STIFFNESS OF THIN-WALLED CHASSIS REINFORCED BY VERTICAL L-GUSSET PLATE UNDER BENDING AND TORSIONAL LOADS

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ABSTRACT: It has been a great concern to increase the efficiency of a vehicle in the automotive industry. Typical energy breakdown of the energy consumption reveals that around 22% of the total fuel energy were used, where the rest were loss to the environment. Huge reserved of fuel can be made when a fraction of the loss can be minimized. Thin-walled chassis is one of the suggested methods in order to reduce weight of a vehicle. However, it was also debated that the beam or shell model might lose its ability to withstand forces acting on it when the critical load reach the highest point. Thus, this study intended to analyze the effect of gusset plate reinforcement on chassis towards bending and torsional load. From the study, it was found that the bending stiffness of the chassis reduced about 222.45% and increase about 84.75% for torsional stiffness. Hence, it can be concluded that gusset plate reinforcement designed and placed in this study is a good alternative to improve torsional stiffness and not the bending stiffness of thin-walled chassis.

KEYWORDS: *thin-walled chassis; thin-walled beam; bending; torsion;*

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1.0 INTRODUCTION

It is well known that weight is an important feature in designing and fabricating a vehicle in order to improve the performance in automotive industry. The performance that often discussed in passenger car are speed, acceleration, and fuel consumption. There were plenty of research has been conducted in order to increase the performance of vehicle including modification of engine and body design, additional of component to increase the effectiveness of combustion, introduction of new type of lubricant, and reduction of vehicle's weight [1–6].

Despite those improvements, it has to be highlighted that altering or modification of a structure must not compromise the strength and stiffness of a vehicle since these parameters has huge effect on the safety and ride comfort for drivers. This issue has been highlighted by other researchers where simulation software are the simplest possible method to alter the weight of a vehicle structure without jeopardizing the safety of the vehicle [7, 8].

Thin-walled chassis is one of the suggested methods in order to reduce weight of a vehicle. However, it was also debated that the beam or shell model might lose its ability to withstand forces acting on it when the critical load reach the highest point [9], [10]. It was also point out that high stress could cause failure on the thin-walled chassis. Apart from that, it was also highlighted that acceptable bending and torsional rigidity are also needed for a better handling feature [8, 11–13].

Chassis stiffness generally indicates the resistance to bending or flexing meanwhile torsional stiffness indicates the resistance to twisting. Solid structure has high resistance to bending and torsion meanwhile thin-walled structure are not so great in resisting these forces. When subjected to compression in flexural bending, axial compression, shear or bending, thin elements may buckle locally at stress level lower that the yield point of steel. Thin-walled column are often presents failure such as Euler buckling and localize buckling [8]. Hence, in order to retain the low weight and not compromising the buckling resistance, this study attempt to introduce additional gusset plate as additional member in order to improve the stiffness of thin-walled chassis for bending and torsional loads.

2.0 METHODOLOGY

This study is focusing on the experimental work to analyze the performance of gusset plate as reinforcement element on thin-walled chassis structure. The test was carried on 2 loading conditions in order to evaluate the strength and stiffness of thin-walled chassis (with and without gusset plate). The relation between stress, stiffness and load for both models and loading condition will be obtained from the test finding.

2.1 Preparation of Thin-Walled Chassis for Testing

In this study, thin-walled beams were used to replicate the thin-walled chassis by using MIG technique. For reinforced thin-walled chassis, thin plate was used as gusset plate to reinforce the joint areas. The detail of beam and plate used were shown in Table 1 meanwhile the design for both thin-walled chassis (with gusset and without) are shown in Figure 1.

