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Buckling analysis on various material profiles for truck chassis of ladder frame type

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Abstract: The chassis is the most critical component of a truck as it greatly impacts the safety and weight of the vehicle. There are three common profiles used for truck chassis, namely, C-channel, U-channel, and rectangular tube. This study aims to determine the most suitable profile for use as a truck chassis through finite element analysis, specifically, buckling analysis. The variables measured for each test profile include free vibration, buckling safety factor, and deformation scale. The results show that the C-channel profile is the most ideal for use as a truck chassis. The simulation revealed a buckling safety factor greater than 1 and the smallest average deformation in each shape mode. The U-channel profile has a lower weight but a higher deformation scale than the C-channel profile. On the other hand, the rectangular tube profile has the highest safety factor in each shape mode but the largest deformation scale and weight.

Keywords: Truck chassis, FAE, Ladder frame, Buckling study

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1. Introduction

Manufactured truck chassis must meet stringent requirements to ensure driver safety, be light to minimize fuel consumption, and be simple to minimize production costs. The truck chassis serves as the shell that supports all of the truck's components, houses and protects the driver, and mounts the suspension to withstand all the forces of the tires (Krzikalla et al., 2020). A strong, non-heavy chassis can provide sufficiently high crash energy that the truck chassis is more likely to break in the event of a crash. Vibration is an important consideration when designing a truck chassis, as road excitation forces on the truck cause random vibrations and noise that affect occupant comfort (Muzakkir and Natrayan, 2022).

Ladder frame are widely used as chassis forms for large trucks and sport utility trucks because they are simple and sturdy. The chassis design consists of two symmetrical frame rails along the length of the truck, connected by several transverse frames. The profile materials used for frame rails differ as follows: C- channel, U channel and rectangular tube. Each car uses different material profiles for the chassis, requiring a detailed study of the materials used for safety and comfort (Baroux et al., 2021; Kengkongan et al., 2020; Widiyanto et al., 2021).

This study aims to analyze the profile shapes used for frame rails on ladder frames. The analysis is carried out to see the bending of the structure when it is given a load. The chassis is usually defined as the frame (backbone) of the car and is the most important part that buckles (Hedayati et al., 2015). Therefore, the right type of material profile must be selected so that it can withstand dynamic and static loads.

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2. Methods

Buckling analysis was performed using Solidworks Research License 2021-2022. The use of Solidworks can find out the types, critical points in a design (Vardaan and Kumar, 2022). The phenomenon of impact and buckling on materials that have rigidity properties is very difficult to analyze because of the very complex conditions at the time of contact between metal materials with one another, including deformation and friction of metal molecules (Li et al., 2004). Material for chassis used AISI 4130 Steel.

Table 1. Properties of AISI 4130 steel

Property	Value
Elastic modulus	205000 N/mm^2
Poisson' ratio	0.285
Shear modulus	80000 N/mm^2
Mass density	7850 Kg/M^3
Tensile strength	731 N/mm^2
Yield strength	460 N/mm^2

The independent variable in this research is material profile used make truck chassis, as follows: C channel, U channel, and rectangular tube (Figure 1). The length of the test object is 1000 mm. Each test model is given a critical load (P_{cr}) of 98100 N with a clamp type of support. Mesh uses a Curvature-based mesh type with a fine mesh size. The variables observed in each test model are the free vibration, buckling safety factor and deformation scale.

