9th International Interdisciplinary Congress on Renewable Energies, Industrial Maintenance, Mechatronics and Informatics
Booklets

RENIECYT
Registro Nacional de Instituciones y Empresas Científicas y Tecnológicas
1702902 CONAHCYT

RENIECYT - LATINDEX - Research Gate - DULCINEA - CLASE - Sudoc - HISPANA - SHERPA UNIVERSIA - Google Scholar DOI - REDIB - Mendeley - DIALNET - ROAD - ORCID - V|LEX

Title: Design of a single-seater chassis for a BAJA SAE vehicle

Authors: Lozano-Díaz, Alberto, Alfaro-Méndez, Jonathan, Serrano-Ramírez, Tomás and Peña-Aguirre, Julio C.

Universidad Politécnica de Guanajuato LLK-6709-2024 0009-0009-4379-2929 710206
Universidad Politécnica de Guanajuato LCD-9769-2024 0009-0001-4179-9221 782725
Universidad Politécnica de Guanajuato G-6039-2018 0000-0001-6118-3830 493323
Universidad Politécnica de Guanajuato rid87285 0000-0002-6211-7760 737665

Editorial label ECORFAN: 607-8695
BCIERMMI Control Number: 2024-01
BCIERMMI Classification (2024): 241024-0001
RNA: 03-2010-032610115700-14
Pages: 15

CONAHCYT classification:
Area: Engineering
Field: Engineering
Discipline: Mechanical Engineering
Subdiscipline: Mechanical Design

ECORFAN-México, S.C.
Park Pedregal Business. 3580, Anillo Perif., San Jerónimo Aculco, Álvaro Obregón, 01900 Ciudad de México, CDMX,
Phone: +52 1 55 6159 2296
Skype: ecorfan-mexico.s.c.
E-mail: contacto@ecorfan.org
Facebook: ECORFAN-México S. C.
Twitter: @EcorfanC

www.ecorfan.org

Holdings
Mexico, Bolivia, Spain, Ecuador, Peru, Colombia, Cameroon, El Salvador, Taiwan, Paraguay, Guatemala, Democratic Republic of Congo, Nicaragua

