JIM Vol.8 (1) 2026

Received: 07 11 2025 | Revised: 10 12 2026 | Accepted: 20 04 2026

DOI: 10.15294/jim.v8i1.17957

Page 41 - 50

JIM: Jurnal Inovasi Mesin

Analysis of Electric Low Entry Microbus Chassis Strength by Using Finite Element Method

Assa Affitra Ilham Alifian[1*], Widya Aryadi[1], Andri Setiyawan[2]

1 Department of Mechanical Engineering, Faculty of Engineering, Universitas Negeri Semarang, Indonesia
2 Linz School of Education, Johannes Kepler University Linz, Linz, Austria
* assaaffitra4554@students.unnes.ac.id

Keywords:
Chassis
Low entry microbus
Structural strength
FEM
Simulation

Abstract

Chassis is a component of a vehicle that functions as a support for all components and the weight of the vehicle such as the body, engine, transmission, suspension, to the load of passengers or goods. This study aims to determine the value of von mises stress, displacement, and safety factor, from each variation of the chassis thickness tested. This study uses a finite element simulation method with SolidWorks 2022 software to obtain von mises stress, displacement, and safety factor values from various variations of chassis thickness. The results of the finite element method simulation produce data in the form of von mises stress, displacement, and safety factor from 3 chassis thicknesses, the data also shows that the chassis with a thickness of 4mm has the most ideal results

1 Introduction

Clearly describing: (1) Low Entry Bus is a type of bus that is included in the low-floor bus category and has the characteristic of a lower floor design when coMPAred to conventional buses. The bus floor design is usually made parallel to the sidewalk, this design aims to make it easier for passengers to get in and out, in addition, this low floor design is also friendlier to the elderly and passengers with special needs [1–3]. Low Entry Buses are generally used as mass transportation in urban areas due to the ease of passenger access they offer. Most Low Entry Buses currently in use are 12 meters long, but there are still not many Low Entry Buses with more coMPAct dimensions used or made as public transportation in Indonesia. Microbuses are a type of vehicle that has a design and function like buses in general but has relatively small dimensions, the size of a microbus ranges from 6 to 9 meters. Microbuses are usually used as public transportation such as city buses, intercity buses, and tourism. Microbus category vehicles with a low-floor concept such as Low Entry buses are still rarely found on the market, this research is expected to be a starting point for the development of low entry microbuses. The advantages of this vehicle concept are easy access for passengers to get in and out and the vehicle size is relatively more coMPAct than a 12-meter bus so it can access roads that are not too wide. One of the vital components of a bus is the chassis. The chassis is a component of a vehicle that functions as a support for all components and the weight of the vehicle such as the body, engine, transmission, suspension, to the load of passengers or goods. The chassis also has the purpose of maintaining the shape of the vehicle, as well as being a place to attach all the supporting components to the vehicle [4–6]. A chassis must prioritize rigidity but be designed to be as light as possible so that the resulting vehicle chassis can carry the desired load while remaining efficient [7–9]. It concluded that by using the stress analysis feature equipped with (FEA) in SolidWorks Premium 2016 software, they could determine the reactions that occurred in the research object, namely in the form of a prototype electric car chassis with Rectangular Tube aluminium Alloy 6063-T6 material. The results of this study consisted of Von Mises Stress, Displacement, and Safety Factor.

ISSN 2746-7694

The total load used in this study was 1059.48 N, and the Von Mises Stress was 2.15 x10^7 N/m^2. The maximum deflection was 1.31 mm, and the safety factor was 2.6. It was also found that the rollbar of this car could withstand a load of 700 N [10–12]. This study conducted static loading on a knuckle design for the Ganesha Sakti (GASKI) electric car. The material used in the simulation was ASTM A36 carbon steel, with loads of 86 and 166 kg. Modifications were then made to the steering knuckle shape for simulations with the same loads [13–15]. Experiments using the FEM method on 3 designs of 2-wheeled vehicle chassis. The material used in the three chassis is steel, and all three are given a load of 3600 N. The results of the simulation found that in design 1, the maximum von mises stress obtained was 84.03 MPA where this value is still below the maximum pressure limit allowed for steel materials, but for reasons of load reduction, designs 2 and 3 are superior with von mises stress values of 50.37 MPA and 48.86 MPA [16–18] as shown in Table 1.

