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Flexural Behavior of RC Beam using External Steel Channel at Soffit of the Beam

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Abstract:- Numerous strategies were produced for strengthening RC beams against flexure. Retrofitting of RC beams using external holding of steel channels was one of the prominent. This paper demonstrates behavior of RC beams by flexure using external holding of steel channel at soffit of the beam. Steel channels with different bolt arrangements were fitted to the soffit of reinforced concrete beams. The test outcome confirmed that all steel channel fitted with RC beam enhanced the strength of the specimen essentially. With different arrangement of bolts in the beam the behavior varies and that had been analyzed and also the deflection of the reinforced concrete beam with steel channel were tested.

***Keyword**:- flexural behavior; RC beams; Retrofitting.*

I. INTRODUCTION

Strengthening of reinforced concrete (RC) structures is commonly needed for overloading, corroded steel reinforcement, inadequate maintenance, change in use or in code of practice, and exposure to unfavorable conditions like earthquakes and blasts. The buildings and bridges are in need of repair or upgrade. For that steel reinforcements are provided inside the concrete and this type of structure is named as reinforced concrete structure. It is overcome by composite structures depends on massive loading conditions such as fatal disasters like earthquake, wind and tsunami etc., Even though composite structures has a good reputation in the construction field, it is not economical. Nowadays plate bonding technique is widely used in strengthening and retrofitting techniques. We can strengthen the beam through flexure and shear. Flexural strengthening reduces the deflection and increasing the load carrying capacity of the beam. External strengthening technique can be done by providing steel channels on the surface of the beam.

Various plates are available for external strengthening technique such as FRP, CFRP, GFRP, Steel plate etc. Of these steel channels is more economical. A crumbling infrastructure is a reality that all groups are managing. Existing beam that are insufficient as for flexural capacity are expensive to pulverize and recreate. A productive, practical method for reinforced existing beams is required so a risky or unusable structure can be used. The Bonding of steel channel is done by using resins and bolts. While using the resins and bolted connection for bonding, bonding failure will be avoided. The crack width will also be reduced since the steel channel at the soffit increase the yielding capacity of the beam.

On bonding steel channels, brittle failure may be avoided and also the ductility of the beam is increased. Due to increase in ductility character the load carrying capacity of the beam is increased and at the same time dimensions of the beam is decreased if we provide steel channels to the beam. The deflection of the conventional reinforced concrete beam and beam with different bolt arrangements is compared. This retrofitting technique gives more durable to structure.

II. OBJECTIVE

- To investigate the flexural behavior of RC beam using external steel channel at soffit of the beam.
- To investigate and compare the behavior of conventional RC beam and beam with steel channel by finite element software ANSYS 15.0
- To investigate and compare the flexural behavior of RC beam and beam with steel channel in stagger row bolt and inclined row bolt in corner.

III. METHODOLOGY

- Preliminarytests
- Mixdesign
- Hardened concretetest
- Analysis of beam using ANSYSsoftware
- Casting and curing ofspecimens
- Retrofit beam with steel channels of boltedconnections
- Testing ofbeams
- Results anddiscussion

IV. MATERIALPROPERTIES

A. Steel Channel

The steel channel used in the specimen is ISMC 100 @ 9.56 kg/m, which comply with the standards in IS: 808 – 1989.

B. Cement

Ordinary Portland cement of 53 grade complying with IS: 12269-1987 was utilized. Fineness 9.8%, initial setting time 30 min, final setting time 480 min, specific gravity 3.05.

C. Fine Aggregate

The fine aggregate used in this study is manufacturing sand. As per IS: 2386 (part 1). . Fineness 2.88, specific gravity 2.54, Water absorption 1.01%.

D. Coarse Aggregate

The aggregate of 20mm size is taken. The properties of Coarse aggregate were obtained by leading tests according to IS: 2386 (Part 3) – 1963. Fineness 2.68, specific gravity 2.63, Water absorption 0.5%.

V. ANALYTICALSTUDY

Finite element modeling technique is utilized to study the behavior of RC beam using external steel channel at soffit of the beam. Beams are modeled in ANSYS and graphical user interface are used to create the model. In ANSYS, Static structural model sections are utilized, meshing of the sections into the finite elements, solving and reviewing outcomes as shown in fig. 1&2 A beam was modeled with 1000x 100 x 150mm cross and the steel channel is about 800mm in length and 5mm in thickness is placed on the soffit of the beam usingbolts.