PRESENTATION CONTENT

Introduction

Methodology

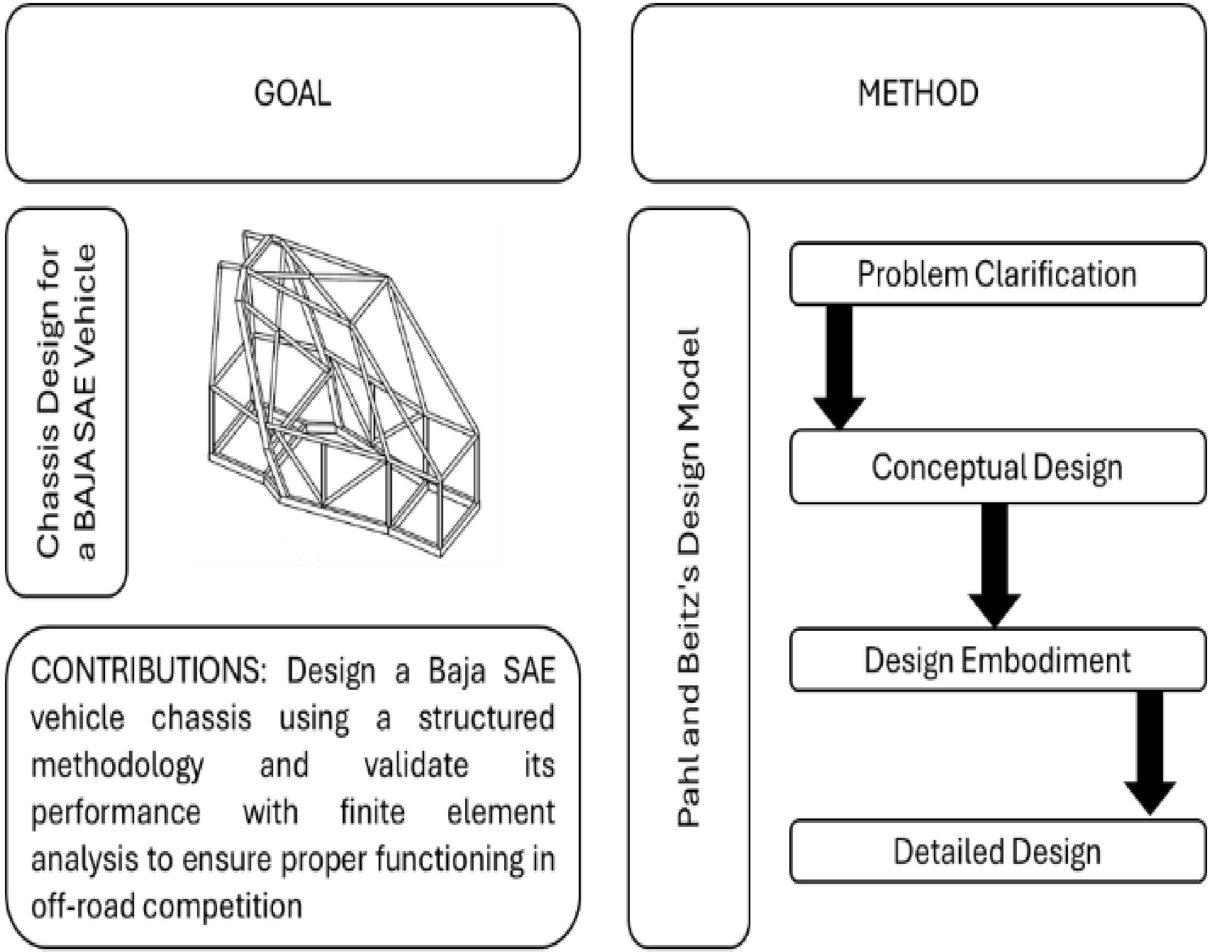
Results

Conclusions

References

Introduction

This article explores the design and analysis process of a single-seat chassis for a BAJA SAE category vehicle, adhering to the standards established by the Society of Automotive Engineers (SAE), specifically the BAJA SAE regulations (Society of Automotive Engineers, 2024). The primary focus of this study is to ensure that the designed chassis is safe and efficient, with optimal performance in front, side, and rear impacts, as well as rollovers. To achieve this, a Finite Element Analysis (FEA) has been conducted, allowing for the assessment of the chassis's strength and performance under various loads (Hibbeler, 2020).



Source Author's own contribution

Methodology

Conceptual design of the SAE Baja Chassis.

Figure 1 illustrates the methodology diagram used in the design of the single-seat chassis system for a BAJA SAE vehicle, based on the design methodology of Pahl and Beitz (Pahl, Beitz, Feldhusen, & Grote, 2007) and supplemented by the approaches proposed by Nigel Cross (Cross, 2021). The process is |divided into four fundamental stages: problem clarification, conceptual design, embodiment design, and detailed design.

