Comparative Study of Structural Strength in the Selection of VU-EV Car Chassis Materials (Vokasi Unesa-Electrical Vehicle) Using Solidworks 2020 Software

Muhamad Nahrudin ibad[1], Ferly Isnomo Abdi[2], Firman Yasa Utama[3] , Andita Nataria Fitri Ganda[4]
[1,2,3,4]Jurusan Teknik mesin, Fakultas Vokasi, Universitas Negeri Surabaya, Surabaya, 60231, Indonesia
[1]muhamadibad.22045@mhs.unesa.ac.id
[2]ferlyabdi@unesa.ac.id
[3]firmanutama@unesa.ac.id
[4]anditaganda@unesa.ac.id

Abstract

The development of electric cars in recent years has changed very rapidly. The Vocational Faculty of Surabaya State University also wants to develop an electric car in the form of a golf car that is efficient and energy efficient. The chassis is one of the important parts of an electric car that functions as a support for the weight of the car. A simple and lightweight chassis design is one of the factors in saving energy, because the lighter the vehicle, the less power is used to move the vehicle. The selection of chassis materials is also very important because it affects the strength of the chassis and the weight of the chassis. Three materials are considered for making the chassis, namely; aluminum 6061-T6, AISI 4130 steel, and AISI 1020 steel. Structural strength testing uses a load pressure of 1500 N on the front of the chassis, 4000 N on the middle of the chassis, and 3000 N on the rear of the chassis. Structural analysis of the chassis using the FEA (Finite Element Analysis) method using Solidwork 2020 software. In the structural strength test, the stress and displacement values of each material were known: aluminum 6061-T6 = 7.251 Mpa and 0.199 mm, AISI 4130 steel = 10.815 Mpa and 0.065, and AISI 1020 steel = 11.151 Mpa and 0.065 mm.

Keyword: *Chassis, FEA, Stress, Displacement.*

I. INTRODUCTION

Transportation facilities are currently continuing to develop. One of them is electric cars which are currently being promoted by governments around the world, because electric cars are considered a good solution to significantly reduce dependence on oil or fossil fuels (Efendi, 2020). Electric cars have been considered one of the most effective ways to reduce carbon emissions and fuel consumption (Aprillia et al., 2024).

One type of electric car that has received special attention is the golf car. Golf cars are a means of transportation that is suitable for short distances, limited mobility in certain areas, and can even be made to carry many passengers (Sihombing et al., 2023). Golf cars are also suitable for use as campus infrastructure, used to pick up and drop off students from the gate to points in each faculty around the campus. Facilitates student mobility to move from faculty to faculty.

This study focuses on the structural strength analysis of the VU-EV car chassis (Vokasi Unesa-Electrical Vehicle) by applying three different materials. Structural strength analysis uses the FEA (Finite Element Analysis) method on Solidworks 2020 software, which provides accurate structural analysis tools. This study aims to determine the stress and displacement values that occur in the VU-EV car chassis.

II. THEORY

The chassis is one of the most important parts of a car, which functions as a support for the weight of the vehicle (Kengkongan et al., 2020). The ladder frame chassis is a type of chassis commonly used in cars. Ladder Frame is a simple and oldest type of chassis, which is now widely used in electric cars. The ladder frame chassis is made of symmetrical steel material or a beam model. For some ladder frame designs, cross-sectional iron is generally added to maintain the rigidity of the structure (Arifin, 2017).

Structural strength testing on this chassis uses the FEA (Finite Element Analysis) method using Solidworks 2020 software. This method can solve complex structural problems in solid mechanics and identify how much stress, strain, and displacement occurs (Prasetyo et al., 2020). The advantage of using this FEA method is the minimal cost and time used, even this method can be used before making the actual prototype (Toteles, 2021).