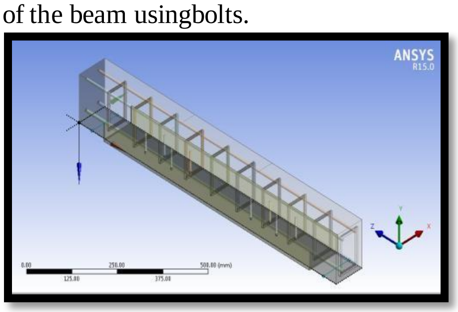

Fig 1:- Longitudinal section of beam with Steel Channel

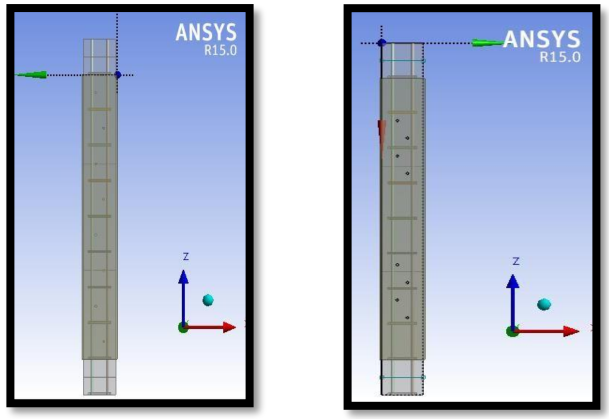

Fig 2:- Steel Channel with stagger row bolt arrangements and inclined row bolt arrangements in corner

Load-deflection results from ANSYS for control beam and steel channel retrofitted beam for different bolt arrangements is shown in table3.

In the analytical results it is found that the ultimate load for the control beam is 75 kN and for staggered row bolted connections beam is 120 kN and for inclined row bolts connections in corners is 116 kN as shown in fig.3&4

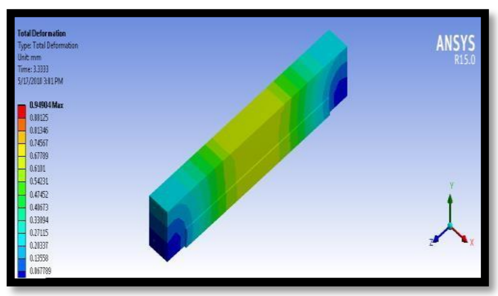

Fig 3:- Deflection occurred on beamS1

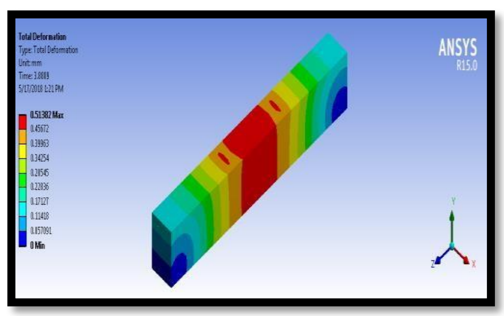

Fig 4:- Deflection occurred on beamS2

VI. EXPERIMENTAL INVESTIGATION

Experimental investigation is done for the study of flexural behavior of RC beam using external steel channel at soffit of the beam. The following section contains specimen details and the testing procedures as shown in table.1

The beams were reinforced with 2 nosof 10mm rebar in tension and 2 nos of 8mm rebar in compression side with stirrups of 6mm provided at 100mm c/c. A clear cover of 15mm is maintained all around for compression and tension reinforcement. The size of steel channel, where length is 800mm, width is 100mm, depth is 50mm and thickness is 5mm. The size of bolts is length 75mm and diameter 10mm are fixed to the steel channel in stagger row and inclined row in corners. The steel channel is placed at soffit of the beam with bolts connected using epoxy resins forbonding.

Beam ID	Beam Size(mm)	Steel Channel Thickness(mm)	Description
C1	1000*100*150	-	Control beam
S1	1000*100*150	5	Steel channel staggered bolted
S2	1000*100*150	5	Steel channel inclined bolted

Table 1. Specimen details

The beam mould is placed over a plain surface and the sides of mould are oiled well to facilitate easy removal of the specimen. Covers blocks are made up of cement mortar and it is utilized while casting of beam. The ingredients for concrete such as cement, F.A, C.A and water were weighed and mixed well for the designed mix proportions. The mixing is done with pan mixer until the uniform mix of concrete was attained. The mixed concrete is placed inside and compacted well.

