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Design, Analysis and Testing of Square Bar Welded and Bent Chasis for Indonesian Rural Transport Vehicles

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Abstract**—** *The chassis design has been done for rural transportation vehicles in Indonesia with welding and bending methods. The result of static analysis using ANSYS software shows that the chassis produced by the welding and bending method has the same performance if seen from bending load and torque. Likewise with the results of construction tests, welded chassis and bent chassis has a linear approaching deformation characteristic, proportional to the force load. However, the characteristic of chassis deformation of bent chassis is only linear up to 3.3 Nm load, then decreases drastically at more than 3.3 Nm of loading. In torsional tests, welded chassis and bent chassis have the same linear deformation characteristics, but the performance of the welded chassis is better than the bent chassis. Overall, ANSYS simulation and Static test results for a 250 Nm load indicates that the welding chassis and bent chassis are both still under the permitted critical conditions or it is secure against the provided loads.*

Keyword—Bending chassis, welding chasis, bending test, torsional test

I. INTRODUCTION

The frame is defined as a fabricated structural assembly that supports all functional vehicle systems. This assembly may be a single welded structure, multiple welded structures or a combination of composite and welded structures [1]. The materials used for the construction of the frame must be rigid and strong so that it can withstand shocks, bends, pressures and vibrations during operation on the road. As it is known that some of the main functions of the chassis frame are as below:

1. To carry all stationary loads attached to the chassis and load of passengers and transported goods.
2. To withstand the torque and vibrations caused by the movement of the vehicle.
3. To resist the centrifugal force that occur when the vehicle is cornering.
4. To control the vibrations that occur when the vehicle is operating.
5. To withstand the bending stress due to up and down and/or front and back axles movements.

The type of chassis that is created and analyzed is ladder frame type made by using 2 (two) methods involving welding and bending. The performance between ANSYS structure simulation and the real construction test of chassis prototype will be compared. Depending upon application of loads and their direction, chassis is deformed in respective manner briefed as follows Longitudinal Torsion, Vertical Bending, Lateral Bending, Horizontal Lozenging [2]. To calculate the structural strength, some assumptions are made which are:

1. The loads that work on the chassis are considered to be evenly distributed.
2. The welding and bending joints on the chassis are considered to be perfectly bonded.
3. The strength and deflection that occur are calculated based on the total load.

The research was conducted in order to learn the chassis production technique of rural transport vehicles, which is currently being run by the Indonesian government.

II. RELATED WORK

A. Hari Kumar CS [3] used ANSYS 14.5 Softwareis to find out best material and most suitable cross-section for an Eicher E2 TATATruck ladder frame chassis with the constraints of maximum shear stress, equivalent stress and deflection of the chassis under maximum load condition. Dhandapani Cs [4] performs a torque load analysis by providing a load on the front and the back of the dump truck chassis, diagonally vertical upward and vertical downward directional loads acts on the chassis. In this research the torque load test is performed only on the front of the chassis, by giving the load on two sides of the frame opposite, while the back of the chassis is clamped.

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To measure the torsional stiffness, Mr. Navnath V. Cs [5] used two dial indicators was used at front end to measure the opposite resultant vertical deflection at the left and right front knuckles and two at rear end. The load was added at load at the side rear right to avoid the tilting of test rig and fixed the rear part of test rig. .The chassis is twisted in increments by loading masses at load at the side front left in steps with deflection data recorded by using dial indicator at each step at front and rear side. After adding the load equal to require torque final deflection was measure and then the twist angle is reversed until reaching zero by unloading masses in steps. In this research, to know the magnitude of deformation and strain occurring on the chassis as a result of static load bending and torque, it will be measured with a strain gauge and dial indicators sensor. Placement of strain gauge sensors on chassis is done based on the critical position obtained from ansys simulation result.

III. MODEL DESIGN AND FINITE ELEMENT ANALYSIS OF CHASIS D

Taking into consideration: the strength in load support, light construction, and ease of manufacturing process; the material to be used in manufacturing chassis is Structural carbon steel SS 400 ≈ ASTM A36. The properties of this material can be seen in Table 1.