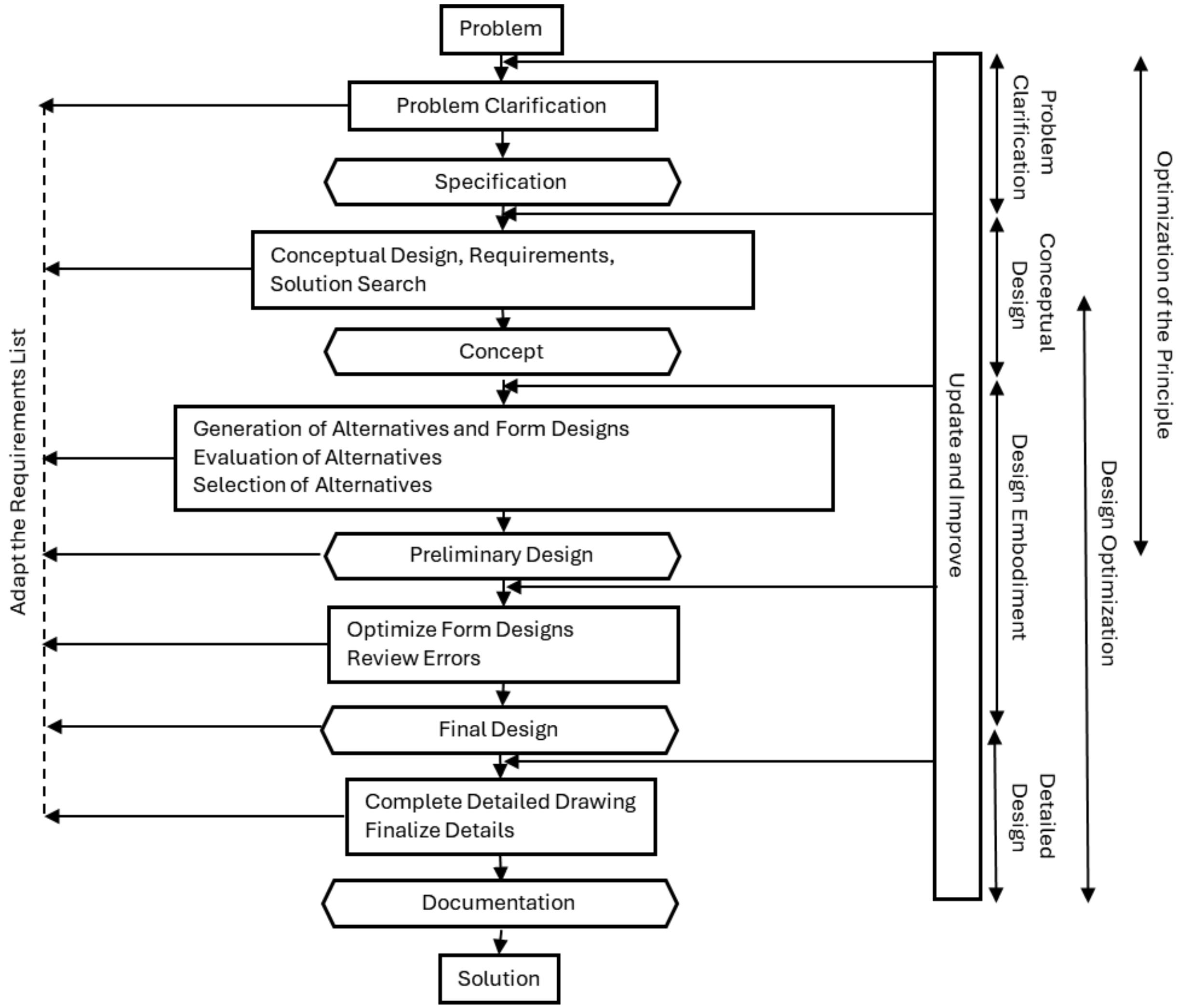


Figure 1 Pahl and Beitz's design methodology. *Source: Cross. (2021)*

Methodology

Clarification of Objectives

It is essential to establish clear goals that guide the design process, recognizing that these objectives may evolve as the understanding of the problem deepens and solutions are developed. The objectives tree method is a key tool within this design methodology. By using the objectives tree, the design team can ensure that all proposed solutions align with the established objectives and that all critical aspects of the design are considered, as illustrated in Figure 2.