Stress is one of the fundamental concepts in the analysis of the structural strength of an object, which is defined as the internal force per unit area acting on an object when subjected to an external load (Anggry A, 2021). Stress can be tensile or compressive, depending on the direction of the force applied. In the structural strength analysis of the VU-EV car chassis material, an understanding of stress is essential to ensure that the material is able to withstand dynamic and static loads during car operation. Displacement/deflection is a change in structure due to a force pressing on the structure. Deflection can be seen from how much structural change occurs due to loading from the point before loading (Radyantho et al., 2024). Deflection has limits in order to have good stiffness. In the IS 800:2007 standard for steel construction, the deflection limit is L/350, where for every length (L) of 1000 mm, the structure is deflected by a maximum of 0.35 mm (IS:800, 2007).

The materials used in the design of the VU-EV car chassis greatly affect the structural strength and weight of the car. In selecting the VU-EV car chassis material, aluminum 6061-T6 is an attractive material choice because it has a light weight and high strength. Aluminum 6061-T6 has a tensile strength (ultimate tensile strength) of around 310 MPa and an elastic modulus of around 70 Gpa (Tan & Said, 2009), making it ideal for application in the VU-EV car chassis that requires light weight and good strength.

AISI 1020 steel is a low carbon steel with a carbon content of around 0.20-0.30%, which provides an optimal combination of strength and ductility. AISI 1020 steel has a tensile strength of around 420 MPa and an elastic modulus of around 205 Gpa (Gusniar & Putra, 2021). Making it suitable for application in VU-EV car chassis that require resistance to static and dynamic loads.

AISI 4130 steel is an alloy steel containing chromium and molybdenum, which provides superior mechanical properties, including tensile strength of about 560 MPa and elastic modulus of about 210 GPa. AISI 4130 steel has good resistance to deformation and wear (Wasi & M, 2021), making it very suitable for application in VU-EV car chassis that require resistance to dynamic loads.

III. METHODE

A. Chasis Desain

The chassis model used in the VU-EV car is a ladder frame chassis type. This chassis design uses a hollow frame measuring 10 x 10 cm with a thickness of 1 cm. The chassis length is 2.87 m and a width of 0.8 m, with a total volume of 0.0274219 m3.

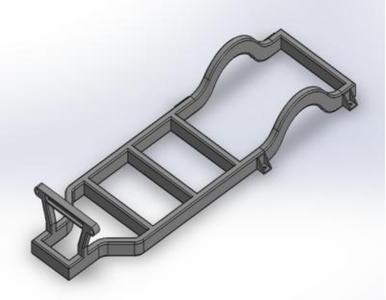

Figure 1. VU-EV Chassis Design
(Source: Solidworks, 2025)

B. Chasis Loading

The loading on the chassis was carried out at 3 different points with different force loads, including: 4000 N, 1500 N, and 3000 N, with the following details:

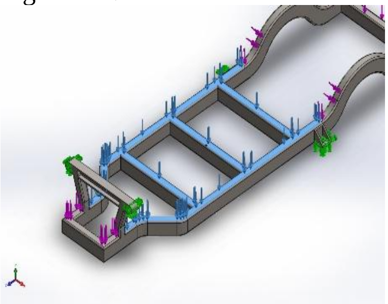

Figure 2. Chassis Loading with 4000 N Force
(Source: Solidworks, 2025)

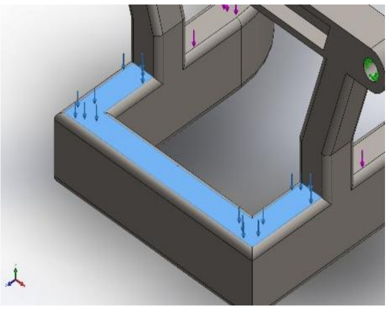

Figure 3. Chassis Loading with 1500 N Force
(Source: Solidworks, 2025)

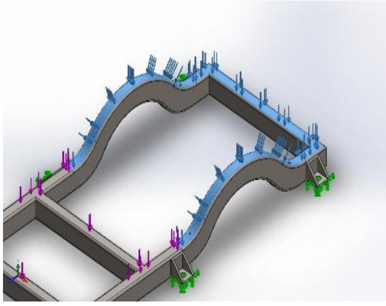

Figure 4. Chassis Loading with 3000 N Force
(Source: Solidworks, 2025)

C. Meshing Process

The meshing process aims to divide the chassis structure into smaller shapes that are connected between points (nodes) in order to find out where the deformation or stress points are accurately. The smaller the mesh dimensions or the more nodes, the more accurate the location of the stress points or deformations.

