Cold-Formed Steel Beam-Column Joints with Latex Layer Wrapping

P.S.Aravind Raj, R.Divahar, K. Naveen Kumar, K.Rakkshana

Abstract*:*Columns are the primary element of a structure and are the first element to face the effect of lateral load during an earthquake. To resist such lateral seismic loading high strength and ductile steel frames with higher energy absorption capacity are generally preferred. The nominal ductile capacity of the steel can be boosted up with additional wrapping that could optimize the seismic performance significantly. The present work deals on the behaviour of cold-formed steel beam and cold formed steel column wrapped with latex layers for strengthening. The specimens were subjected to reversed quasi-static cyclic loading to partially simulate the seismic forces. Experimental results shows significant increase in strength capacity of beam-column with latex layer wrapping.

Keywords **:Seismic, reversal load, Latex wrapping, beam-column joint, composite.**

I. INTRODUCTION

Structural steel are preferred more that the reinforced concrete in resisting seismic loads because of its ductility nature and fatigue strength. Also steel framed structures are lighter, more flexible and ensure hysteretic energy absorption capacity making them an ideal system for earthquake resistance structures. Under the seismic loading the failures occur at the connections between the beam and column. Hence the beam-column joint need to be strengthened to increase the strength, stiffness and ductility.

Cheng et al studied the moment connections under earthquake load simulation for the rigid frames of steel structures. The groove weld at the beam flange reduced the plastic strain and stress concentration as the result improving the performance. Han et al studied seismic performance of the CFST column applied along with the axial load simulating the practical loading condition. The author concludes with the results obtained that the seismic criteria are found to be superior in the CFSTRC columns. Broderick et al. investigated the columns with hollow sections and tubes infilled with concrete in lateral loading testing. The performance of the element increased even after multiple reversal loading in inelastic zones by the infill provided within the tubes. Alameddine et al (1991) studied the corner beam-column joint made of high strength concrete at quasi-static reversed lateral loading for various grades of concretes and different shear stress. The reduced shear stress with improved and required confinement at the joints ended up with higher performance and was useful in shifting the hinge zone away from the joint.

In this paper, the effect of latex layers on the strength, ductility, and energy dissipation capacity of the cold-formed steel beam-columns wrapped with latex layers was experimentally studied. Four specimens including with and without latex layer over cold-formed steel beam-column joints were tested. The specimens were tested under reversed quasi-static cyclic lateral loading and lateral load versus lateral displacement behaviour are presented.

II. METHODOLOGY

In the course of study of the quasi-static behaviour of the cold-Formed steel beam-column joint wrapped with the latex layer, following stages of study as shown in Fig.1 were done to arrive at the results.

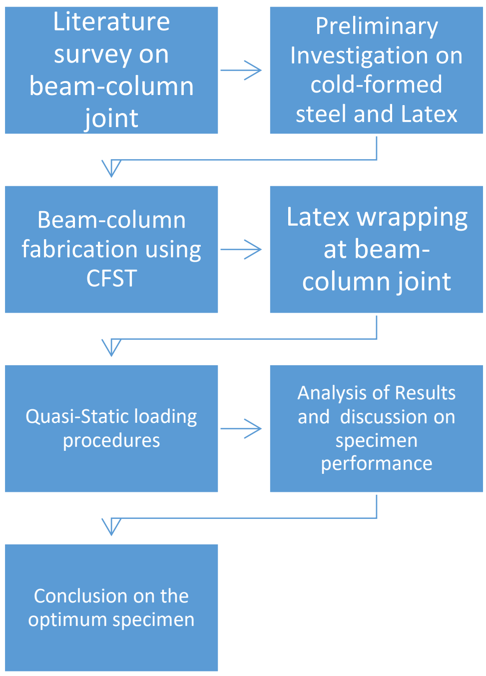

Fig.1 Methodology

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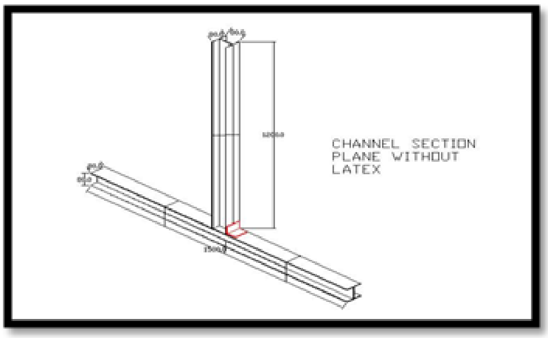
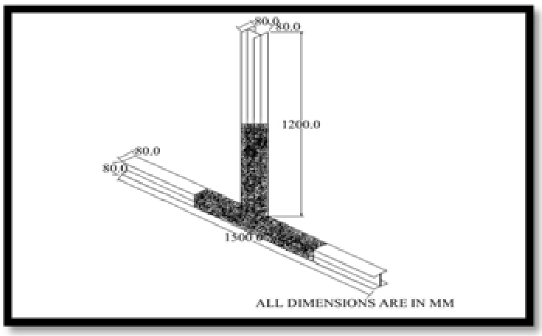
III. SPECIMEN DETAILS