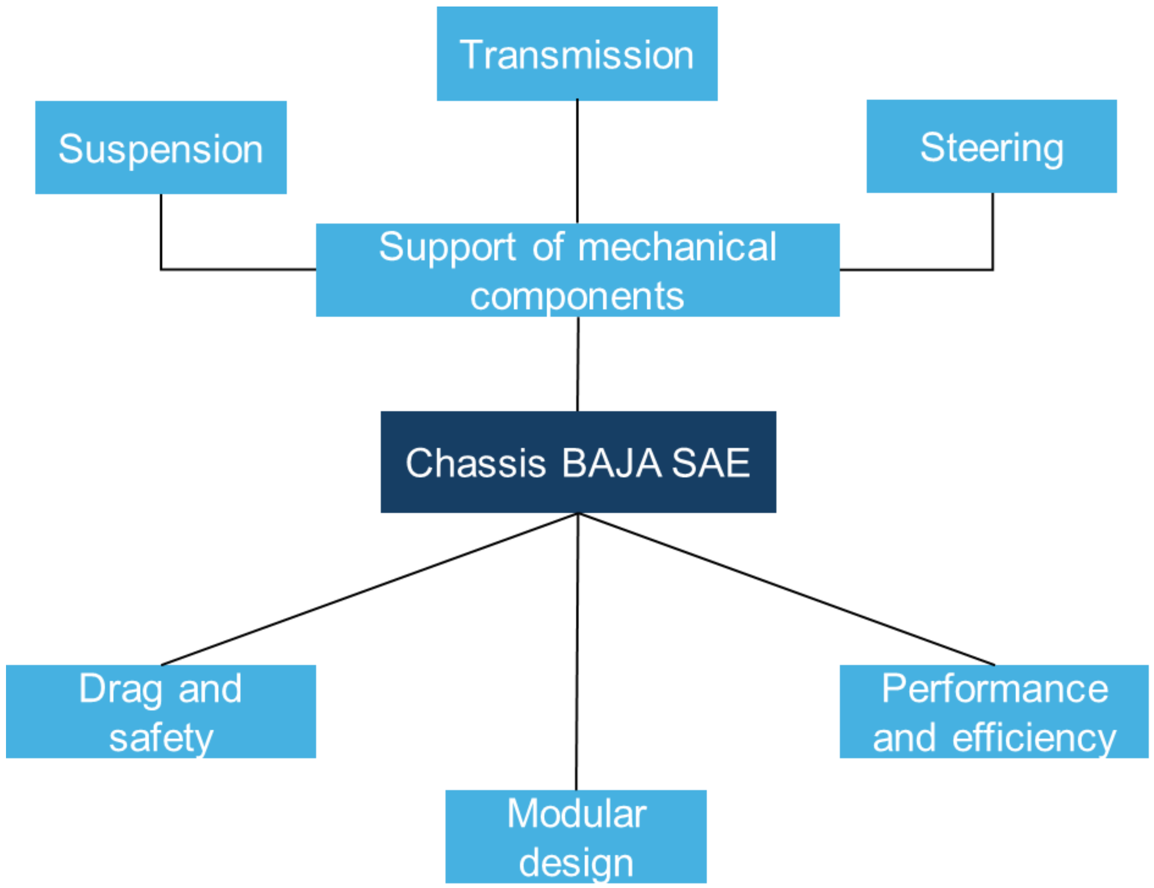


Figure 2 *Source Author's own contribution*

Methodology

Establishing Roles

This tree breaks down general requirements into specific objectives, such as safety, material optimization, and compliance with regulations. Next, the function establishment phase is carried out using the black box concept figure 3, which allows the focus to be on what the chassis must achieve (such as converting external forces into stability and strength) without initially concerning itself with how these goals will be accomplished. This combined approach, transitioning from the black box to the transparent box, ensures a coherent, efficient design process that is aligned with the project goals, optimizing chassis performance and ensuring compliance with competition regulations.

