre bed with a specially designed cement based slurry. Laboratory experiments have shown that SIFCON is an innovative construction material possessing both high strength and large ductility. In the present study, the use of SIFCON will be investigated as an externally bonded strengthening material on reinforced concrete beams The experimental programme will be carried out to study the behaviour of flexural RC beams with precast SIFCON laminates. A total number of fifteen specimens of size 150mm x 300mm x1800mm to be cast and tested under a two point loading system to study the load deformation behaviour and ductility associated parameters. The concrete beams will be designed to obtain a concrete grade of M20.For laminates the fibre volume fraction 10% and 12% to be taken. The steel fibres used in the study will be hooked end steel fibres having 0.6mm diameter and aspect ratio of 50. Previous results indicate that the strengthening of RC beams with SIFCON laminates has significantly improved the cracking behaviour in terms of significant increase in first crack load and the formation of larger number of finer cracks. The stiffness, ductility and energy absorption are found to be increased to a great extent when the beams are strengthened by three face confinement (bottom& side faces).

KEYWORDS:SIFCON Laminates, Aspect Ratio, strengthening, Fibre, Deflection.

I. INTRODUCTION

Reinforced concrete structures often have to face modification and improvement of their performance during their service life. The main contributing factors are change in their use, new design standards, deterioration due to corrosion in the steel caused by exposure to an aggressive environment and accident events such as earthquakes. In such circumstances there are two possible solutions; replacement or strengthening and sometimes strengthening is the only option available and favoured, notably for historical structures were new construction option is not available and in some most crowded cities where very old habitable structures are considered for re-strengthening due to its historical value and strict governmental new developmental rules. Full structure replacement might have determinate disadvantages such as high costs for material and labor, a stronger environmental impact and inconvenience due to interruption of the function of the structure e.g. traffic problems.

SIFCON is a high-strength, high-performance material containing a relatively high volume percentage of steel fibres as compared to steel fibre reinforced concrete (SFRC). It is also sometimes termed as „high - volume fibrous concrete". The origin of SIFCON dates to 1979, when Prof. Lankard carried out extensive experiments in his laboratory in Columbus, Ohio, USA and proved that, if the percentage of steel fibres in a cement matrix could be increased substantially, then a material of very high strength could be obtained. While in conventional SFRC, the steel fibre content usually varies from 1 to 3 percent by volume, it varies from 4 to 10 percent in SIFCON depending on the geometry of the fibres and the type of application. The process of making SIFCON is also different, because of its high steel fibre content. While in SFRC, the steel fibres are mixed intimately with the wet or dry mix of concrete, prior to the mix being poured into the forms, SIFCON is made by infiltrating a low-viscosity cement slurry into a bed of steel fibres „pre-packed" in forms/moulds. The matrix in SIFCON has no coarse aggregates, but a high cementitious content. However, it may contain fine or coarse sand and additives such as fly ash, micro silica. The matrix fineness must be designed so as to properly penetrate (infiltrate) the fibre network placed in the moulds.A controlled quantity of high -range water -reducing admixture (super plasticizer) may be used for improving the flowing characteristics of SIFCON. All types of steel fibres, namely, straight hooked, or crimped can be used..

II. LITERATURE / HISTORY

R.Hitha and GopikaMoorthy – Has studied Analysis on strengthening of RC frame by SIFCON laminates using ANSYS. This study deals with the strengthening of RC beams externally bonded SIFCON laminates using ANSYS.After Analysis on ANSYS they concluded that, The Strengthening of the frame by the SIFCON laminates decreases the deflection values. By strengthening, the performance of the weakest structure can be improved and it will protect many lives from sudden failure.

AswathiSisupalan and Dr. Mathews M. Paul - Has Studied Strengthening of RC and FRC beams with Precast SIFCON laminates.This study presents a method for strengthening of reinforced concrete beams and fibre reinforced concrete beams to enhance the actual load carrying capacity using precast SIFCON laminates, which are directly bonded to bottom face and side faces of the beam by epoxy adhesives and are tested under two-point loading test.Based on experimental investigation they concluded that, The optimum percentage of SIFCON was obtained by compression testing. Cubes were casted and tested on different steel fibre volumes of 5% ,7% ,9%, 11%.
The SIFCON samples of 5% steel fibre volume were attained as optimum value. The ultimate load carrying capacity of RC beams with confinement only on bottom face was found to be 14% more than that of conventional RC beams. The ultimate load carrying capacity of beams with three face confinement was found to be 29 % more than that of conventional RC beams.