Table 1: Detail of beam and plate used for chassis fabrication

	Beam	Gusset plate
Materials	ASTM A36 Structural steels	
Ultimate Strength	400 – 500 Mpa	
Yield Strength	250 MPa	
Modulus of Elasticity	200 GPa	
Bulk Modulus	140 GPa	
Thickness	1.2 mm	
Size	50 x 50 mm	100 x 50 mm

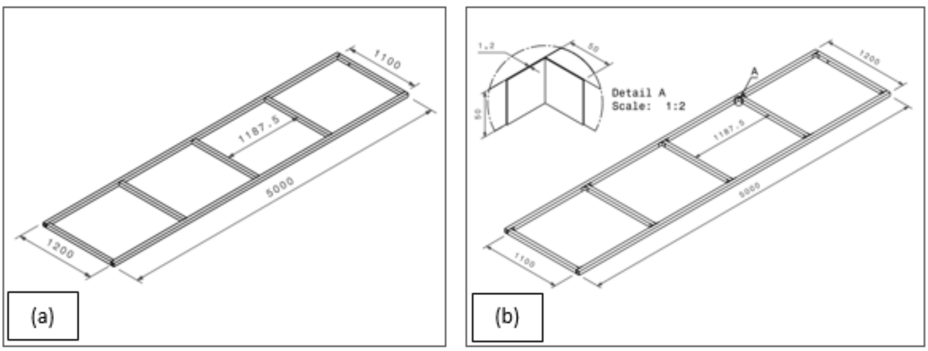

Figure 1: Detail dimension for (a) thin-walled chassis and (b) thin-walled chassis with gusset plate

2.2 Experimental Setup

The test was set up in order to test the beam based on bending and torsional test. The experimental setup is shown in Figure 2. Both with and without gusset plate will be tested at the same condition as shown in Figure 3. For bending test, load will be placed on the centre of the chassis meanwhile for the torsion test, the load will be placed at the 1 edge of the chassis. In both conditions, the load will be controlled by a hydraulic jack that was connected with load cell and data logger to record the force exerted.

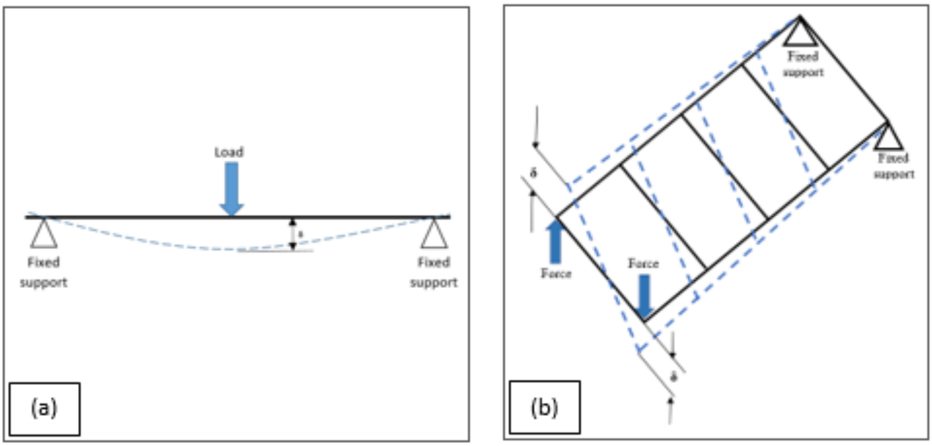

Figure 2: Experimental setup for the loading condition of the chassis

Figure 3: Bending and torsional loading condition

3.0 RESULTS AND DISCUSSION

The deflection of the chassis was recorded each time the load increased. The data collected were then plotted into force against displacement as shown in Figure 4 and 5. Then, best fit lines are plotted for both with or without gusset reinforcement are compared in order to obtain the percentage difference. The differences are shown in Table 2.