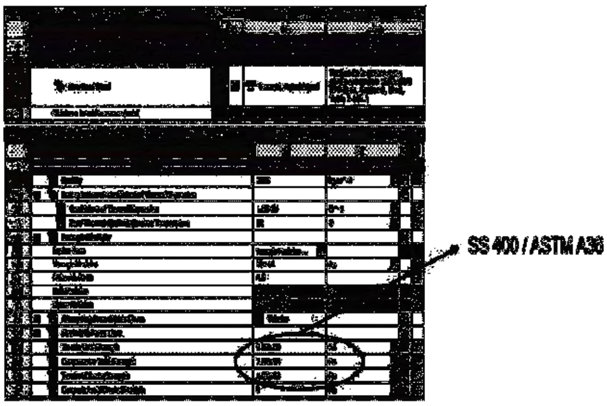

Table 1. Mechanical properties SS 400

The CAD software used for 3D modeling of chassis components (welding and bending) was CATIA. The 3D model is then exported to ANSYS software for FEM analysis.

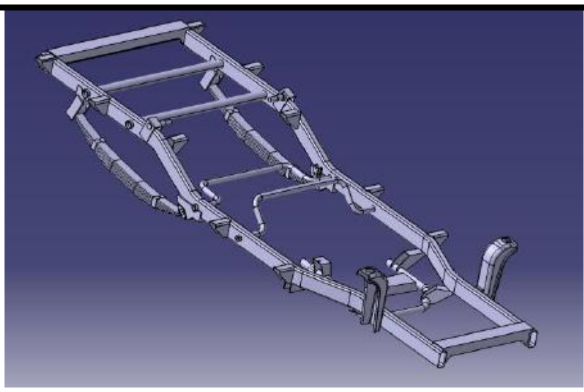

Fig.1: 3D model Chassis

3.1. Meshing and Boundary condition

The chassis is modeled as a square hollow beam element and the determination of the boundary condition is given evenly over the chassis range. For practical reasons, it is recommended that the load on the chassis frame, including its own weight should be applied at the joints (nodes) of structural members. These point loads were statistically equivalent to the actual distributed load carried by the vehicle [6]. Figure 2 shown chasis load distribution. The analysis was performed with some limitation as follows:

1. Bending load was 250 kgf or 2500 N (see area C in figure below).
2. Fixed support was on the front suspension holder area (see area B in the picture below)
3. Roll support was on the rear suspension mounting area (see area D in figure below).

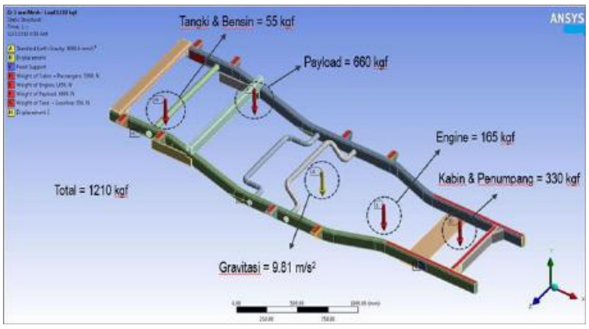

Fig.2: Chasis Load Distribution

The mesh used on the model was a combination of the tetrahedron and hexagonal. The mesh density used for welded chassis was 828,143 elements, 1,977,273 nodal, and 5,931,819 degrees of freedom, while for bent chassis was 853,764 elements, 2,033,171 nodal, and 6,099,513 degrees of freedom.

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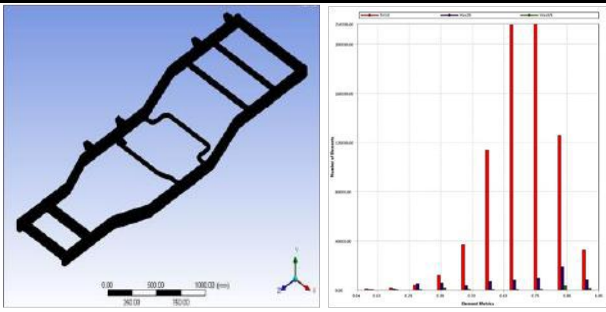

Fig.3: a. Mesh condition and quality matrix of welded chassis.