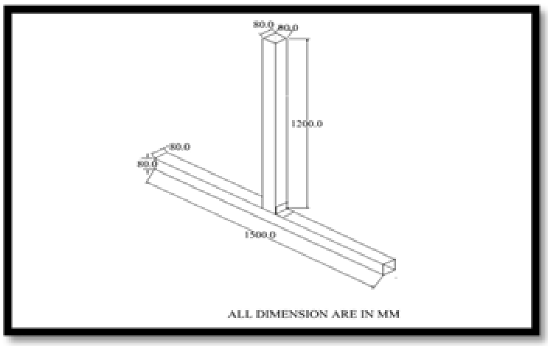
Experiments were conducted on fourcold-formed steel frames of height 1200mm and beam length of 1500mm with the joints welded with cleat angle of 6mm thickness. The frame consisted of cold- formed steel square tube section and clod-formed channel sections. Fig.2 shows schematic view and details of the tested specimens. Two specimens were wrapped with latex layers of 3 mm each at the beam-column joint. The wrapped were done for a length of 750mm in beam and for a height of 600mm in the column from the joint. 'Hemlock' solution was used as the binding compound for the layers with the steel sections. These wrapped systems were steam cured at a temperature of 120°C with 3.5 kg/cm² pressure. Table 1 shows designation and details of the specimens tested.



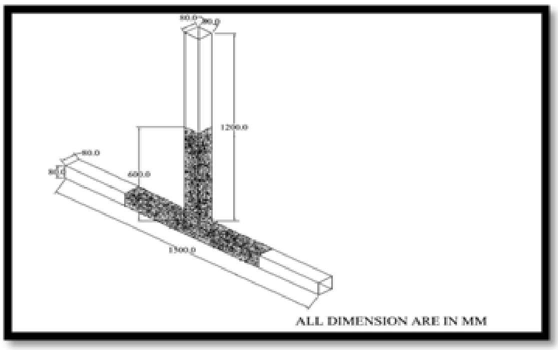
(a) Channel section without latex layers (CS-N)



(b) Channel section with latex layer wrapping (CS-W)



(c) Hollow square tube without latex layer wrapping(HS-N)



(d) Hollow square tube with latex layer wrapping(HS-W)

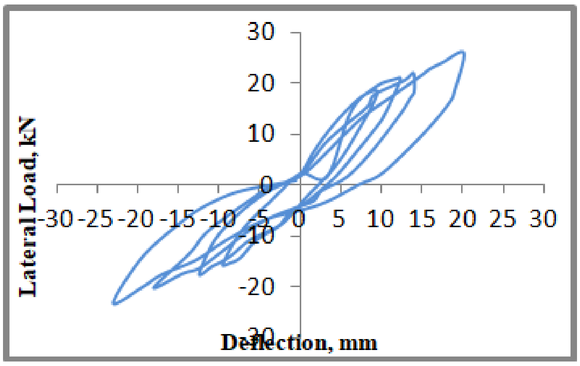
Fig. 2. Test specimen details of the beam-column

Table I. Details of specimens tested

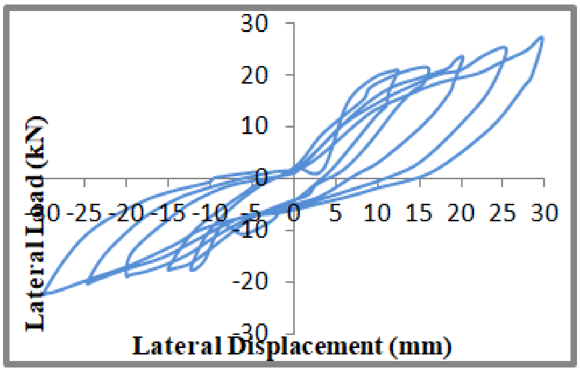
Sl. No.	Specimen ID	Description	Dimension of sections (mm)	Wrapping of latex sheet
1	CS-N	Two channel sections	40 x 40 x 3	Without latex layer
2	CS-W	Two channel sections	40 x 40 x 3	With latex layer wrapping
3	HS-N	Square Hollow section	80 x 80 x3	Without latex layer
4	HS-W	Square Hollow section	80 x 80 x 3	With latex layer wrapping