Figure 3 *Source Author's own contribution*

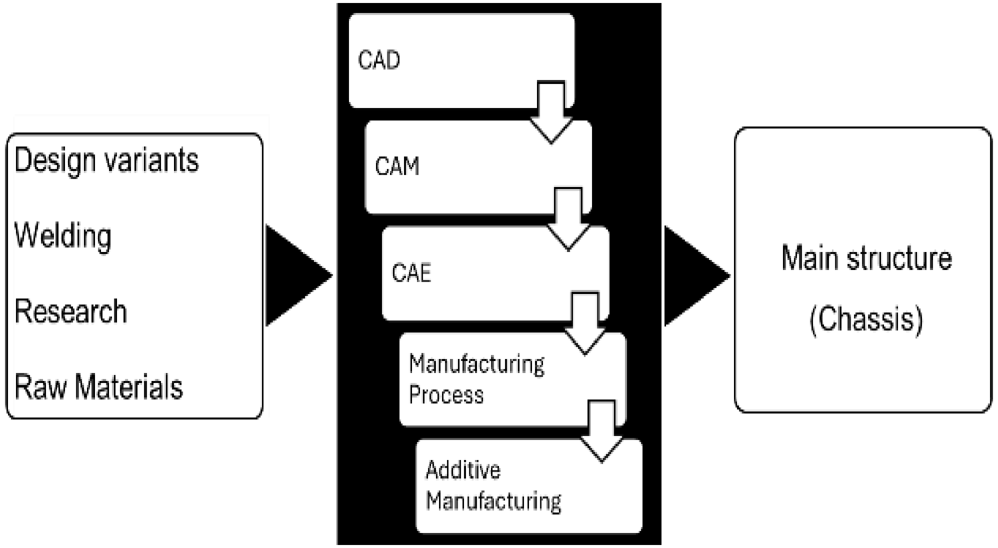


Figure 4 *Source Author's own contribution*

Methodology

Setting requirements

The performance specification method focuses on defining the performance objectives that the design must meet without imposing restrictions on specific physical components. This approach gives the designer the freedom to explore various technical solutions to achieve those objectives, encouraging creativity and innovation.

Tabla 1. Chassis requirements for Baja SAE vehicles. *Source Author's own contribution*

Requirements	Specification
Load	Up to 200 Kg
Structure	Lightweight, stable, rigid
Assembly	Easy assemble
Compact design	Modular
Maintenance	Simple
Repairs	Simple and quick
Durability	maximum

Methodology

Generation of alternatives

During the alternative generation stage, 20 different options were developed considering three key aspects: chassis material, structural geometry, and type of tubing used. These alternatives were carefully designed to meet the established requirements, such as a load capacity of up to 200 kg, a rigid, lightweight, and stable structure, ease of assembly, and a modular design.

The requirements table shown below was crucial in this process, serving as a guide to ensure that each alternative met critical specifications, including ease of maintenance, quick repairs, and maximum durability.

Tabla 2. Generation of Alternatives

Source Author's own contribution

Alternative	Tubular Type	Material Type	Chassis Geometry Type
4	Circular tube	Aluminum	Tubular chassis
5	Combined tube (circular and square)	Steel	Combined chassis (tubular and angular)
6	Square tube	Steel	Angular chassis
7	Rectangular tubing	Aluminum	Tubular chassis
10	Rectangular tubing	Steel	Angular chassis
11	Combined tube (circular and rectangular)	Combination of steel and aluminum	Combined chassis (tubular and angular)
14	Combined tube (circular and square)	Aluminum	Angular chassis

Methodology

Tabla 2. Generation of Alternatives

Source Author's own contribution

Alternative evaluation

Subsequently, a thorough evaluation of all alternatives was conducted based on the established requirements. Each option was assessed in terms of its ability to meet key criteria, such as maximum durability, simplicity in maintenance, and speed of repairs. As shown in Table 3, the alternatives that best met these criteria were selected, with alternatives 4, 5, 6, 10, 11, and 14 standing out as the most promising. These alternatives were considered the most suitable to advance to the next design phase due to their alignment with the project objectives and their ability to meet the operational and structural demands of the chassis.

Requirement	weight (%)	4	5	6	10	11	14
Load-bearing capacity	20%	8	8	7	8	8	8
Structure	25%	8	8	8	9	8	9
Mounting	15%	8	7	7	8	8	8
Compact design	10%	7	8	7	7	8	8
Maintenance	10%	6	7	8	7	7	7
Repairs	10%	7	8	7	8	8	8
Durability	10%	8	8	7	9	8	8
	100%	7.6	7.75	7.35	8.15	7.85	8.35

Methodology

Description and design of alternative selected

Designing a vehicle for the Baja SAE competition requires strict adherence to specific regulations, ensuring that the chassis is both strong and lightweight. To achieve this, materials such as AISI 1020 steel tubing are used, and an appropriate geometry is designed for off-road performance.