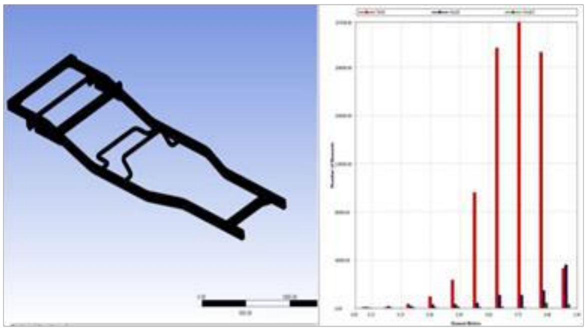

Fig.3: b. Mesh condition and quality matrix of bent chassis.

3.2. Total Deformation Analysis Due to Bending Load

The analysis results for maximum deformation on welded chassis and bent chassis with load up to 250 kg are as seen in Figure 4 and 5.

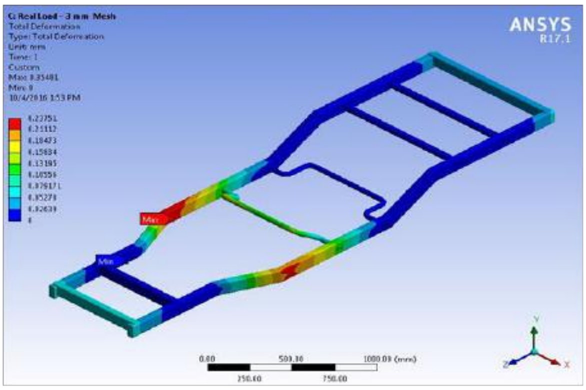

Fig.4: The result of total deformation for welded chassis

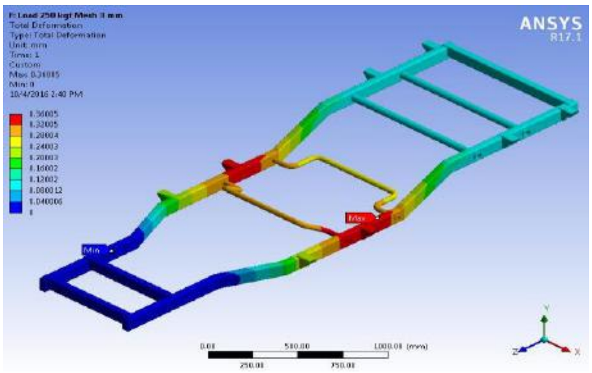

Fig.5: The result of total deformation for bent chassis

From figure 4 and 5, maximum deformation for welded chassis is 0.23751 mm, while for bent chassis is 0.36005 mm.

3.3. Equivalent Stress Analysis

Based on figures 6 and 7, the maximum equivalent stress obtained for the welded chassis is 110.97 MPa. While for the bent chassis is 66.681 MPa.