The specimens are demolded and cured in curing tank for 28 days. The steel channel is fixed in soffit of the beam using 10mm diameter bolts with Epoxy Resins for bonding of Steel channel and concrete as shown in fig.5
.

Fig 5:- Retrofitted specimens with steel channel and bolted connections

The instrumentation setup for testing the specimen is shows in figure 6. A 40 tons capacity Universal Testing Machine (UTM) is used to apply two-point load beams. The load meter in machine shows the applied load. Dial indicator is used the measure the deflection and maximum deflection is noted at the mid section as shown in fig. 6

Fig 6:- Test setup and instrumentation

VII. RESULTS AND DISCUSSION

This section describes the results obtained experimentally and analytically for the control beam and the beam with steel channel. Six beams were cast, out of which two are control beams, two are beam with steel channel with stagger row bolt arrangements and remaining two are beam with steel channel with inclined row bolt arrangement in corner. Experimental as shown in table 2 and fig 7 and analytical results shown in table 2 and fig 11 are compared for ultimate load, deflection and crack pattern. Modes of failure were observed during thetest.

Beam ID	Ultimate load (kN)	Deflection (mm)
C1	91.14	5.96
S1	141.2	4.31
S2	137.2	3.97

Table 2. Experimental Results

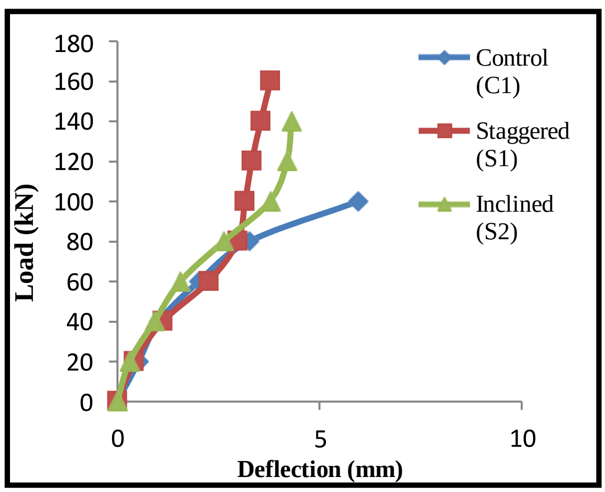

Fig 7:- Load Vs Deflection curve for C1, S1 and S2 Experimental Study

The first crack load for the specimen S1 was perceived as 58% more than the conventional one and for the specimen S2 it was perceived as 40% more than the conventional beam. The crack occurred in the control beam was shear crack. For the S1 and S2, flexural - shear cracks were followed on static two point loading condition.

Based on the mode of failure and crack patterns which are obtained from the specimens, it shows shear failure mode. At the initial load stage, entire specimens expose similar cracking pattern. As the load increases, the mid-point region exhibits cracks and at the part of shear region, the cracks passes towards compression zone. In the specimens C1 shear crack appear first and the cracks developed gradually for the increase of the load and in the specimens S1, S2 Shear cracks appeared first shown in fig 8,9&10.

