Behaviour of Exterior Beam Column Joints using SIFCON

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Abstract

An experimental investigation was conducted to study the behaviour of exterior beam column joints using SIFCON and fibre reinforced concrete at the hinging regions and the results were compared with conventional Reinforced Cement Concrete joints subjected to reversed cyclic lateral loading.

Tests were conducted in 1/8 scale size of the specimens. SIFCON and Fibre reinforced concrete specimens were provided with farther spacing of stirrups (two times than conventional) and SIFCON and Fibre reinforced Concrete were used only at the beam column joints and to a distance of 2d(two times the depth of the beam) from the joint region. The test results were focused in the aspects of strength, stiffness, and energy absorption capacity. Besides, reduced crack widths and less number of cracks were noticed in the joint region in the case of Sifcon specimens. The load carrying capacity of SIFCON specimens were found to be greater than Fibre reinforced cement concrete and Conventional specimens.

Keywords: Fibre Reinforcement, High Performance Concrete, Beam Column Joints, SIFCON, Shear reinforcement.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 1 Issue 5, July - 2012

1. Introduction

Slurry Infiltrated FibreCONcrete (SIFCON) is a preplaced fibre concrete. It was investigated in 1978 at Lankard materials laboratory by incorporating higher amount of steel fibresupto 20% by volume against steel fibre reinforced concrete containing 1 to3% of fibres. It is one of the High Performance Fibre Reinforced Concrete (HPFRC) as it possess high strength in compression, tension, shear and flexure comparing with conventional concrete and Steel Fibre Reinforced Concrete. Sifcon has been characterized as a highly ductile material and absorbing high energy. It also possesses high resistance to impact and explosive loading. Sifcon has proved as an economical material if it is particularly used in the regions where its desirable properties are consumed such as beam column joints and base of shear walls in structures to resist blast and earthquake loads. It also finds its applications in airport pavements, industrial floors, bridge decks, and channel lining and military storage systems.

The engineering properties and applications were studied by many authors [1,2,3].Naaman et al summarized the progress of Sifcon in the development of a ductile moment resisting connections for precast prestressed concrete frames [4,5].Studies of SIFCON and steel fibre reinforced concrete at beam column joints were studied in multibay, single bay multistorey frames[6]. Limited literatures are available on the actual behaviour of SIFCON in real structures.

The main objective of the present study is to provide a better understanding of the behaviour of SIFCON utilized in the hinging regions of three dimensional beam column joints.

2. Materials and Methods

Concrete grade of M30 was designed as per IS10262 (Bureau of Indian Standards 1982). Graded coarse aggregate of maximum size 8mm, river sand,ordinary Portland cement conforming to IS269 (Bureau of Indian Standards 1989) and potable water were used for the preparation of the concrete. The mix 1:1.3:2.2 with water cement ratio 0.5 was used for all the specimens. Crimped fibres (1% by volume) with aspect ratio 80 having diameter 0.45mm was used in fibre reinforced concrete specimens and 1% of superplasticizer (ceraplast300) by weight to cement was added to the mix to aviod balling of fibres in fibre reinforced concrete specimens. In SIFCON specimens crimped fibres (8% by volume) with aspect ratio of 80 were used. The mix was mortar of cement and sand was adopted in the ratio 1:1 with water cement ratio 0.35. The sand passing through 1.18mm sieve was used in the mortar. 3% of superplasticizer (Ceraplast300) by weight to cement was added to obtain the flowable mortar.

