Failure Modes for I-Section GFRP Beams

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Abstract

This paper presents calculations for the failure modes for I-section Glass Fiber Reinforced Polymer (GFRP) beams with single mid-span web brace. Theoretical predictions are made using ASCE-LFRD Pre-Standard for FRP structures. For the member length considered, it is found that for small and medium I-sections the failure mode is governed by lateral-torsional buckling and for bigger I-sections the failure mode is governed by material rupture. The outcome of the predicted lateral-torsional buckling mode is compared with that observed experimentally.

Index terms— failure modes, I-section GFRP ASCE-LFRD standard for FRP structures.

1 I. Introduction

azzaq, Z, Prabhakaran, R., and Sirjani, M. B [1] have conducted an experimental and theoretical study of the flexural-torsional behavior of reinforced beams using LFRD approach. The same authors have also provided a load and resistance factor design (LFRD) approach for fiber-reinforced plastic (FRP) [2]. The paper presents the outcome of a study on failure modes for I-section GFRP beams.

2 II. Experimental Study

A 93 inches long GFRP beam with a 8 x 4 x 0.5 in. is tested as shown in Figure **??**.

3 Fig. 1 : Schematic of I-Section GFRP beam

The test procedure involved applying the load, P, in small increments and recording the resulting deflections. Figure **??** shows the experimental test setup. In this figure, the ends have shear-type connections and a hydraulic jack of 50-kip capacity with load cell and a loading device are also shown. ?? ð ??"ð ??" = Distance from the neutral axis to the extreme fiber of the flange, in. ?? ?? = Distance from the neutral axis to the extreme fiber of the web, in. The resistance factor ? = 0.65 is used.?? ???? = 4?? ???? ?? (6) ?? ð ??"ð ??"???? = 4??ð ??"ð ??" ???? ?? (7) ?? ?????? = 4???? ???? ?? (8) ?? ð ??"ð ??"ð ??"ð ??" = 4?? ð ??"ð ??"ð ??"ð ??" ?? (9)

In Equations 6 through 9, ?? ???? , ?? ð ??"ð ??"???? , ?? ?????? , and ?? ð ??"ð ??"ð ??"ð ??" are the load-carrying capacities due to lateraltorsional buckling, local instability in the flanges, local instability in the webs, and material rupture, respectively.

If ?? ???? = ?? ð ??"ð ??"???? = ?? ?????? = ?? ð ??"ð ??"ð ??"ð ??" = ?? ð ??"ð ??" is the loadcarrying capacity of the member, a LFRD approach is proposed as follows:?? ð ??"ð ??" ??? ??**(10)**

where ?? ?? is the minimum of the values obtained in Equations 6-9. The resistance factor ? = 0.7, 0.8, and 0.65 depending whether the failure is due to lateral torsional buckling, local instability in the flanges or webs, and rupture of the materials, respectively. The beam design load is expressed as:?? ?? = 1.2?? ?? + 1.6?? ??**(11)**

?? ?? ? ?? ð ??"ð ??" (12) For 8 x 4 x 0.5 in., the experimental lateraltorsional buckling load is found to be 4.70% higher than the predicted result. However, the experimental cracking Lastly, applying the formula of maximum moment for a simply supported beam with a point load as shown in Figure **??**, the respective loads are obtained: in which ?? ?? and ?? ?? are the dead and live loads for the beam. The proposed LFRD approach criterion for the member can finally be written as:

where ?? ?? and ?? ð ??"ð ??" are defined in Equations 10 and 11, respectively. Table 1 shows the maximum loads for the following I-beams: 3x1x0.25 in., 6x3x0.375 in., 8x4x0.5 in., 10x5x0.375 in., and 12x6x0.5 in. load is 27.60% lower than the predicted result. As seen in Table 1, for the first three I-sections namely 3x1x0.25, 6x3x0.375, 8x4x0.50, the failure mode is governed by lateral-torsional buckling. However, for the last two Isections namely 10x5x0.375 and 12x6x0.5, the failure mode is governed by material rupture.

4 IV.

A study on failure modes for I-section GFRP beams is presented. The predicted buckling load for the GFRP beam is in agreement with the experimental value. Based on the analysis for the member length considered, the failure mode is governed by lateraltorsional buckling for smaller and medium cross sections. However, the material rupture governs the failure mode for the bigger sections.

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Figure 1: Fig. 2 :) 2 2 + 3 ?? ?? ?? ?? 3 ,

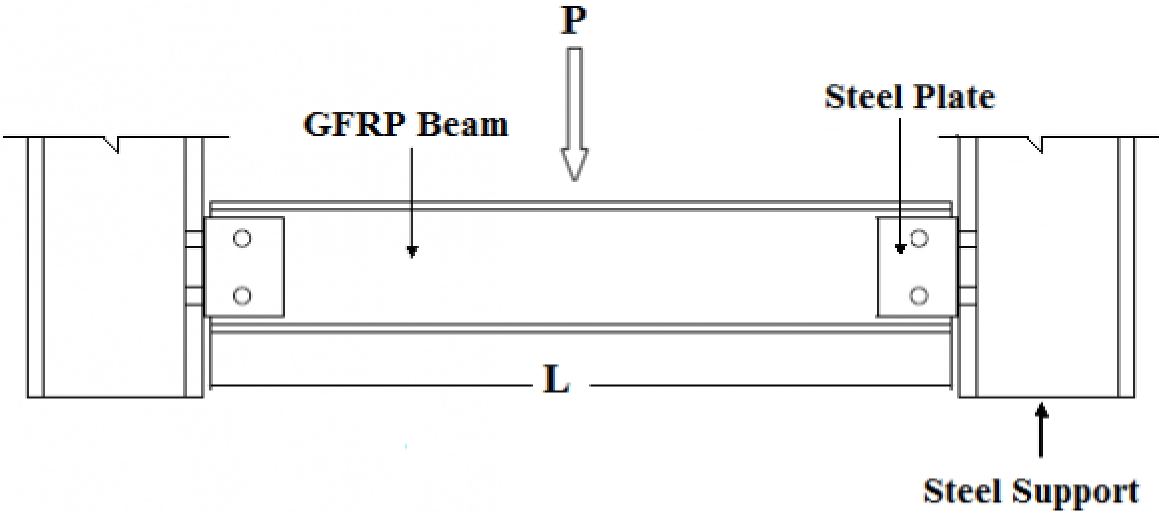

Figure 2: Failure

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I -Section	?P LB	?P fLB	?P wLB	?P cr
in.	lbs	lbs	lbs	lbs
3x1.5x0.25	170	2526	35389	8867
6x3x0.375	2041	8506	162479	4980
8x4x0.50	8026	20162	385136	11804
10x5x0.375	13581	15522	279162	13890
12x6x0.5	37399	20220	592231	26635

Figure 3: Table 1 :

[Razzaq et al. (30 January-1 February)] ‘Flexural-Torsional Behavior of FRP Channel Section Beams’. Z Razzaq , R Prabhakaran , M B Sirjani . *Proceding 50 th Annual Conference, Composites Institute, The Society of the Plastic Industry*, (eding 50 th Annual Conference, Composites Institute, The Society of the Plastic IndustryInc., Cincinnati, Ohio) 30 January-1 February.

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