Fig 8:- Shear crack at specimen C1

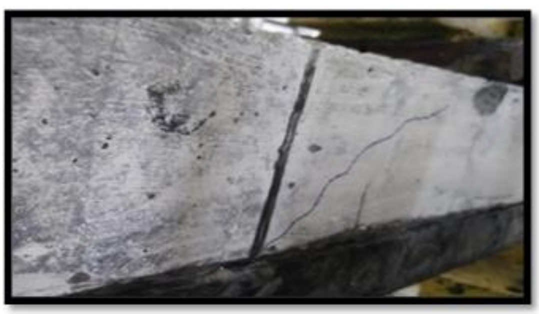

Fig 9:- Shear crack at specimen S1

Fig 10:- Shear crack and failure at supports in specimen S2

Beam ID	Ultimate load (kN)	Deflection (mm)
C1	75	0.74
S1	120	0.95
S2	116	1.04

Table 3. Analytical Results

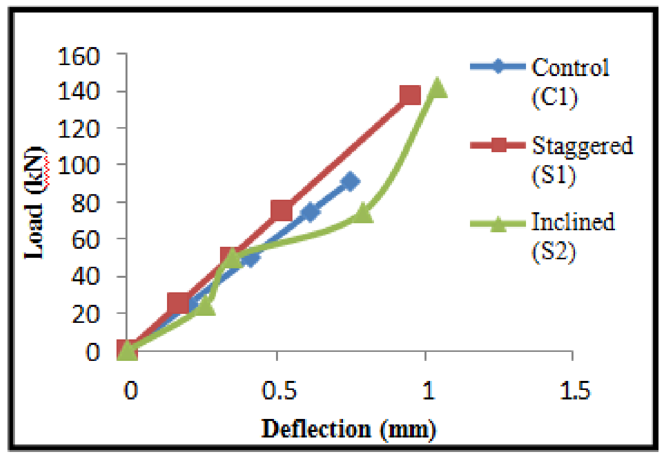

Fig 11:- Load Vs Deflection Curve for C1, S1 and S2 Analytical Study

VIII. COMPARISONS OF EXPERIMENTAL RESULTS WITH ANALYTICAL RESULTS

Experimental results were compared with numerical results obtained by ANSYS results shows that good agreement with numerical result obtained through ANSYS, load-deflection curve obtained through experimentally coincide with numerical load-deflection curve. So it is clear that the experimental and analytical results obtained are relative to each other shown in table4.

Specimen ID	Ultimate load (kN)		Difference
	Experimental	Analytical	
C1	91.14	75	20.5
S1	141.2	120	18.9
S2	137.2	116	19.4

Table 4 Comparison of experimental and analytical results

In experimental and analytical results, the behavior of steel channel retrofitted reinforced concrete beams showed an increase in load bearing capacity more than the control specimen. The overall behavior of beam with stagger row bolted connection was slightly more than the beam with inclined row bolted connections in corner.

IX. CONCLUSIONS

The experimental and analytical results drives the following conclusions were drawn

- Steel channel retrofitted with reinforced concrete beam for stagger row bolt arrangement and inclined row bolt arrangement in corners showed a significant increase in load carrying capacity by 56% and 52% over the control beam.

- From the analytical results it was found that the ultimate load carrying capacity for control beam, beam with steel channel for staggered row bolted connection and inclined row bolted connection in corner has adifference of 20.5%, 18.9% and 19.4% when compared with the experimental results.

- From the analytical results it was found that the deflection for control beam, beam with steel channel for staggered row bolted connection and inclined row bolted connection in corner has a difference of 20.4%, 15.6% and 16% when compared with the experimental results.
- Failure mode and crack pattern of retrofitted beams showed shear failuremode.

The proposed method of strengthening the RC beams with steel channel connected using different bolt arrangements is found to be very efficient in terms of load carrying capacity and deflection compared to control beam.

REFERENCES

[1]. AkhtarGul, Bashir Alam, YasirirfanBadrashi, Khan Shahzada "Strengthening and evaluation of reinforced concrete beams for flexure by using external steel", International Journal of Advanced Structures and Geotechnical Engineering, vol. 04, no. 01, p.p no. 2319-5347,2015.
[2]. Varshney Kumar Patel "Maintenance of RCC Beams by Retrofitting Technique using steel plates", International Research Journal of Engineering and Technology (IRJET), Vol. 04 p.p no. 3407 – 3410,2017.
[3]. SivaganeshSelvaraj and MahendrakumarMadhavan "Enhancing the structural performance of steel channel sections by CFRP strengthening", Journal of Thin- Walled Structures, vol. 108 p.p no. 109–121,2016.
[4]. G. Arslan, F.Sevuk and I. Ekiz "Steel plate contribution to load- carrying capacity of retrofitted RC beams", Construction and Building Materials vol. 22, p.p no. 143–153, 2008.
[5]. IS: 2386 (Part I) – 1963, Methods of test for aggregates for concrete, Particle size andshape.
[6]. IS: 456 – 2000, Plain and Reinforced concrete – code ofpractice.
[7]. IS: 10262 – 2009, Concrete Mix Proportioning –Guidelines.