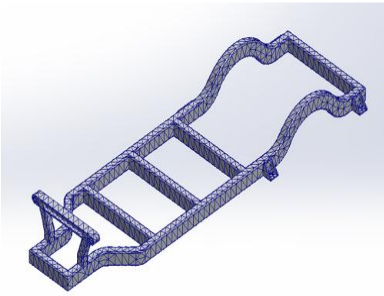

Figure 5. *VU-EV Chassis Meshing*
(Source: Solidworks, 2025)

TABLE I
Mesh Detail Information

No	Properties	Value
1	*Total Node*	19348
2	*Total Elements*	9976
3	*Maximum Aspect Ratio*	24,679
4	*% of elements with Aspect Ratio < 3*	4,15
5	*% of elements with Aspect Ratio > 10*	8,2
6	*% of distorted elements(Jacobian)*	0

(Source: Solidworks, 2025)

D. Materials Used

In this test, 3 different types of materials were used, to find out which material is good to be applied to the chassis. The types of materials used are: Aluminum 6061-T6, AISI 4130 Steel, and AISI 1020 Steel. For detailed material specifications, see the table below:

TABLE 2
Properties of Aluminium 6061-T6

No	Properties	Value	Unit
1	*Elastic Modulus*	69000	N/mm^2
2	*Shear Modulus*	26000	N/mm^2
3	*Mass Density*	2700	Kg/m^3
4	*Tensile Strength*	310	N/mm^2
5	*Yield Strength*	275	N/mm^2

(Source: Solidworks, 2025)

TABLE 3
Properties of AISI 4130 Steel

No	Properties	Value	Unit
1	*Elastic Modulus*	205000	N/mm^2
2	*Shear Modulus*	80000	N/mm^2
3	*Mass Density*	7850	Kg/m^3
4	*Tensile Strength*	560	N/mm^2
5	*Yield Strength*	460	N/mm^2

(Source: Solidworks, 2025)

TABLE 4
Properties of AISI 1020 Steel

No	Properties	Value	Unit
1	*Elastic Modulus*	205000	N/mm^2
2	*Shear Modulus*	80000	N/mm^2
3	*Mass Density*	7870	Kg/m^3
4	*Tensile Strength*	420	N/mm^2
5	*Yield Strength*	350	N/mm^2

(Source: Solidworks, 2025)

IV. RESULT AND DISCUSSION

A. Chassis Weight

The following is a table of chassis weight comparison results:

TABLE 6
Chassis Weight Comparison

No	Materials	Mass
1	Aluminium 6061-T6	74,0392 kg
2	AISI 4130 Steel	215,262 kg
3	AISI 1020 Steel	215,811 kg

(Source: Solidworks, 2025)

B. Stress

Stress is when some external force or load is applied to an object, the internal force (of the object) will react to resist the external force. The internal force per unit area on each part of the object is called stress (Anggry A, 2021). The following are the results of the stress simulation that occurs on the chassis after loading:

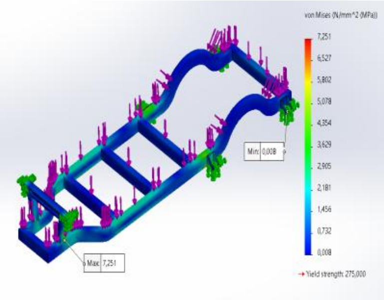

Figure 5. Aluminium 6061-T6 Chassis Stress Simulation Result
(Source: Solidworks, 2025)