3. Description of the specimens

The specimens taken for study were intermediate exterior beam column joint subassembly of 1/8-scale model designed to earthquake loads as per IS1893 (Part-I)-2002 and detailed as per IS13920-1993. They were named as IEJC (conventional), IEJF(frc) and IEJS (SIFCON).The specimens details and reinforcement details were shown in fig [1&2]. The joint subassembly has one main beam and two transverse beams on either side of the vertical column. The size of the column was 100 x50 mm and beam was 50x75 mm. The main reinforcement of 4Nos of 8mm Ø twisted bars and 4Nos of 6mm Ø mild steel bars were adopted in column and beam respectively. The shear reinforcement for both the column and beam was 3mm Ø mild steel bars. The stirrups was provided at 20mm c/c to a distance of 2D (two times the depth of the beam) in conventional column and 40mm c/c in SIFCON and FRC columns.[7]. The stirrup spacing was 16mm c/c to a distance of 2D in conventional beam from the joint region and 32mm c/c in SIFCON and FRC beams. The joint region and a distance 2D from the joint region in columns, main beam and transverse beams were only filled with SIFCON and FRC. The remaining region was filled with the mix used in conventional specimen.

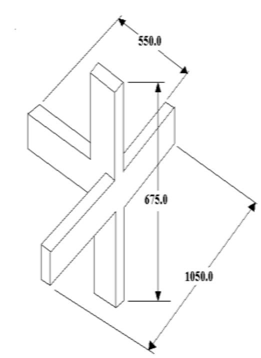

Fig.1 Specimen details

ISSN: 2278-0181
Vol. 1 Issue 5, July - 2012

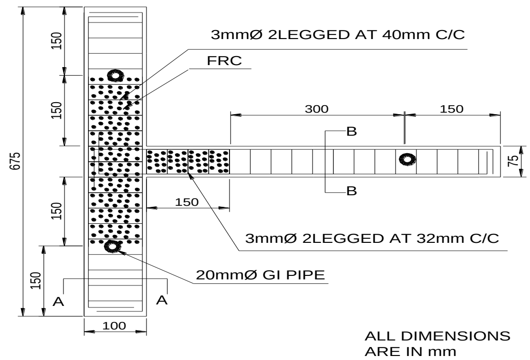

Fig.2 Reinforcement details

4. Experimental Program

The center of the column and the beam was assumed as hinge points and provision of hole with bolt and nut was adopted as shown in fig [3]. Loading frame for testing the joint subassemblies was fabricated separately. Two steel columns were fabricated using mild steel channel section. The top and bottom of the columns were connected using mild steel channel sections on either side of the columns. Two mild steel channel sections were cantilevered horizontally at 0.75 m and 1.25 m above the floor level from one of the vertical steel columns. Arrangements for fixing the specimens were made on the cantilevering channel section. The screw jack used for loading the specimen was fixed vertically hanging at the top of the channel section.

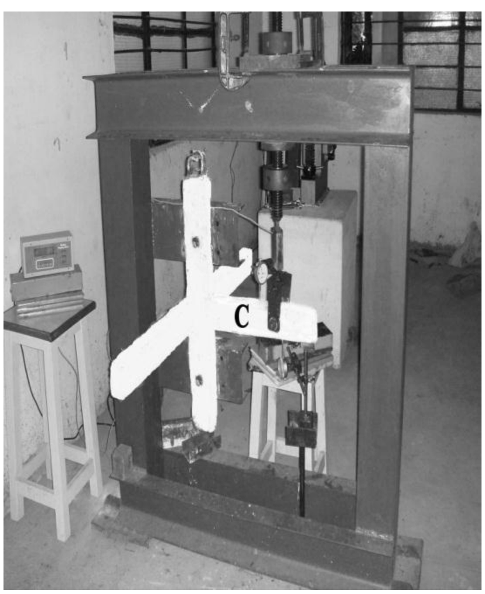

Fig.3 Test set up

Specially fabricated screw jack was used to apply the reversed cyclic loading manually. The loading sequence was adopted as shown in fig [4]. For every increments of load, deflections were measured using dial gauge at the loading point both in the forward and backward cycle of loading.