The development of the model began with a conceptual sketch, shown in Figure 5, which originated from three design variants and served as a guide for the entire project, ensuring compliance with regulations and objectives. This sketch was refined to precisely define the shapes and dimensions of the chassis and its components

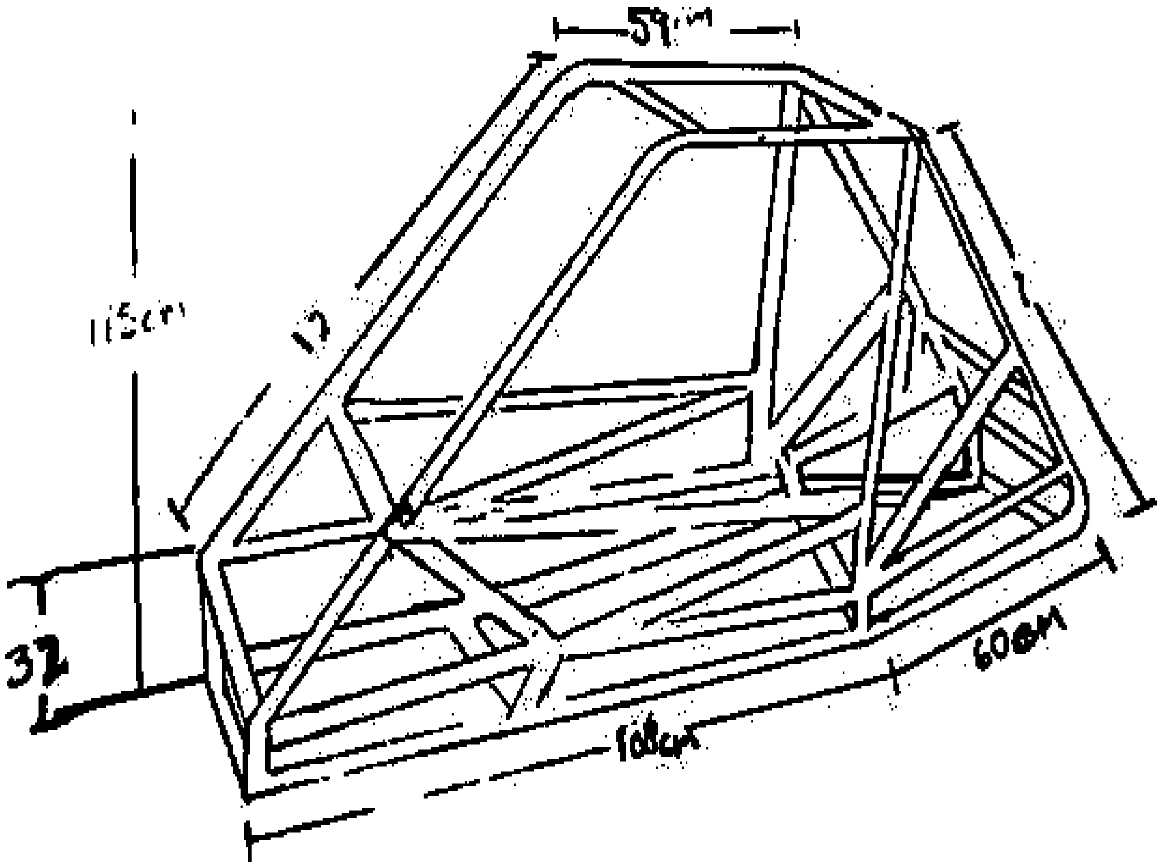


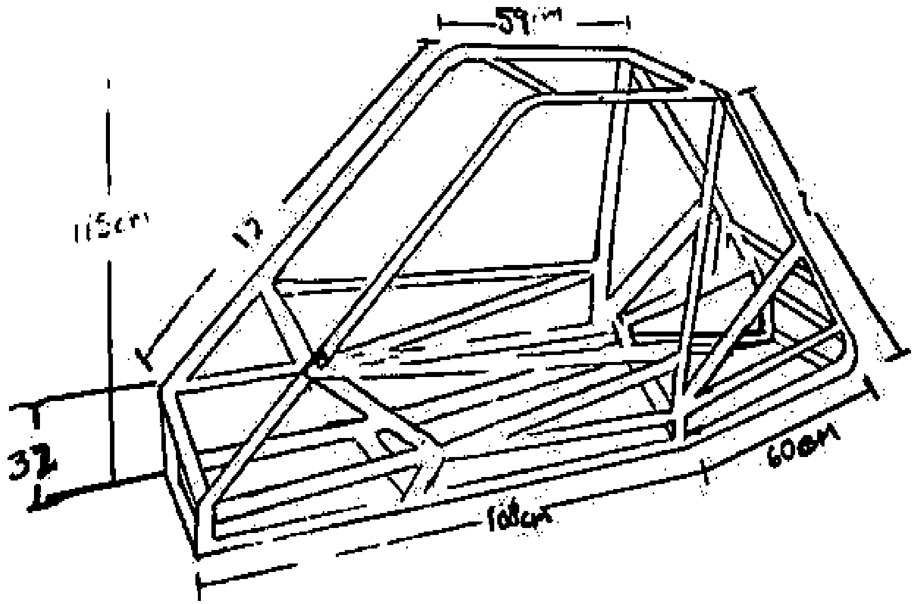
Figure 5 *Source Author's own contribution*