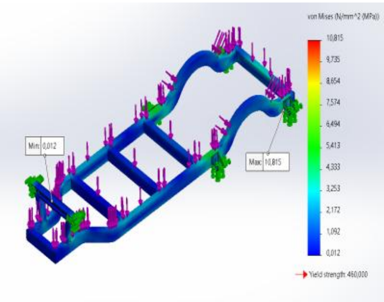

Figure 6. AISI 4130 Steel Chassis Stress Simulation Result
(Source: Solidworks, 2025)

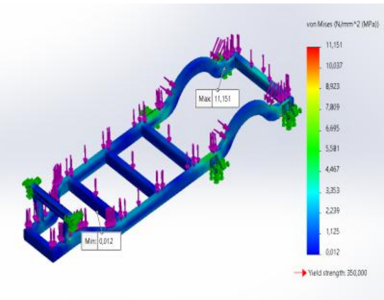

Figure 7. AISI 1020 Steel Chassis Stress Simulation Result
(Source: Solidworks, 2025)

Based on the results of the stress simulation above, it can be seen how much stress occurs in the three chassis with different materials. The highest stress concentration point in the 6061-T6 aluminum material is on the left front suspension bearing with a maximum stress value of 7.251 Mpa. While in the AISI 4130 steel material, the highest stress concentration point is on the left rear suspension bearing with a value of 10.815 Mpa. And for the AISI 1020 steel material, the highest stress concentration point is on the right rear suspension bearing with a maximum stress value of 11.151 Mpa. Of all the maximum stress values of the three materials, they are still far below the yield strength value of each material, each of which has a yield strength value of 275,000 Mpa, 460,000 Mpa and 350,000 Mpa respectively. So it can be concluded that the three materials are still strong enough to support the weight of the vehicle.

C. *Displacement*

Displacement/deflection is a deformation of a structure due to a force pressing on the structure. Deflection can be seen from how much the structure changes due to loading from the point before loading (Radyantho et al., 2024). The following are the results of the displacement simulation that occurs on the chassis after loading:

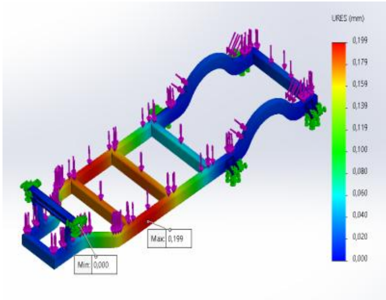

Figure 8. Displacement Simulation Results of Aluminium 6061-T6 Chassis
(Source: Solidworks, 2025)

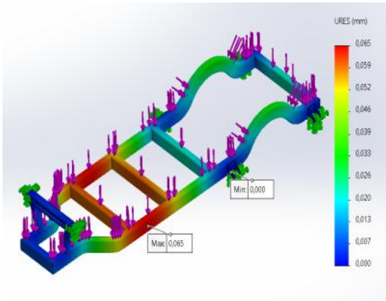

Figure 9. Displacement Simulation Results of AISI 4130 Steel Chassis
(Source: Solidworks, 2025)

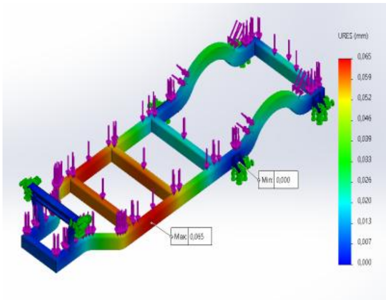

Figure 10. Displacement Simulation Results of AISI 1020 Steel Chassis
(Source: Solidworks, 2025)

From the results of the displacement simulation on the three materials above, it can be seen how large the maximum displacement value is. The highest deflection/displacement point in the three materials is relatively the same, which is located in the middle of the chassis. The highest deflection value in the 6061-T6 aluminum material is 0.199 mm, AISI 4130 steel with a value of 0.065 mm, and AISI 1020 steel with a value of 0.065 mm. In other words, the deflection value of the three materials is very small. So it can be concluded that the three materials are still in the very safe category.