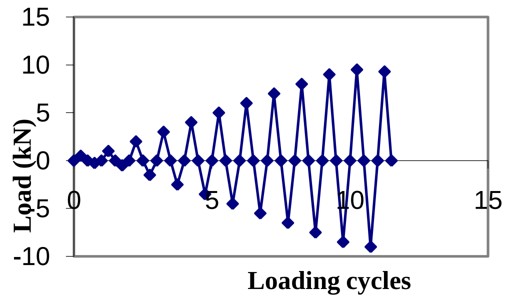

Fig.4 Loading sequence

5. Results and Discussions

5.1 Load capacity and crack formation

When the load was 3 kN in the reversed cycle of loading (upward) cracks started at the bottom of the main beam near the column and it was closed to a certain extent in the succeeding forward cycle in SIFCON specimens. But on increasing the loads in the next cycle the crack was widened in frc specimens but the widening is negligible in SIFCON specimens. When the load was 7 kN in the forward cycle of loading (downward) cracks started at the top of the main beam and the cracks started to form diagonally in the joint region in conventional and frc specimens but no diagonal crack was noticed in the SIFCON specimens. The ultimate load in the SIFCON specimen was observed as 9.5kN and 8kN in the forward and backward cycle respectively. The load capacities were presented in fig.5.

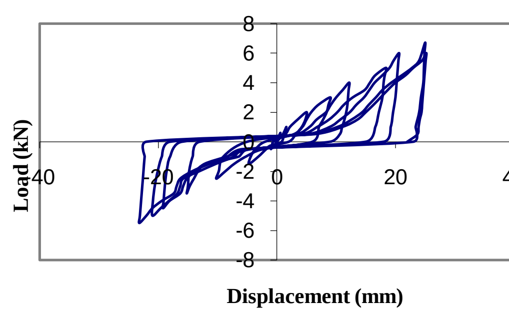

Fig.5 Load vs displacement (IEJC)

5.2 Load deflection response

The hysteresis loops of the load versus displacement curve for the various load cycles were presented in fig.[6,7,8]. The deflection of the

SIFCON specimen was noted to be very much less than the conventional and frc specimens from initial level of the loading to the ultimate load level.

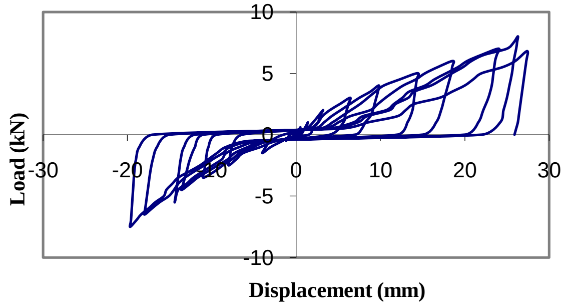

Fig.6 Load vs displacement (IEJF)

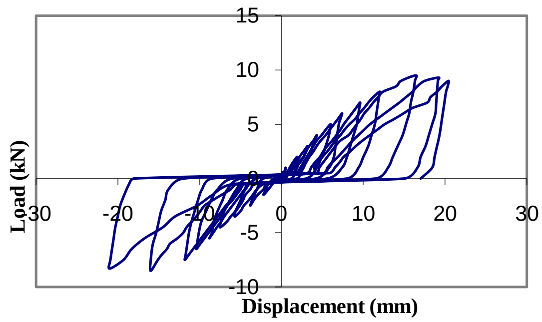

Fig.7 Load vs displacement (IEJS)

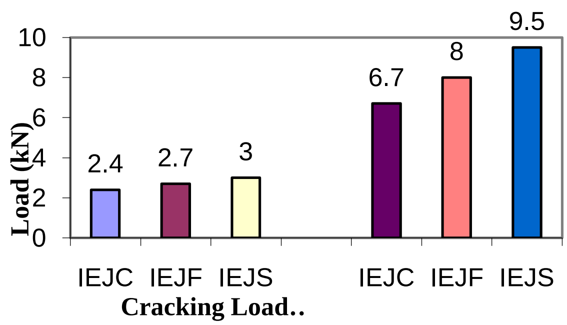

Fig.8 Load capacities

5.3 Stiffness

The stiffness was calculated as the load divided by the deflection. The stiffness versus load cycles was shown in fig [9]. The stiffness of Sifcon specimen is more compared to frc and conventional specimens. They are stiffer at all load levels than frc and conventional specimens.