Safna A.M and Anila S - Has studied Finite element Analysis of RC beams with externally bonded SIFCON and SIMCON laminates using ANSYS. The focus of this study is to determine if a RC beam is strengthened using SIFCON and SIMCON laminates and study the load deformation characteristics of the strengthened beam and compare it with conventional beam. After Analysis on ANSYS software they concluded that, By strengthening of beam using SIFCON and SIMCON, Ultimate load carrying capacity have increased. Beams Strengthened using SIFCON and SIMCON laminates, the ultimate load value is 111.6% and 127.78 % respectively are more than that of the conventional beam.

V.Nandhini and Mrs.K.Selvi – Has studied strengthening factors for RC beams by using Precast SIFCON lamination. In the study the use of SIFCON has been investigated as an externally bonded strengthening material on reinforced concrete beams. The experimental programme has been carried out to study the behavior of flexural RC beams with precast SIFCON laminates.The result indicate that, the strengthening of RC beams with SIFCON laminates has significantly improved the cracking behavior. The stiffness, ductility and energy absorption found are to be increase to a great extent.

D.ChandiraKumar ,J.Soundharajan and M.Sarathkumar - Has studied strengthening of RC beams of SIFCON laminates. This study focuses on Slurry infiltrated fibrous concrete (SIFCON) as an option for strengthening the conventional reinforcement concrete beam. This study has been aimed at characterizing the flexural strength of the beam strengthened with precast SIFCON laminate externally.After the test they concluded that, the ultimate load Carrying capacity of strengthened beam was found to be higher than that of conventional flexural beam. SIFCON Strengthened beam performs well In all aspects compared to conventional beam. hence proves to be an effective material to enhanced the strength and for the repairing or strengthening of RC beams.

J.Sandanshiv, Dr.S.KDubey and Prof. S.S Bachhav - Has studied experimental study on Retrofitted RC beams, with externally bonded SIFCON laminates. This study presents a method for retrofitting of reinforced concrete beams to enhance the actual load carrying capacity using SIFCON laminates.After the test result they concluded that,the SIFCON strengthened beams exhibits an increased in flexural strength of 47% for laminates having volume of fraction 6% and aspect ratio 70 for three face confinement. The SIFCON strengthened beams exhibits an increased in flexural strength of 72.40% for laminates having volume of fraction 8% and aspect ratio 70 for three face confinement.

III. METHODOLOGY

Beam - Mix proportion for M20 grade concrete was obtained based on the guidelines given in IS codes. A total number of fifteen beam specimens of size

150 x 300 x 1800 mm were cast and tested under loading. All the beams were provided with 2 numbers of 10 mm diameter bars at the top and 2 numbers of 12mm diameter bars at bottom. Two legged stirrups of 8 mm diameter at 200 mm c/c have been used as shear reinforcement. The reinforcements are designed to ensure flexural failure. The beams were tested with laminate confinement in the bottom face and on three faces (bottom & side faces). The details of cast specimens are shown in Table 3.19 and Table 3.20

Table 3.1 Details of cast specimen

Sr. No.	Beam designation	Laminate confinement	No. of beams
1	CB	Control beam	03
2	CB1	Bottom face confinement	06
3	CB2	Three face confinement	06

Table 3.2 Casting sequence of laminate

Sr. No.	Laminate Designation	Size	No. of Laminates For Fibre Vol. 10%	No. of Laminates For Fibre Vol. 12%
1	SIFCON 1	1800x150x20mm	06	06
2	SIFCON 2	1800x200x20mm	12	12

