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Strength Assessment of Laminated Cold form Steel Beams

KEYWORDS: Gfrp, Silicone fabric, Coupons, Cold form steel

A.Mohammed Imran
P.G.Student, School of civil engineering, VIT University, Vellore, Tamilnadu.

Dr. A Abdul Rahim
Associate Professor, Department of civil engineering, VIT University, Vellore, Tamilnadu.

ABSTRACT *Cold form steel has lower strength compared to that of structural steel. In recent years Fiber Reinforced Polymers (FRPs) are used for repairing of steel sections. In this study Glass FRP, Silicone Fabric are coated over cold formed steel and its strength characteristics are studied experimentally and analytically. Cold formed steel are prepared in coupons, channel section and lipped sections in standard dimensions. The steel are laminated and are tested experimentally. The results obtained from experimental works are used to determine the strength enhancements in cold form structural sections.*

INTRODUCTION

In the last decade, The use of composite materials such as Carbon FRP, Glass FRP, Aramid FRP, Silicone fabric have been increased in the construction purposes. Various studies have been conducted in the retrofitting and the repair of steel structures. Thus these laminates had proven that, it's an excellent option for external reinforcement due to its high Tensile strength, high resistance to corrosion and high durability. The main applicability of this laminates are, It's cost efficiency, strengthening and also in rehabilitation purpose of deteriorated steel. Most noticeably several laminates in which GFRP and Silicone fabric are able to achieve an elastic modulus that is greater or similar to that of steel.

In the recent study, various tests have been conducted in the retrofit and repairing of steel structures. Thus the test results indicated that strengthening and retrofitting of steel beams with GFRP and silicone fabric (a) To control the propagation of cracks arising from fatigue (b) To increase its overall moment strength (c) And also it helps in recovery of stiffness loss due to corrosion.

In this paper the strengthening behavior of steel beams with GFRP and silicone fabric is presented and discussed. Four steel beams are strengthened with GFRP and Silicone fabric strips. The other two beams is tested without laminating strips in it. After the testing of this two beams and then it is rehabilitated, and its structural behavior is studied by laminating it and tested once again. This is due to the purpose of facilitating comparison. The materials used and the test method(s), details of beam sections, test results are briefly discussed and outlined in this paper.

MATERIALS AND METHODS

To understand the pull-form of epoxy-glass and silicone composite laminating strip was used to strengthen the steel test beams. In phase1, a total of 10 coupons cut to a length of 250mm were tested .In phase 2,a total of 12 specimens of GFRP and silicone fabric were tested under different cases. The compression test specimen dimensions are shown in Table 1. A schematic view of both coupons and beam specimens is shown in Fig 1. C and simple lipped sections of 2.0mm thickness and 800mm length were chosen for the compression tests.

Figure 1: Glass Fiber Reinforced Polymer(GFRP) and silicone Fiber

Methods of testing:

Coupon specimen are prepared for the required dimension as per IS 1608:2005. Testing is carried out for coupons without laminate and coupons laminated with one layer and two layers. The dimensions of the coupon are given below. Thickness of coupon specimen is 2mm.

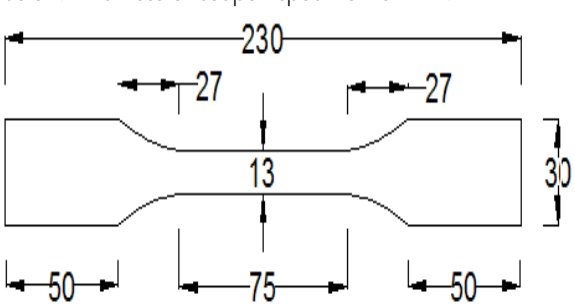

Figure 2. Coupon specimen details

The grip ends of the coupon are fixed to the Universal Testing Machine (UTM) with the clamp provided to it. Ten-

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sile loading is applied to the specimen with gradual increase of the intensity of the load. The loading is applied until the coupon gets failure. The failure is obtained due to the breakage at the gauge of the coupon.

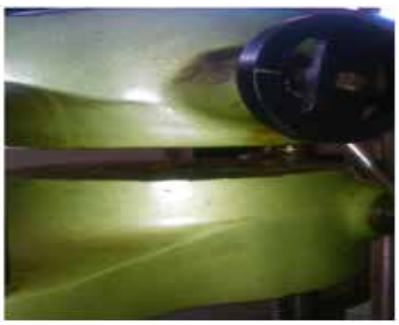

Figure 3. Testing set up of coupons Testing of beams:

Two types of beams are prepared for the testing. The beams are plain C section and C sections with lip. Dimensions of the beam are 80x50 x 2 for plain C section and 50 x 80 x 15 x 2 for lipped section. The laminate is bonded over the flanges of the beam using epoxy resin adhesive.

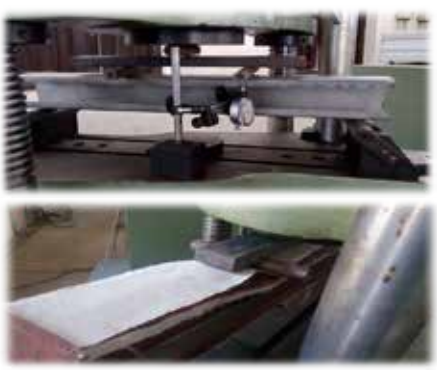

Figure 4. Beam testing setup

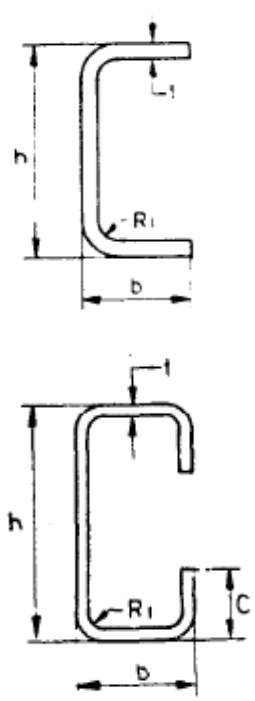

Figure 5. Beams sections

The beam is tested by two point loading method in Universal Testing Machine (UTM). The two loading points are 133mm away from the center of the beam on either side. The loading is applied by increasing gradually until buckling occurs.