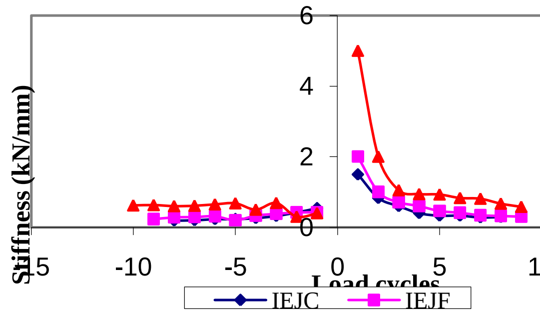

Fig.9 Stiffness

5.4 Energy absorption capacity

The energy absorption capacity was calculated by taking the area under the load deflection curve. The cumulative energy absorption capacity versus load cycles was shown in fig [10]. The energy absorbed by SIFCON and frc was found to be 37% and 92% more compared to conventional specimens.

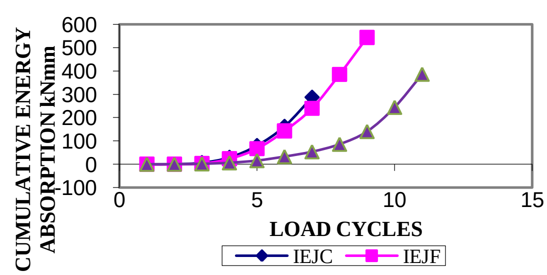

Fig.10 Cumulative Energy Absorption

5.5 Cracking pattern and mode of failure

Diagonal cracks were noticed more in conventional specimens compared to frc specimens and no diagonal cracks were noticed in the case of SIFCON specimens. Crack width is negligible to measure in Sifcon specimens.

6. Conclusions

The experimental study on the exterior beam column joints with Sifcon in the hinging regions resulted in the following conclusions:

1. The load carrying capacity of sifcon specimen 20-50% more compared to frc and conventional specimens respectively.
2. The displacement was very much less compared to frc and conventional specimens at the ultimate load level also.

ISSN: 2278-0181
Vol. 1 Issue 5, July - 2012

3. The sifcon specimens were found to possess 4times more stiffness than frc and 4.5times than conventional specimens.
4. The energy absorption of Sifcon is 1.4times more compared to conventional specimen and frc is 1.9times more than conventional.
5. No diagonal cracks were noticed in Sifcon specimens.

References

[1] D.R. Lankard, Slurry Infiltrated Fibre Concrete (SIFCON), Concrete International, Vol6, No.12, December (1984) 44-47.
[2] V.S.Parameswaran, High performance Fibre Reinforced Concrete, Indian Concrete Journal, November (1996) 621-627.
[3] S.K.Kaushik, S.P. Singh, Strength of SIFCON in Shear and Torsion, ACI SP172, High Performance Concrete Proceedings, CANMET, Malaysia (1997) 45-56.
[4] A.E. Naaman, H.W. Reinhardt,H.W. and C.Fritz, Reinforced concrete frames with SIFCON matrix, ACI Structural Journal, Vol89, No.1, January(1992), 79-88.
[5] A.E.Naaman, J.K. Wright, and H.Abdou, SIFCON connections for seismic resistant frame, Concrete International, Vol9, No.1, November (1987) 34-39.
[6] G.S.Thirugnanam, P.Govindan, and A.Sethurathanam, Ductile behaviour of SIFCON structural members, Journal of Structural Engineering Vol.28, No.1,April -June (2001) 27-32.
[7] M.Lakshmipathy, Ductility of Reinforced Fibrous Concrete Structural Members, Ph.D.Thesis, Anna University,Chennai (1983).

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