IV. EXPERIMENTAL SET-UP

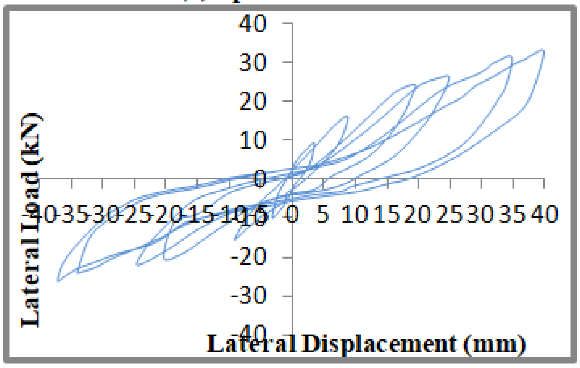
The specimens are tested under lateral loading with the hydraulic actuator which can laterally apply load to the specimens up to 200kN with a lateral stoke range of ± 100mm. The hydraulic jack can be reversed to form a cyclic loading pattern. Linear variable displacement transducers (LVDT) is used for measurement of lateral displacement at the column top and a load cell attached to the actuator was used for the measurement of lateral reversed cyclic loads. The experimental set-up is shown in Fig. 3. The beam of the specimen are held up at the base of the loading frame to resist against the uplift created by the lateral load given at the top of the column. And this fixity condition will be supporting the specimen to develop moment at the joint with the lateral load. Also a roller plate arrangement was provided between the top of the column and the vertical jack.to avoid the transfer of drag created by the horizontal jack to the vertical jack.



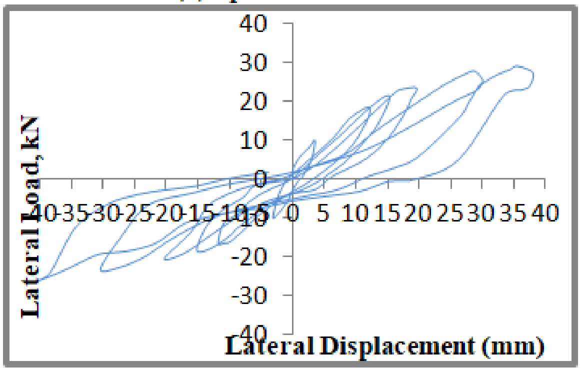
(a) Specimen CS-N



(b) Specimen CS-W



(c) Specimen HS-N



(d) Specimen HS-W

Fig. 3. Hysteresis curve for the specimens


Fig. 3. Test set-up

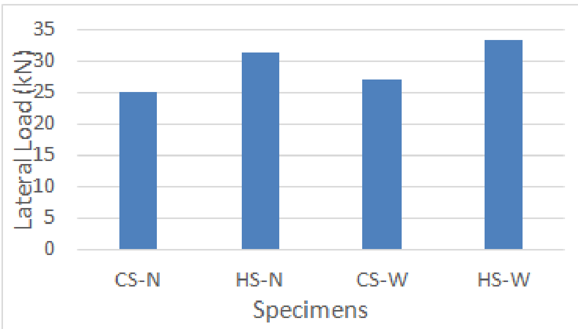


Fig.4 Lateral Load performance of specimens

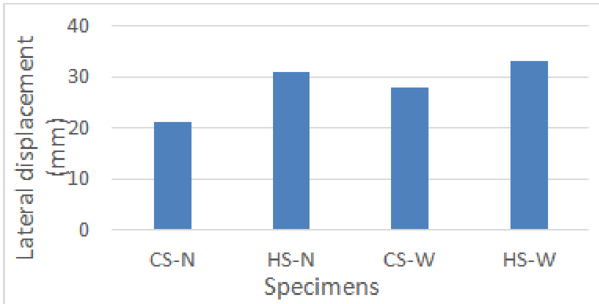


Fig.5 Lateral displacement performance of specimens

V. RESULTS AND DISCUSSIONS

The hysteresis behaviour of all the specimens from the lateral displacement and lateral load plot is shown in Fig. 3.The specimen CS-N and HS-N failed at a load of 25 kN and 31.3 kN respectively with the corresponding displacement of 21 mm and 35 mm, and in which the failure occurred at the flange by buckling of the beam section near the beam-column joint. When the system is wrapped, i.e., specimen CS-W and HS-W failed at a load of 27 kN and 33.2 kN respectively with the corresponding displacement, relatively higher than the non-wrapped specimens of 28 mm and 39 mm. The numbers of cycles that the system with latex layers were also significantly high because of the shift in the buckling occurrence by the wrapping. Fig.4 and Fig.5 shows the

VI. CONCLUSION

An experimental investigation performed to arrive the behavior of cold-formed steel beam-column wrapped with latex layers. Four specimens of cold formed steel beam-columns with and without wrapping were tested under reversed quasi-static cyclic loading and the following conclusions were drawn.

- Lateral load strength capacity of the beam-column joints with two channel sections and wrapped with latex layer is 8 % more than the beam-column without wrapping.
- The lateral strength capacity of the beam-column joints made with hollow open section and wrapped with latex layer is 6.2 % more than the beam-column without wrapping.

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AUTHORS PROFILE

Dr.P.S.Aravind Raj M.E., Ph.D, has completed his doctorate in structural engineering in the year 2015 and has a total research experience of about 8 years. He is passionate on research in the fields of steel-concrete composites, sustainable materials, sustainable structures, etc. He has performed several research on beam-column connection of composite structures. He published and presented his research in many National as well as International conferences and also peer reviewed journals. Currently he is working as Associate Professor in the Department of Civil Engineering, Aarupadai Veedu Institute of Technology, Paiyanoor, Chennai from May 2019.

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