Table 1. Load reduction

Design	Weight	Weight reduction
Modified design 1	30.15 Kg	16.05%
Modified design 2	24.75 Kg	26.15 %
Optimized Design 3	17 .89kg	49.96%

Thus, designs 2 and 3 successfully reduced the weight while maintaining the von Mises stress results below the maximum stress limit for steel. Design 2 obtained a von Mises stress result of 50.37 MPA with a weight reduction of 26.15% and Design 3 obtained a von Mises stress result of 48.86 MPA with a weight reduction of 49.96%. Design and Analysis of Truck Chassis FEM method is used to determine the most effective material and frame model used on the TATA Eicher E2 truck [7] as seen in Figure 1.

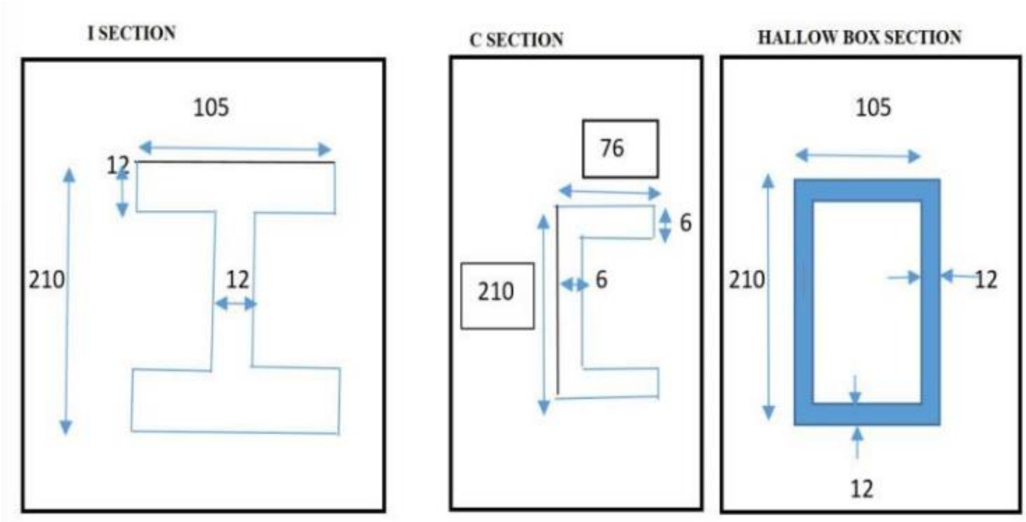


Figure 1. Frame Model Specifications

The CAD software used in this study was CATIA and the software used in this study was ANSYS. The variables used in this study were three frame models shown in Figure 2.2, and the chassis materials were AISI 4130 Steel, AISI A304 Stainless Steel, and Aluminum 6061-T6 Alloy. After conducting simulation experiments, the following conclusions were reached:

1. The rectangular hollow frame model demonstrated higher strength than the C- and I-channel models.

2. AISI 4130 steel material showed the least deformation coMPAred to the other materials.

3. The rectangular hollow frame model exhibited less deflection, lower Von-Mises (Equivalent) stress, and maximum shear stress of 5.01 mm, 73.50 MPA, and 39.50 MPA, respectively.

4. The lowest shear stress was found in Aluminium Alloy 6061-T6 and the maximum was found in AISI 4130 steel, within predetermined limits.

5. The best cross-section for the chassis is C-C / S because it is more cost-effective and the best material among the three is AISI A 304 Stainless Steel because it provides high corrosion resistance with slightly more stress and deformation values than AISI 4130 Steel.

6. Safe design under certain loading conditions.

(3) There has been no research on chassis loading simulation with a 5.9-meter low-entry microbus construction, at least in Indonesian universities. (4) The problems that will be faced in this study are how the results of the vertical load test simulation of the Low Entry Microbus chassis using the Finite Element Method (FEM), for variations in chassis material thickness of 3mm, 4mm, and 5mm, which chassis variation is the most ideal for application to the Low Entry Microbus, and What are the results of the braking test simulation of the Low Entry Microbus chassis using the Finite Element Method (FEM). (5) The finite element simulation method is used in this study to obtain the von mises stress, displacement, and safety factor values from various variations in chassis thickness. (6) This research aims to find data on the results of load simulations of low entry microbus type electric vehicles from 3 variations of chassis thickness, as well as to find data on the results of braking simulations.