Methodology

Description and design of alternative selected

The development of the model began with a conceptual sketch, shown in Figure 5, which originated from three design variants and served as a guide for the entire project, ensuring compliance with regulations and objectives.

With the 3D model in development, as shown in Figure 6, structural analyses were conducted to assess the strength and behavior of the chassis under typical load conditions of the Baja SAE competition



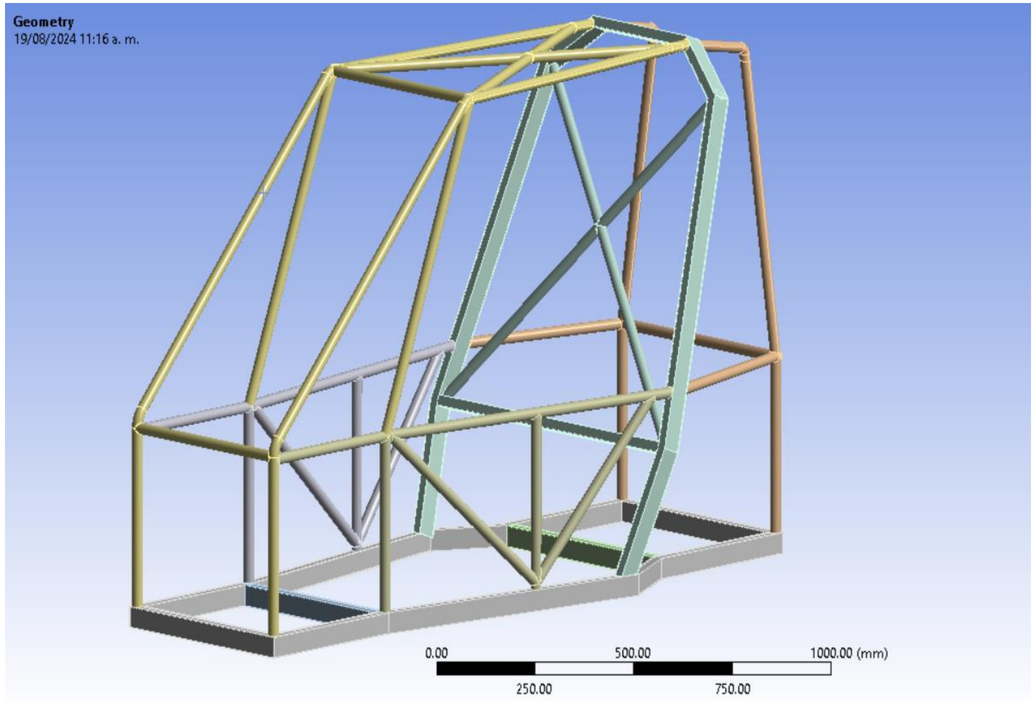


Figure 5 & figure 6 *Source Author's own contribution*

Results

In the development of the chassis for the BAJA SAE competition vehicle, multiple structural analyses were conducted using the Finite Element Method (FEM). The scenarios considered included front and rear impacts. In each of these scenarios, specific boundary conditions and representative loads were applied to accurately simulate the forces acting on the chassis in real-world situations.