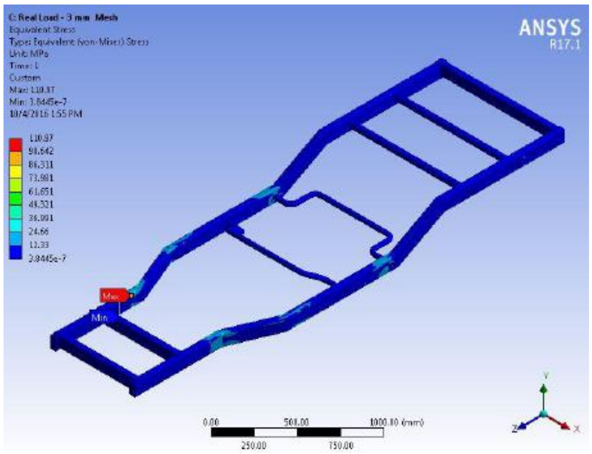

Fig.6: The result of equivalent stress for welded chassis

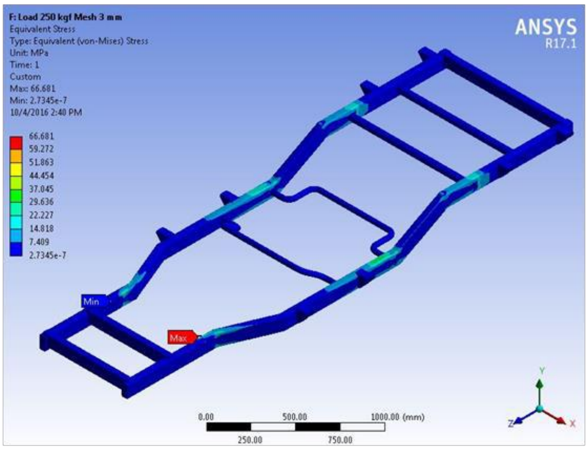

Fig.7: The result of equivalent stress for bent chassis

The ANSYS analysis of Welded and Bent chassis can be seen in Table 4.

Tabel. 2 ANSYS Bending load analysis

No.	Description	Welded Chassis (W)	Bent Chassis (B)
1	Load	250 kgf	250 kgf
2	Meshing		
	- Density	828,143	853,764
	- Nodes	1,977,273	2,033,171
	- Degree of freedom	5,931,819	6,099,513

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3	Maximum Total Deformation	0.2375 mm	0.3600 mm
4	Maximum Equivalent Stress	110.97 Mpa	66.68 MPa

3.4. Deformation Analysis Due to Torque Load

The torque load is given at the front end of the chassis frame in opposite directions (up and down by 250 Kgf) The analysis results with ANSYS software is shown in Figure 8 and Figure 9.

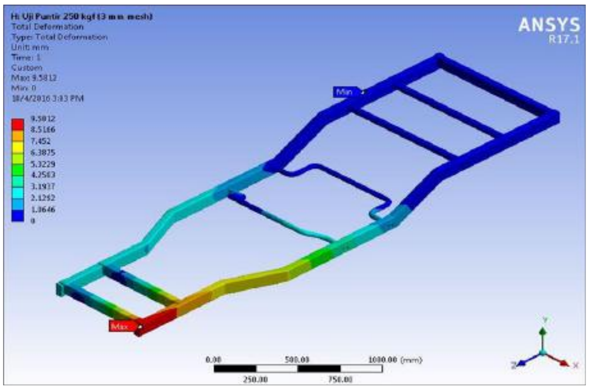

Fig.8: The result of total deformation for welded chassis due to torque load

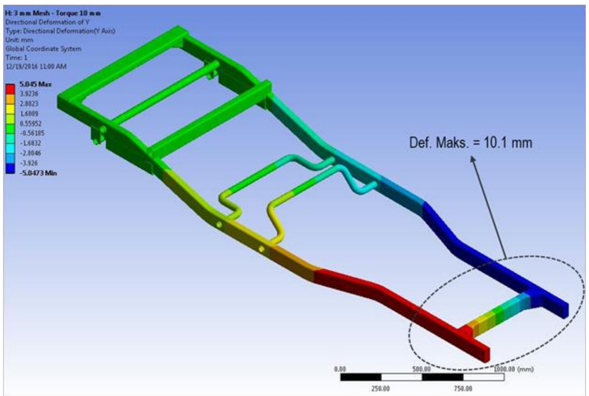

Fig.9: The result of total deformation for bent chassis due to torque load

From Figures 8 and 9, it can be concluded that the maximum total deformation due to torque load for the welded chassis is 9.5812 mm. while for the bent chassis is 10,090 mm.

The ANSYS results of Welded and Bent chassis due to torque load can be seen in Table 5.

Table.3: ANSYS Torque load analysis

No.	Description	Welded Chassis (W)	Bent Chassis (B)
1	Load	250 kgf	250 kgf
2	Meshing		
	- Density	828,143	853,764
	- Nodes	1,977,273	2,033,171
	- Degree of freedom	5,931,819	6,099,513
3	Maximum Total Deformation	9.5812 mm	10.0900 mm

From the analysis result of bending load, it can be concluded that the performance of welded chassis is equivalent with bent chassis. Similarly, for the torque load, the performance of welded chassis is also equivalent with bent chassis. This can be seen from the maximum total deformation value of both chassis is not so much in different.