2 Methods

The simulation experiment method is used to conduct modeling analysis with the help of software, where the model or product being studied is a low entry microbus chassis. This approach is designed to create certain conditions or events, which are then analyzed to understand the iMPAct caused by the model or product based on the material used, so that conclusions can be drawn (Sugiyono, 2013). The approach used in this study is quantitative and uses an experimental method, namely with finite element method simulation of various material sizes using Solidworks 2022 software. Independent Variables The independent variables in this study were the variations in chassis frame thicknesses used: 3mm, 4mm, and 5mm. Dependent Variables in this study were von Mises stress, displacement, and safety factor. The control variables in this study were AISI 1018 mild steel material and the load mass, as shown in Table 2.

Table 2. Parameters input

Components	Weight (Kg)
Body	1224
Chair	122,347

Passengers (70 Kg)	1.190
Crew (70 Kg)	210
Middle Battery	974
Additional Battery	341,3
Total	4061,647

3 Result and Discussion

The dimensions of the chassis design refer to the dimensions of the Toyota Hiace Premio vehicle, the dimensions of the vehicle are shown in Figure 2.

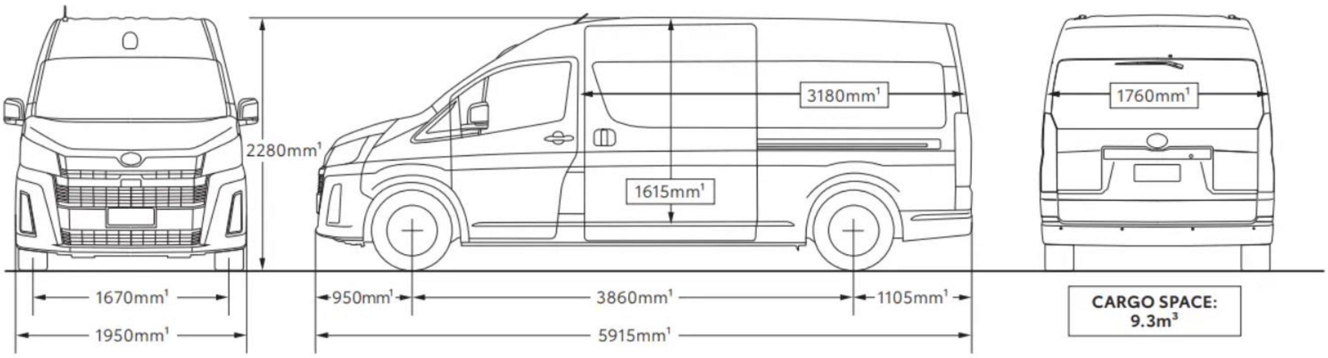


Figure 2. Toyota Hiace Premio Dimensions

After obtaining the dimensional data for the Toyota Hiace Premio, these dimensions were then applied to the construction of a ladder frame chassis, which was built with a low-entry model. Simulations conducted in Solidworks 2022 showed a von Mises stress of 108.289 MPA, while simulations conducted by Dabair et al. showed a von Mises stress of 108.12 MPA. These results are quite close to the simulation results conducted by Dabair et al. with an error percentage of 0.156% as shown in Figure 3.

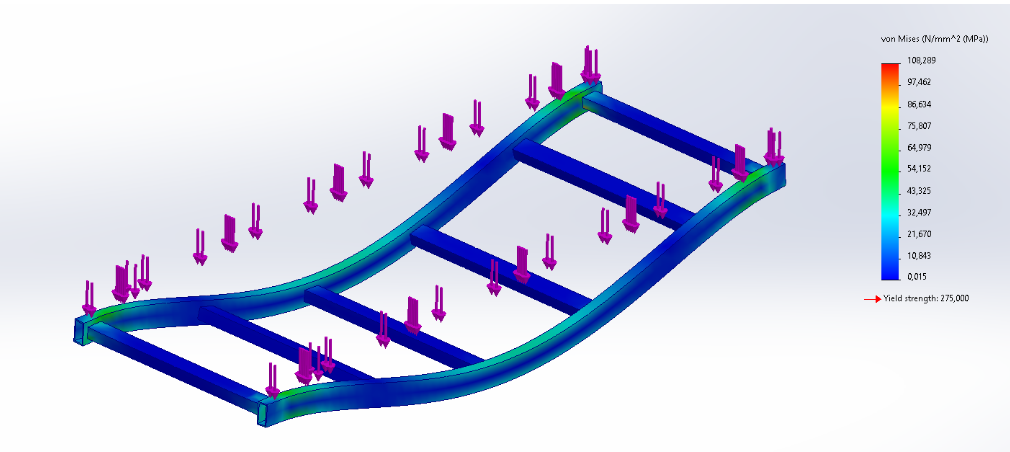


Figure 3. Software validation

The chassis model with a frame thickness of 4 mm was used as a sample to perform the mesh convergence test, the results of the mesh convergence test are shown in the Table 3.