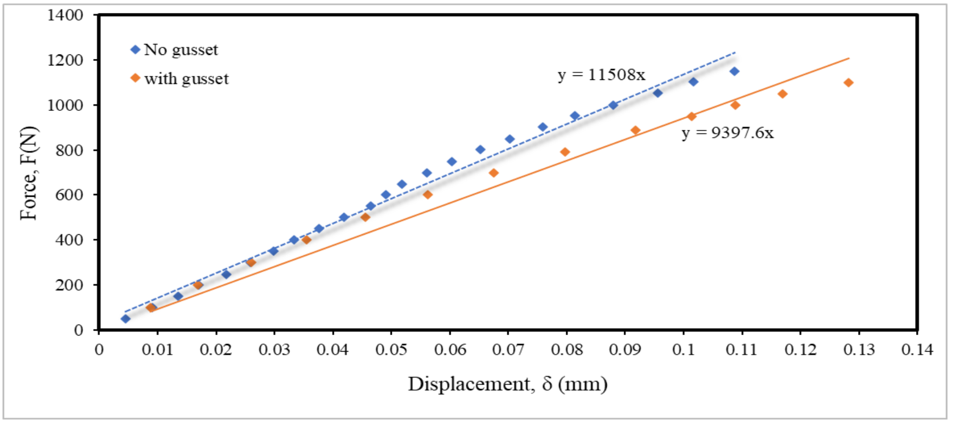

Figure 4: Graph plotted for bending test

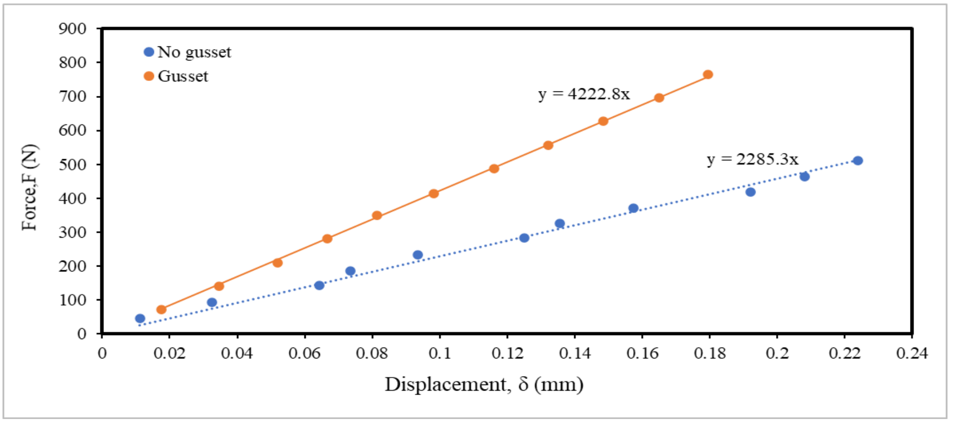

Figure 5: Graph plotted for torsional test

Table 2: Differences between slopes for bending and torsion test

Type of test	Differences (%)
Bending	-22.45
Torsion	84.78

From Figure 4, it can be seen that chassis with no gusset reinforcement has lower displacement compared to chassis with gusset reinforcement. Meanwhile, Figure 5 shows that chassis with gusset reinforcement was indeed has lower displacement compared with chassis without gusset. When comparing the differences based on the best fit line slopes, it can be said that additional of gusset reinforcement on chassis structure has weaken the structure by 22.45 % (by 0.22 times) in withstanding the bending but increase the resistance in torsion by 84.78% (0.85 times).

Here, it can be seen that the additional of gusset plate are only effective in withstanding the torsional force and not the bending force. It was believed that the position of the placement of the gusset plate plays an important role in determining the stress distribution along the structure. This was in agreement with other research where the performance of the strengthening scheme depends upon the size of the core material, the presence of bond between the steel plate and core material, and the existence of extra plates for double angle members [14]. It was also discussed and suggested by other researcher that the reinforcement could be in a more 3-dimension structure with combinations of two or more materials [15–19].

4.0 CONCLUSION

In this research work, the effect reinforcement of gusset plate to increase the strength of stiffness of thin-walled chassis under bending and torsional loads were identified. From this study, it was found that the reinforcement of gusset plate weakens the chassis structure by 22.45% for withstanding bending load and increase the integrity by 84.78% for withstanding the torsional load. It was suggested that in the near future, this study can be improved by variates the type and location of gusset placement.

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