IV. CONTRUCTION TEST OF PROTOTYPE CHASIS

The prototype chassis construction testing is intended to compare and verify the design and simulation results with its real condition. The test was performed in the same condition with the simulation, by providing static load (bending) and torque load on the chassis construction.

To know the amount of strain that occured, strain gauges were mounted at some critical areas of chassis which location was determined from ANSYS analysis result. While the magnitude of deformation was measured by placing two dial indicators under the loading position (hydroulic). The position of the strain gauge sensors and the dial indicators can be seen in Figure 10.

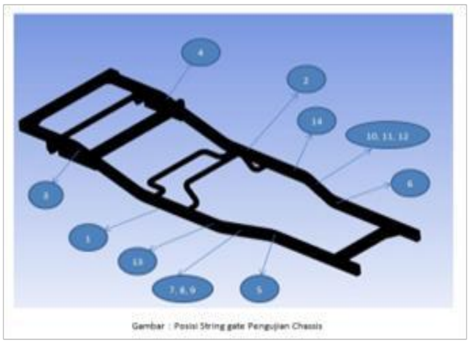
Fig.10: The Position of strain gauge sensors on the chassis

4.1. The Bending Test of Welded and Bent Chassis

The bending load was applied on the center of the chassis or at the Center of Gravity (CoG) position of the vehicle, with a deformation limit of 2.5 mm. The test configuration can be seen in Figures 11 and 12. The strain and deformation values that occurred were recorded with the data record equipment as shown in Figure 13. The test results then plotted in graphic of load versus deformation that can be seen in Figure 14.

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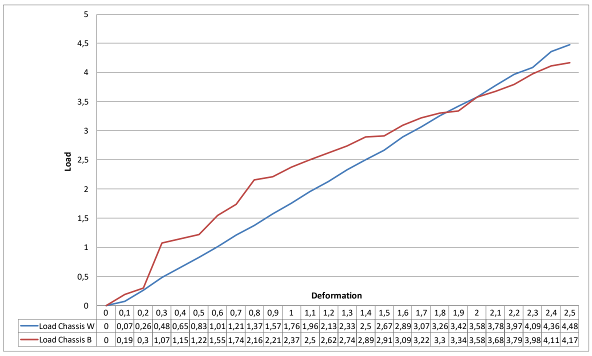
Fig.11: Bending test on welded chassis

Fig.12: Bending test on bent chassis

Fig.13: Data loger / recorder



	0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1	1,1	1,2	1,3	1,4	1,5	1,6	1,7	1,8	1,9	2	2,1	2,2	2,3	2,4	2,5
Load Chassis W	0	0,07	0,26	0,48	0,65	0,83	1,01	1,21	1,37	1,57	1,76	1,96	2,13	2,33	2,5	2,67	2,89	3,07	3,26	3,42	3,58	3,78	3,97	4,09	4,36	4,48
Load Chassis B	0	0,19	0,3	1,07	1,15	1,22	1,55	1,74	2,16	2,21	2,37	2,5	2,62	2,74	2,89	2,91	3,09	3,22	3,3	3,34	3,58	3,68	3,79	3,98	4,11	4,17

Fig.14: Bending Test Graph of load versus deformation

4.2. The Torque Test of Welded and Bent Chassis

In torque test, the position of the strain gauge sensors were the same as the bending test, but the dial indicators position were moved to the under of torque load. The torque load was applied on the front side of the chassis, with a deformation limit of 6 mm. Figures 15 and 16 shown the torque test process. The test results then plotted in graphic of load versus deformation that can be seen in Figure 17.