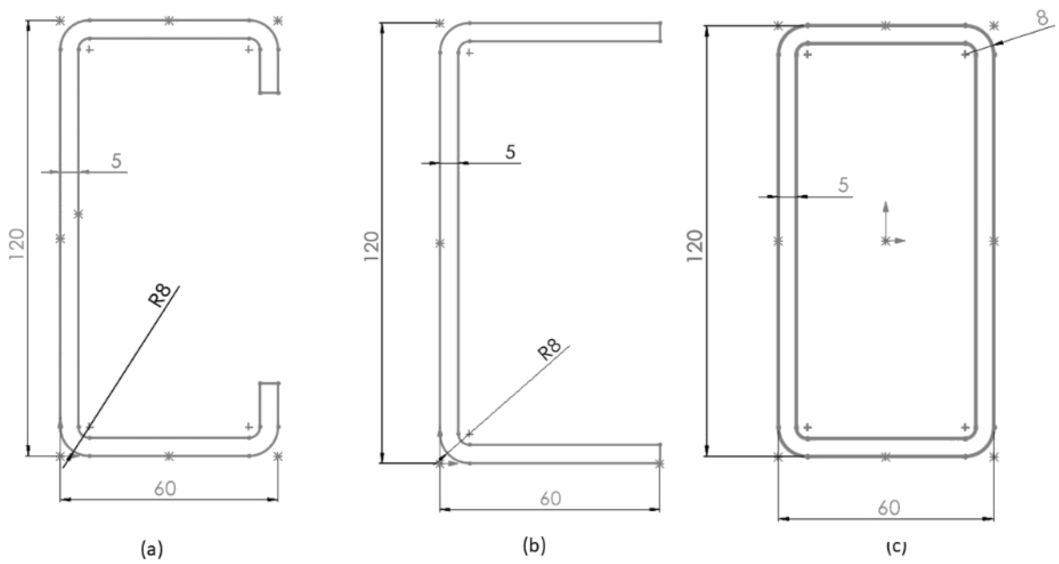
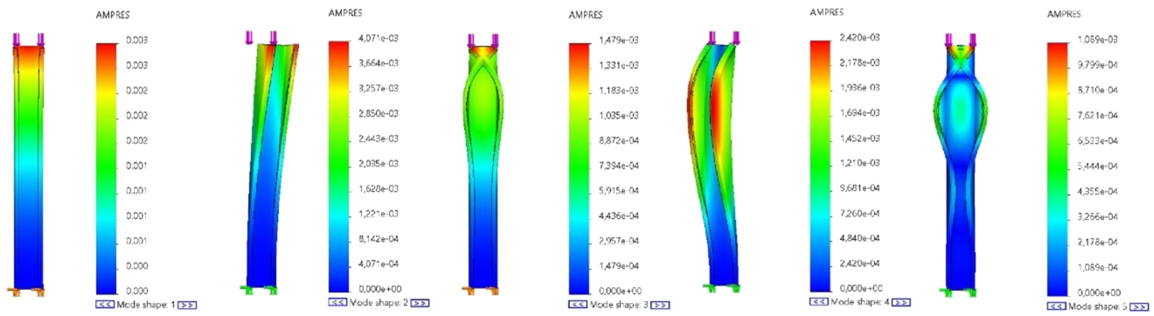


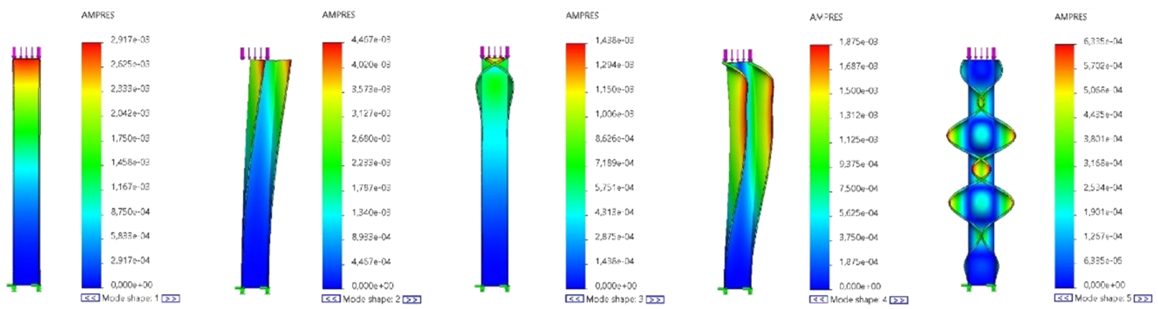
Figure 1. (a) C channel, (b) U channel, and (c) rectangular tube

3. Results and discussions

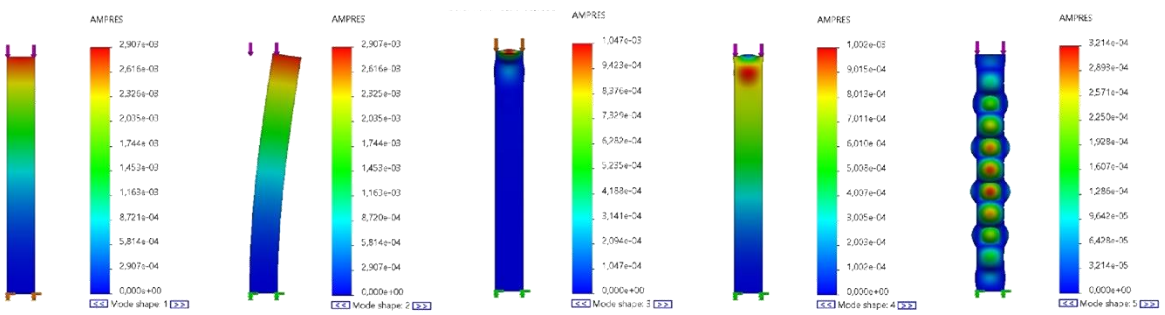
In this study, free vibration for each material profile if it exceeds the critical load is shown in Figure 2. The load frequency given to each material profile is not repetitive but static. Buckling factor of safety for each material profile for each free vibration (table 2). Buckling factor of safety > 1 can be said to be safe, whereas if 0 < buckling factor of safety > 1 it is stated in a dangerous condition. All material profiles have a buckling factor of safety > 1, so it can be said that the three material profiles are safe to use. In the shape mode of all the material profiles the highest buckling factor of safety is the rectangular tube profile. The lowest buckling factor of safety in each shape mode is the U channel profile.