SIFCON Laminates - Hook end steel fibers of 0.6 mm diameter and aspect ratio of 50 are used to cast SIFCON laminates. Fibre volume fraction is 10% and 12%. Cement, Micro Silica and fly ash powder used for making cement slurry with the mix proportion 1:0.2:0.5 Ordinary Portland cement of 53 grade was used. Water binder ratio was about 0.45. Super plasticizer of 1.5% was used to increase the workability of the cement based slurry so as to facilitate easy infiltration of cement slurry into the fiber matrix. Laminates of size 20 x 150 x 1800 mm and 20 x 300 x 1800 mm were cast for bottom face and side face respectively. Wooden moulds were used to cast the laminates. Initially the fibers were placed in the mould to its full capacity and then the cement based slurry was made to infiltrate into the mould. The laminates were demoulded after 24 hours and were cured for 28 days. The laminates are then bonded to the RC beams with the help of a commercial bonding agent.

IV. EXPERIMENTAL RESULTS

First crack load:

Table 4.1 First crack load for 10% fiber volume

Beam	First crack load(kN)		
	A	B	C
CB	58.34	58.15	58.25

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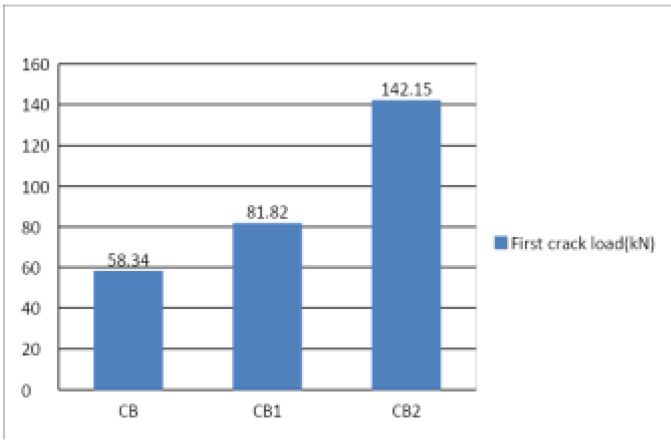
CB1	81.48	81.82	80.20
CB2	142.11	142.15	140.25

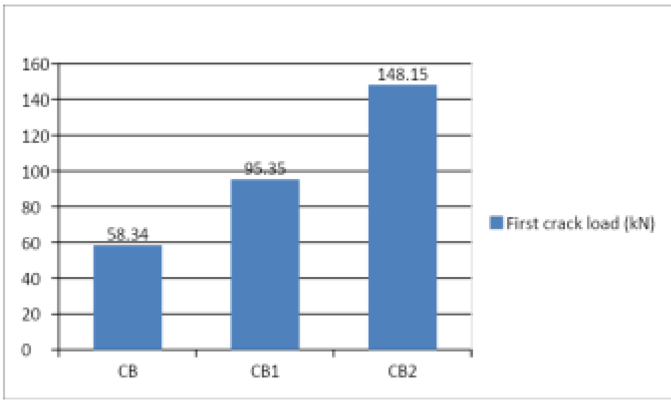


Graph 4.1. Comparison of first crack load (10% fiber volume)

It was observed that for 10 % fiber volume, the first crack load of three face confinement beam was 142.15 kN whereas the corresponding values of bottom face confinement and control beam were 81.82 kN and 58.34 kN respectively.

Table 4.2 First crack load for12%fiber volume

Beam	**First crack load(kN)**		
	A	**B**	**C**
CB	58.34	58.15	58.25
CB1	94.10	94.25	95.35
CB2	147.11	148.15	147.25



Graph 4.2. Comparison of first crack load (12% fiber volume)

It was observed that for 12 % fiber volume, the first crack load of three face confinement beam was 148.15 kN whereas the corresponding values of bottom face ,two side face confinement and control beam were 95.35 kN and 58.34 kN respectively .