RESULTS AND DISCUSSIONS:

Coupon test results:

From the table 1 the tensile stress of various coupons with different layers is studied. It is seen that tensile stress is increasing rapidly by the application of laminates.

Single layer laminate with GFRP gives high ultimate load and tensile stress when compared to coupon without laminate

Coupons laminated with silicone fiber also give high ultimate load when compared to plain coupons but when compared to GFRP.

A coupon laminated with double layer doesn't increase the ultimate load and tensile stress up to expected level. It is because the bonding between the two layers gets stiffened and fails at initial stages.

Thus the lamination of steel with one layer is good for strengthening the sections. Based on the coupon results the Beams sections are laminated with single layer of GFRP

Table 1 Results of coupon test

Sl. No.	Specimen description	Ultimate load (KN)	Tensile stress (N/mm^2)
1	Coupon without laminate	28.25	1139.11
2	Coupon laminated with Glass fiber for single layer	34.55	1393.14
3	Coupon laminated with Glass fiber for double layers	35.42	1428.22
4	Coupon laminated with Silicon fiber for single layer	30.16	1216.12
5	Coupon laminated with Silicon fiber for double layers	31.52	1270.96

(ii) Beam test results:

Beam tests results

From the table 2 various beams sections are tested results, the percentage of increase in ultimate load and deflection are compared.

Higher percentage of strength was observed in all laminated specimens of C sections and compared without laminated C sections and the C section was observed % of strength gain.

Compared with C sections and C-lipped sections, were showed best performance and higher strength behaviour in all specimens. The lamination made specimens gave higher flexural strength then non laminated specimens and which reduces the deflections during the testing. Thus the Increase of strength due to GFRP strengthening gives the increase in flexural strength by 15.61%.

In back to back connect cases, the effect of lamination, bolting of two sections is verified. Thus it doubles the ultimate load when compared to plain sections. Thus the Increase of strength due to GFRP strengthening gives the increase in flexural strength by 15.61%.

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Table 2. Results of beam sections

Sl. No	Sections dimensions of the beam in mm	Ultimate load KN		Deflection mm	
		Without laminate	With laminate	Without laminate	With laminate
1	Plain channel section	32.8	38.15	6.85	6.55
2	Lipped channel section	38.87	45.40	7.54	7.38
3	Plain channel section connected back to back	81.27	92.65	13.86	13.5
4	Lipped channel section connected back to back	107.59	121.95	12.62	11.72

Percentage increase of load:

Table 3. Increase of strength due to GFRP strengthening

S.no	Section dimension of the beam in mm	Ultimate load (KN)		Percentage of difference for the loads of laminated beam
		Without laminate	With laminate	
3	Plain channel [80x50x2]	32.87	38.15	16.3%
4	Lipped channel [80x50x15x2]	38.87	45.40	16.8%
5	Back to back plain beam [80x50x2]	81.27	92.65	14.01%
6	Back to back lipped beam [80x50x15x2]	107.59	121.95	15.24%

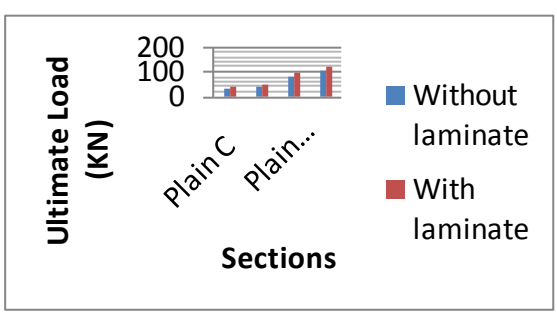

Figure 6. Ultimate load comparison

CONCLUSION

Thus strengthening effect of GFRP and silicone fibre was studied thoroughly for coupons and beam. From the above study the following conclusions are listed below:

Thus the GFRP laminate can be used in the strengthening of cold form steel sections.

From the coupon results, the tensile stress increases drastically by the effect of lamination of both GFRP and silicone fibbers.

It's been found that laminated beam sections increase flexural strength by 15.61% when compared to plain beams.

Lamination of multiple layers of both fibbers on coupons doesn't give much more expected strengthening effect up to a measurable extent.

The coupons showed shear failure and debonding in multiple layers. Hence it is advised; in that post analysis it is to be done with increase in thickness of laminates instead of going for multiple layers.

Thus GFRP can be used in repair and rehabilitation techniques in cold form steel and it can be applied over outer surface of deformed structures with the help of epoxies. So it can increase the loading capacity of the structure.

Compared with C sections and C-lipped sections, were showed best performance and higher strength behaviour in all specimens. The lamination made specimens gave higher flexural strength then non laminated specimens and which reduces the deflections during the testing

In back to back connect cases, the effect of lamination, bolting of two sections is verified. Thus it doubles the ultimate load when compared to plain sections. Thus the Increase of strength due to GFRP strengthening gives the increase in flexural strength by 15.61%.

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