Table 3. Mesh Convergence Test

Mesh size	σ_{von} (MPA)	Convergence
10 mm	152,072	-1,112%
9 mm	150,4	13,730%
8 mm	174,336	-11,155%
7 mm	156,841	2,979%
6 mm	161,656	-1,152%
5 mm	159,815	

From the data presented in table 4.2 and figure 4.9, it is known that mesh sizes of 7 mm, 6 mm, and 5 mm have shown insignificant differences (<5%), so that the mesh size of 5 mm can be said to be convergent and will be used for simulating the thickness of other frames. The forces that will be applied to the chassis model include the gravity of all components that will be supported by the chassis and added passenger loads, component weight data is obtained from software calculations while passenger weight is obtained from a passenger capacity of 20 people. Details of the chassis load are shown in Table 4.

Table 3. Mesh Convergence

Components	Mass (Kg)	Weight (N) ($g = 9.8$)
Body	1224	11995.2
Chair	122.347	1199
Passengers (70 Kg)	1.190	11,662
Crew (70 Kg)	210	2,058
Middle Battery	974	9545.2
Additional Battery	341.3	3344.74
Total	4061.647	39804.14

The support (See Figure 4) used is a spring support type, where the object is considered attached to a spring whose coefficient can be determined (See Figure 5 and 6). The determination of the spring coefficient is based on a translation target of 50 mm after the chassis is given a load, the following calculation of the spring coefficient is stated in the Eq. (1) and (2).

$$k = \frac{F}{x} \quad (1)$$

$$k = \frac{39804,14}{0,05} = 796082,8\ N/m \quad (2)$$

Figure 4. Support boundary

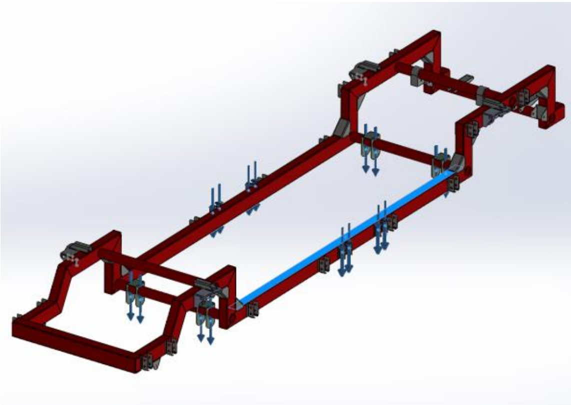


Figure 5. Force location

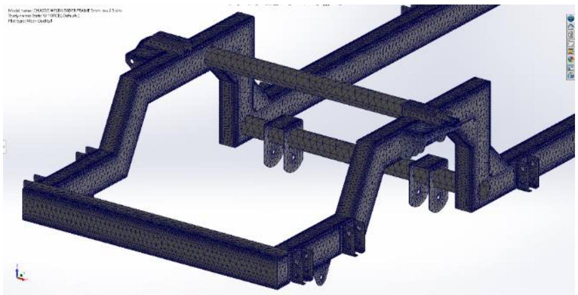
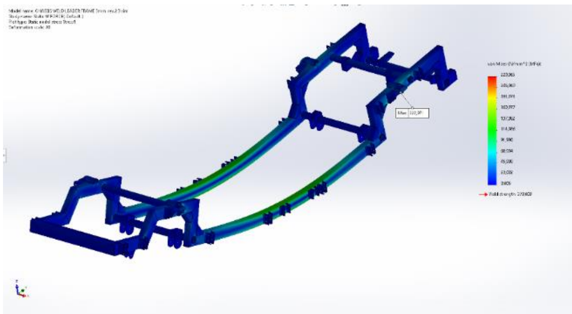
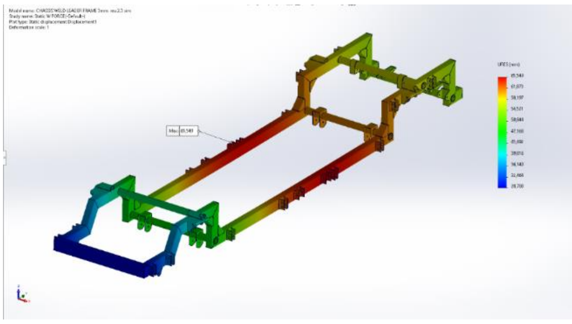