V. CONCLUSION

Based on the results of the structural strength analysis simulation of the VU-EV car chassis using the FEA method, it can be concluded that the selection of 6061-T6 aluminum material is more suitable for application on the VU-EV car chassis. Because 6061-T6 aluminum material has the lightest weight, almost a third of the chassis weight with AISI 4130 steel or AISI 1020 steel material. With its light weight, the 6061-T6 aluminum chassis can significantly reduce the vehicle load, thus saving energy use in its operation. In addition, 6061-T6 aluminum material has the lowest stress value, and a displacement value that is not much different compared to AISI 4130 steel and AISI 1020 steel materials, so it is classified as strong enough to support a total weight of 8500 N.

REFERENCE

[1] Anggry A. (2021). *Kekuatan Bahan : Tegangan Dan Regangan Pada Batang*.

[2] Aprillia, I. S., Vianney, M., Sugara, L., Kheista, K., Rhemrev, E. A., Sari, E. K., & Christie, M. (2024). Kebijakan Mobil Listrik di Indonesia : Tantangan dan Peluang dalam Mewujudkan Mobilitas Ramah. *4*(3), 391–401.

[3] Arifin, H. A. (2017). Perhitungan Ulang Sistem Pengereman Mobil Nogogeni 3 Evo Untuk Shell Eco Marathon Asia 2017. *Institut Teknologi Sepuluh November*, 1–66.

[4] Efendi, A. (2020). Rancang Bangun Mobil Listrik Sula Politeknik Negeri Subang. *Jurnal Pendidikan Teknologi Dan Kejuruan*, *17*(1), 75.

[5] Gusniar, I. N., & Putra, A. S. (2021). Perhitungan Beban Statik pada Rangka Mesin Pengering Padi Menggunakan Baja AISI 1020. *Jurnal Teknik Mesin*, *14*(2), 53–58.

[6] IS:800. (2007). Indian Standard Code of Practice for General Construction in Steel. *Bureau of Indian Standards, New Delhi*, *December*.

[7] 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*(2019), 69–76.

[8] Prasetyo, E., Hermawan, R., Ridho, M. N. I., Hajar, I. I., Hariri, H., & Pane, E. A. (2020). Analisis Kekuatan Rangka Pada Mesin Transverse Ducting Flange (TDF) Menggunakan Software Solidworks. *Rekayasa*, *13*(3), 299–306.

[9] Radyantho, K. D., Rahman, S. M., Fadhillah, M. H., Arrizal, D. A., Ramadhani, S., Malau, K. J., Hakiky, R. M., Wiratmoko, E. Y., Aprillia, H., Sa'adiyah, D. S., Djafar, A., & Haryono, H. D. (2024). Analisis Pembebanan Statis Roll Bar Chassis Mobil Hemat Energi. *Jurnal Crankshaft*, *7*(2), 65–73.

[10] Sihombing, D., Satrijo, D., & Kurdi, O. (2023). Analisis Rangka Mobil Golf Dengan Material Komposit Karbon Menggunakan Metode Elemen Hingga Kapasitas 4 Penumpang. *Jurnal Teknik Mesin S-1*, *11*(3), 1–4.

[11] Tan, C. F., & Said, M. R. (2009). Effect of Hardness Test on Precipitation Hardening Aluminium Alloy 6061-t6. *Chiang Mai Journal of Science*, *36*(3), 276–286.

[12] Toteles, A. (2021). Analisis Material Kontruksi Chasis Mobil Listrik Laksamana V2 Menggunakan Software Autodesk Inventor. *Machine : Jurnal Teknik Mesin*, *7*(1), 30–37.

[13] Wasi, I. A., & M, E. S. (2021). Carburizing Menggunakan Media Quenching Minyak Kotor Sawit (MIKO) Cruide Palm Oil (CPO) Palm Kernel Oil (PKO). *2*(3), 133–140.