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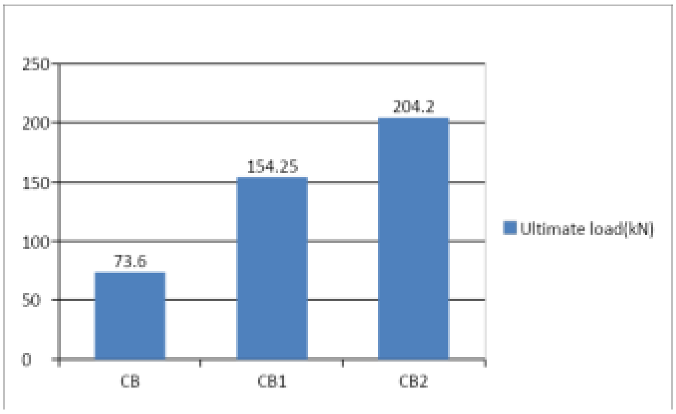
Ultimate load:

Table 4.3: Ultimate load for 10% fiber volume

Beam	**Ultimate load(kN)**		
	A	**B**	**C**
CB	73.60	72.22	73.15
CB1	154.25	152.50	153.18
CB2	204.20	201.23	202.45



Graph 4.3.Comparison of ultimate load (10% fiber volume)

It was observed that for 10% fiber volume, the ultimate load of three face confinement beams was 204.20 kN whereas the corresponding values of bottom face confinement and control beam were 154.25 kN and 73.60 kN respectively.

Table 4.4: Ultimate load for 12% fiber volume

Beam	**Ultimate load(kN)**		
	A	**B**	**C**
CB	73.60	72.22	73.15
CB1	162.60	161.90	162.10
CB2	210.12	209.80	211.30

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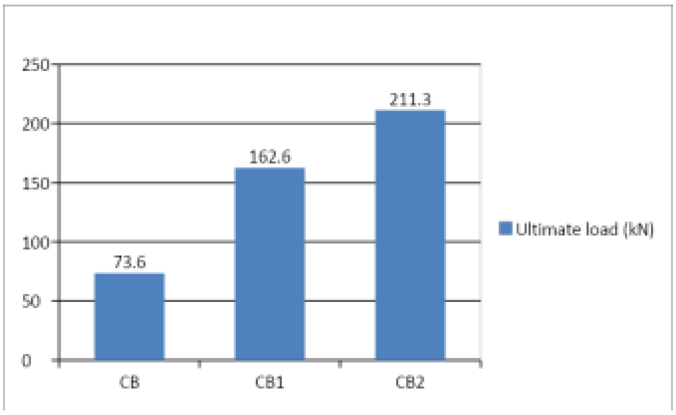

Graph 4.4. Comparison of ultimate load (12% fiber volume)

It was observed that for 12 % fiber volume, the first crack load of three face confinement beam was 211.30 kN whereas the corresponding values of bottom face confinement and control beam were 162.60 kN and 73.15 kN respectively.

V. CONCLUSIONS

Based On The experimental investigation the following conclusions were drawn.

1. for 10 % fiber volume -

- The first crack load beams with confinement with three faces was found to be 143% more than that of conventional RC beam.
- The ultimate load carrying capacity of beams with confinement on three faces was found to be 177% more than that of conventional RC beam.
- The ultimate load carrying capacity of beams with confinement only on the bottom face was found to be 110% more than that of conventional RC beams.
- The ultimate load carrying capacity of the three face confinement beam was found to be 32% more than that of the bottom face confinement beam.

2. for 12 % fiber volume -

- The first crack load beam with confinement with three faces was found to be 144% more than that of conventional RC beam.
- The ultimate load carrying capacity of beams with confinement on three faces was found to be 189 % more than that of conventional RC beam.
- The ultimate load carrying capacity of beams with confinement only on bottom face was found to be 122 % more than that of conventional RC beam.
- The ultimate load carrying capacity of the three face confinement beam was found to be 30% more than that of bottom face confinement beam.

3. Flexural strengthening of the beam increases the ultimate load carrying capacity, but the cracks developed were not visible. Due to invisibility of the initial cracks" it removes the fear from the minds of occupants regarding the collapse. Even though after the failure of beams and excessive deflection beam do not fail suddenly due to the use of U-wrapping of SIFCON laminates.

4. By strengthening the beam, performance of the weak structure can be improved and it will protect many lives from sudden failure.

5. Additionally no minimum concrete cover is needed to prevent corrosion of the reinforcement

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