Figure 6. Mesh control



(a)



(b)

Figure 7. Result of simulations

Table 3. Mesh Convergence

Thickness (mm)	Mass (Kg)	σ_{von} (MPA)	Displacement (mm)	*Sf*
3	201,46	222,917	65,549	1,659
4	252,39	143,685	62,974	2,575
5	295,76	100,775	39,897	3,672

From Table 4.4, one frame thickness with the best performance will be selected for subsequent braking load simulations. The thickness selection is based on the safety factor value that meets the target (Sf > 2) and the lowest mass considerations. Based on the criteria, a 4mm thick chassis will be selected, and braking simulations will then be performed on it. Braking force calculation of several boundary conditions applied in the braking (See Figure 7 and 8) simulation include:

1. The chassis carries a full load during braking.
2. Braking is applied to the front wheels only.
3. Braking is applied from a speed of 70 km/h to 0 km/h.
4. The total time for the vehicle to stop is 5 seconds.

From the above conditions, the braking acceleration can be calculated using the acceleration formula in the following the Eq. (3), (4), (5), and (6).

$$v(t) = v_0 + at \quad (3)$$

$$0(5) = 19{,}444 + a5 \quad (4)$$

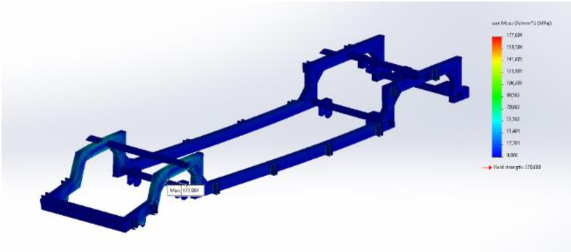
$$0 = 19{,}444 + a5 \quad (5)$$

$$a = \frac{-19{,}444}{5} = -3{,}888\ m/s^2 \quad (6)$$

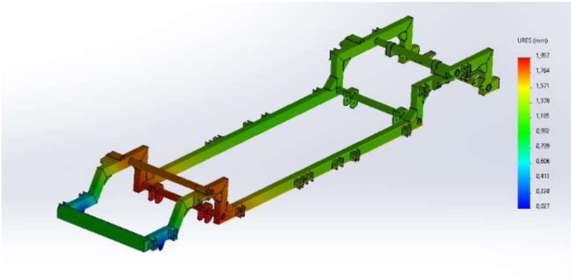
After finding the acceleration, the next step is to change the chassis load mass into a reaction force from braking using the force formula (F=m.a), the calculation results for all loads are shown in Table 4.

Table 4. Calculation of Total Braking Load

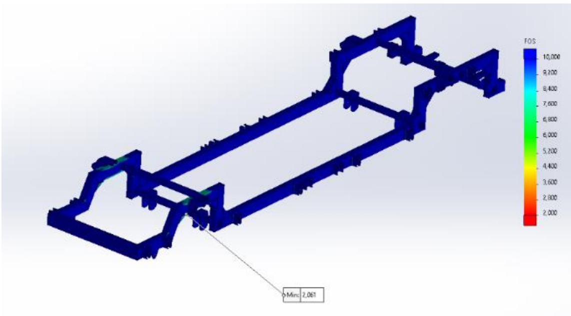
Components	Mass (Kg)	Force (a=3,888)
Body	1,224	4,759.989 N
Chair	122.347	475.793 N
Passengers (70 Kg)	1,190	4,627.767 N
Crew (70 Kg)	210	816.665 N
Middle Battery	974	3,787.769 N
Additional Battery	341.3	1,327.275 N
Total	4,061.647	15,795.258 N



(a)



(b)



(c)

Figure 8. Braking load simulation

4 Conclusion

The results of the research that has been carried out on this paper. Based on the results of the simulation data and analysis carried out in chapter 4, several conclusions can be drawn, namely the simulation data from 3 chassis thicknesses, the 4mm thick chassis has the most ideal properties based on the required criteria. The braking simulation results from the 4mm thick chassis meet the safety factor criteria, namely (Sf>2). As for suggestions for further research, the calculation and braking simulation model are limited to the front wheels, further research is needed to simulate the braking of both wheels. Simulations carried out using Solidworks software should be run on a computer with adequate specifications to support the smoothness of the research. A 5mm thick chassis is more suitable for buses if more durability is needed. Simulations on the chassis are only limited to vertical loading and braking; further research is needed to conduct other tests so that simulation data from the chassis can be more. Further research is needed on chassis design for a more detailed discussion of chassis design.