(a)



(b)



(c)

Figure 2. Free vibration on each profile material (a) C channel, (b) U channel, and (c) rectangular tube

Table 2. Buckling factor safety on each profile material

Mode Shape	Buckling Factor Safety		
	C channel	U channel	Rectangular tube
1	2.8637	1.9893	4.8885
2	3.1806	2.8123	14.776
3	9.9285	8.0102	17.11
4	15.211	10.002	19.342
5	16.23	11.701	31.033

The deformation scale for each material profile is presented in table 3. The largest deformation scale occurs in the rectangular tube profile in shape 5 mode of 311.137 and the lowest is in the U channel profile in shape 2 mode of 27.031. However, on average for each shape mode, the C channel profile has the lowest profile.

Table 3. Deformation scale on each profile material

Mode Shape	Buckling Factor Safety		
	C channel	U channel	Rectangular tube
1	34.074	34.2976	34.4375
2	28.0673	27.031	34.5506
3	79.4841	77.2533	95.8552
4	47.6888	65.56	99.8388
5	99.2312	158.962	311.137

Judging from the weight of each material profile, the lowest is the U channel profile of 8842.19 grams, the C channel is 9834.38 grams and the heaviest is the rectangular tube of 12974.38 grams. Minimum weight is one of the important factors in the car industry (Speirs et al., 2020). The U channel profile does have the lowest weight but the shape 1 mode has the lowest buckling factor safety. However, the selection of the material profile to be used for the truck chassis is a safety factor, because this will be related to safety.

4. Conclusions

The selection of the truck chassis profile is critical as it is a significant aspect of automotive design. Based on a comparison of the buckling study results for each material, the C-channel profile is the most suitable. The safety factor of the C-channel profile is greater than 1, and the average deformation scale for each model is the lowest.

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Declarations

Author contribution

Chau Trung Tin played a role as the conceptual developer of this research, performed data analysis and processing, while Hla Myo Tun contributed to the article writing, manuscript editing, and research execution.

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Conflict of interests

The authors declare no conflict of interest.

Ethical clerance

There are no human subjects in this manuscript and informed consent is not applicable.

References

Baroux, E., Delattre, B., Constantinescu, A., Pamphile, P., Raoult, I., 2021. Analysis of Real-Life Multi-Input Loading Histories for the Reliable Design of Vehicle Chassis. Procedia Structural Integrity 38, 497–506. https://doi.org/10.1016/J.PROSTR.2022.03.050

Hedayati, E., Hedayati, A., Vahedi, M., 2015. Critical Buckling load Analysis of Truck Chassis Using Arclength Method. Journal of Engineering Research 2015 3:2 3, 1–12. https://doi.org/10.7603/S40632-015-0018-3

Kengkongan, A., Rio, A., Imaduddin, F., 2020. Structural assessment of an energy-efficient urban vehicle chassis using finite element analysis - A case study. Procedia Structural Integrity 27, 69–76. https://doi.org/10.1016/J.PROSTR.2020.07.010

Krzikalla, D., Slíva, A., Měsíček, J., Petrů, J., 2020. On modelling of simulation model for racing car frame torsional stiffness analysis. Alexandria Engineering Journal 59, 5123–5133. https://doi.org/10.1016/J.AEJ.2020.09.042

Li, S., Bourke, M.A.M., Beyerlein, I.J., Alexander, D.J., Clausen, B., 2004. Finite element analysis of the plastic deformation zone and working load in equal channel angular extrusion. Materials Science and Engineering: A 382, 217–236. https://doi.org/10.1016/J.MSEA.2004.04.067

Muzakkir, A.M., Natrayan, L., 2022. Dynamic analysis and structural simulation of aluminum composite material based automobile chassis. Mater Today Proc 62, 2244–2249. https://doi.org/10.1016/J.MATPR.2022.03.466

Speirs, J., Balcombe, P., Blomerus, P., -, al, Tong, F., Wolfson, D., Jenn, A., Vardhan Reddy, H., Charan Undamatla, S., Rangarajan Sagunthala, T.R., 2020. Design and Structural Analysis of Truck Frame. IOP Conf Ser Mater Sci Eng 923, 012012. https://doi.org/10.1088/1757-899X/923/1/012012

Vardaan, K., Kumar, P., 2022. Design, analysis, and optimization of thresher machine flywheel using Solidworks simulation. Mater Today Proc 56, 3651–3655. https://doi.org/10.1016/J.MATPR.2021.12.348

Widiyanto, I., Sutimin, S., Laksono, F.B., Prabowo, A.R., 2021. Structural assessment of monocoque frame construction using finite element analysis: A study case on a designed vehicle chassis referring to ford GT40. Procedia Structural Integrity 33, 27–34. https://doi.org/10.1016/J.PROSTR.2021.10.005