Fig.15: Torque test on welded chassis

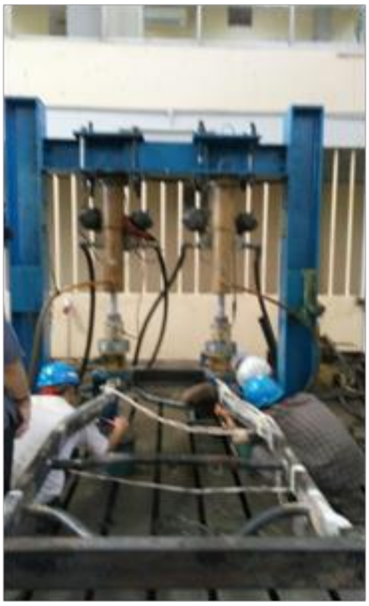
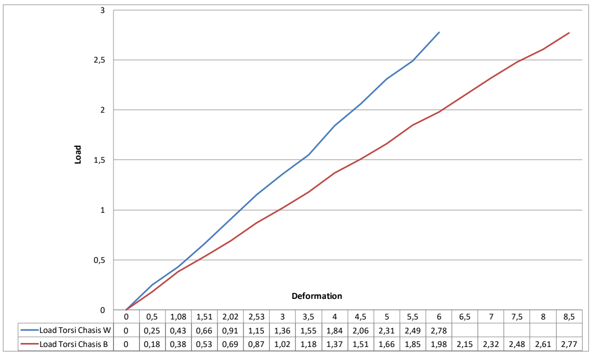


Fig.16: Torque test on bent chassis



	0	0,5	1,08	1,51	2,02	2,53	3	3,5	4	4,5	5	5,5	6	6,5	7	7,5	8	8,5
Load Torsi Chasis W	0	0,25	0,43	0,66	0,91	1,15	1,36	1,55	1,84	2,06	2,31	2,49	2,78					
Load Torsi Chasis B	0	0,18	0,38	0,53	0,69	0,87	1,02	1,18	1,37	1,51	1,66	1,85	1,98	2,15	2,32	2,48	2,61	2,77

Fig.17: Torque Test Graph of load versus deformation

4.3. Test Result Analysis

Based on the above test results, can be obtained information as follows:

1. For the bending test, the deformation took place on both welded and bent chassis has linear characteristics.
2. Based on the graph, at a force level less than 3.3 kN, the deformations happened on bent chassis had a lower value than welded chassis, but at a force level greater than 3.3 kN, the deformations received by welded chassis had a lower value than bent chassis.
3. For the torque test, the deformation occurred on both chassis was linear and increased proportionally to the load increment. Nevertheless, the performance of welded chassis was better than bent chassis.

V. CONCLUSION

Based on the results of finite elements analysis and construction test of the prototype chassis, can be concluded that:

a. The FEM analysis result with 250 kgf bending load has shown that the welded chassis had less total maximum deformation value (0.2375 mm) than bent chassis (0.351 mm).

b. The FEM analysis result with 250 kgf torque load has shown that the welded chassis had less total maximum deformation value (9.6 mm) than bent chassis (10.09 mm).

c. Both welded and bent chassis are still safe against given loads and boundary conditions, according to the result from FEM analysis and construction test.

d. The decreasing of bent chassis performance at force level above 3.3 kN in the construction test was allegedly due to microstructural change developed during hot bending process. The structural, fatigue, and wear strength were affected by this heat exposure.

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REFERENCES

[1] Ravinder Pal Singh, "Structural Performance Analysis of Formula SAE Car", Journal Mekanikal No 31, Page 46-61, Desember 2010.

[2] Riley, W.B., George, A.R. "Design, Analysis and Testing of Formula SAE Race Car Chassis", SAE paper 2002-01-3300, Motorsports Engineering Conference and proceedings, 2002.

[3] A. Hari Kumar, V. Deepanjali, "Design Analysis of Automobile chasis", International Journal of Engineering Science and Innovative Technology (IJESIT) Volume 5, Issue 1, page 187-196, January 2016

[4] Dhandapani N V. Guide(s):, Mohan Kumar G," Modeling, design and analysis of heavy vehicle chassis for the effects of various stress distribution ", shodhganga.inflibnet.ac.in, chapter 3, page 70-92, 2012

[5] Mr. Navnath V. Palde, SVIT Nashik, Prof. V.L.Kadlag, SVIT Nashik, "Design improvement and analysis of car chassis for Static and Dynamic Characteristics", International Engineering Research Journal Page No 238-244

[6] Fui, T.H., Rahman, R.A., 2007. Statics and Dynamics Structural Analysis of a 4.5 Ton Structural Analysis, Jurnal Mekanikal, 24, 56-67.