References

1. F. A. Budiman, A. Septiyanto, S. Sudiyono, A. D. N. I. Musyono, and R. Setiadi, “Analisis tegangan von mises dan safety factor pada chassis kendaraan listrik tipe in-wheel,” *Jurnal Rekayasa Mesin*, vol. 16, no. 1, pp. 100–108, 2021.
2. M. S. Agrawal and M. Razik, “Finite element analysis of truck chassis frame,” *International*

Research Journal of Engineering and Technology, vol. 2, no. 3, pp. 1949–1956, 2015.

3. M. S. Agrawal and M. D. Razik, “Finite element analysis of truck chassis,” *International Journal of Engineering Sciences \& Research Technology*, vol. 2, no. 12, pp. 3432–3438, 2013.

4. T. M. Patel, M. G. Bhatt, and H. K. Patel, “Analysis and validation of Eicher 11.10 chassis frame using Ansys,” *International Journal of Emerging Trends \& Technology in Computer Science*, vol. 2, no. 2, pp. 85–88, 2013.

5. S. Baragetti, “Fail-Safe and Safe-Life Concepts Effects on the Safety Factor in Mechanical Design,” *Current Approaches in Science and Technology Research Vol. 10*, pp. 1–6, 2021.

6. S. Woo, “Failure mechanics, design and reliability testing,” in *Reliability Design of Mechanical Systems: A Guide for Mechanical and Civil Engineers*, Springer, 2019, pp. 101–162.

7. A. Birolini, “Reliability analysis during the design phase (nonrepairable elements up to system failure),” in *Reliability Engineering: Theory and Practice*, Springer, 2013, pp. 25–80.

8. A. Rianto, E. Erwin, W. Apriani, and E. M. Sundari, “Analisis Statis Design Prototype Chassis Tubular Space Frame Kendaraan Listrik Berjenis Buggy,” *Mekanisasi: Jurnal Teknik Mesin Pertanian*, vol. 1, no. 1, pp. 22–29, 2023.

9. A. Y. Dwinanto and F. B. Muhammad, “Analisa Perbandingan Karakteristik Bodi dan Chassis pada Prototype Kendaraan Listrik,” *Jurnal Rekayasa Mesin*, vol. 6, no. 2, pp. 101–105, 2015.

10. Y. Ganin, S. Bartunov, Y. Li, E. Keller, and S. Saliceti, “Computer-aided design as language,” *Advances in Neural Information Processing Systems*, vol. 34, pp. 5885–5897, 2021.

11. P. Li, W. Zhang, J. Guo, J. Chen, and D.-M. Yan, “Revisiting cad model generation by learning raster sketch,” in *Proceedings of the AAAI Conference on Artificial Intelligence*, 2025, vol. 39, no. 5, pp. 4869–4877.

12. K. D. D. Willis, P. K. Jayaraman, J. G. Lambourne, H. Chu, and Y. Pu, “Engineering sketch generation for computer-aided design,” in *Proceedings of the IEEE/CVF conference on computer vision and pattern recognition*, 2021, pp. 2105–2114.

13. P. Manceke, B. Winkler, and B. Manhartsgurber, “Magneto--rheological damper,” *US Patent No. US006623364B2*, 2001.

14. E. Anderfaas, “Magnetorheological rotary damper.” Google Patents, 2004.

15. J. C. Poynor, “Innovative designs for magneto-rheological dampers,” Virginia Tech, 2001.

16. M. A. Hendrawan, P. I. Purboputro, M. A. Saputro, and W. Setiyadi, “Perancangan Chassis Mobil Listrik Prototype ‘Ababil’dan Simulasi Pembebanan Statik dengan Menggunakan Solidworks Premium 2016,” in *The 7th University Research Colloquium*, 2018, vol. 96, p. 105.

17. M. R. Abd Wahab, A. Saepuddin, and M. Sulaiman, “Desain dan simulasi uji kekuatan chassis mobil SEM jenis prototype menggunakan material aluminium alloy 7075,” *Jurnal Teknik Mesin Indonesia*, vol. 17, pp. 78–85, 2022.

18. M. S. D. Ellianto and Y. E. Nurcahyo, “Rancang bangun dan simulasi pembebanan statik pada sasis mobil hemat energi kategori prototype,” *Jurnal Engine: Energi, Manufaktur, dan Material*, vol. 4, no. 2, pp. 53–58, 2020.