Front Impact Analysis

The front loads were applied to the front of the chassis, replicating the forces expected in a severe frontal impact, assuming a 4G load with an estimated weight of 250 kg, including the driver. As shown in Figure 7, the loads were uniformly distributed across the front to ensure a realistic impact simulation.

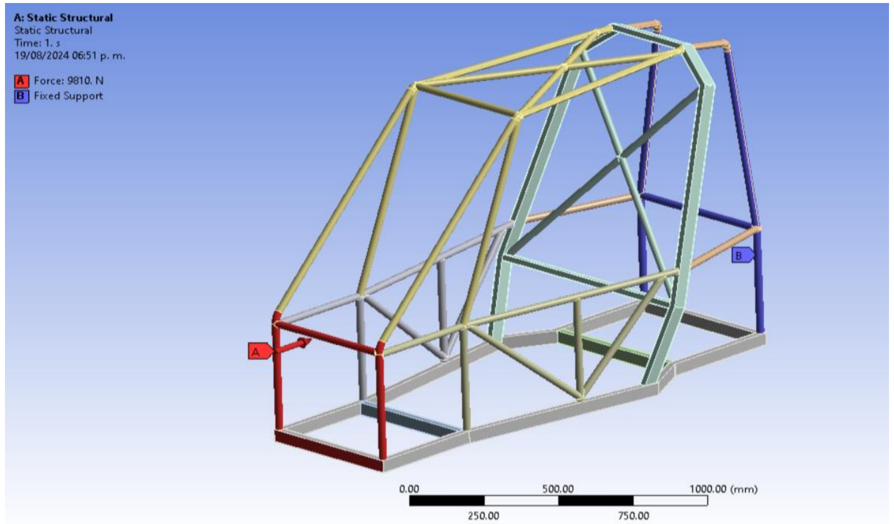


Figure 7. Boundary Conditions for Front Load

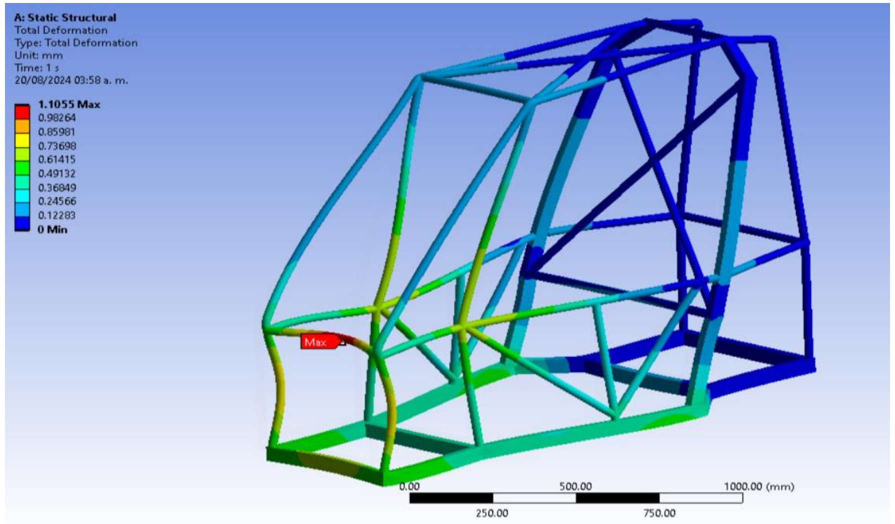


Figure 8. Total Deformation in the Front Impact Analysis

Source Author's own contribution

UNIVERSIDAD POLITÉCNICA DE GUANAJUATO

Results

Front Impact Analysis

The front loads were applied to the front of the chassis, replicating the forces expected in a severe frontal impact, assuming a 4G load with an estimated weight of 250 kg, including the driver. As shown in Figure 7, the loads were uniformly distributed across the front to ensure a realistic impact simulation. The maximum Von Mises stress recorded in these areas reached an equivalent stress of 416.59 MPa, exceeding the yield strength of AISI 1020 steel, which is 350 Mpa. The analysis resulted in a safety factor of 0.788, calculated using the Von Mises criterion. This confirms that the current chassis design with AISI 1020 steel is not safe for withstanding frontal impacts

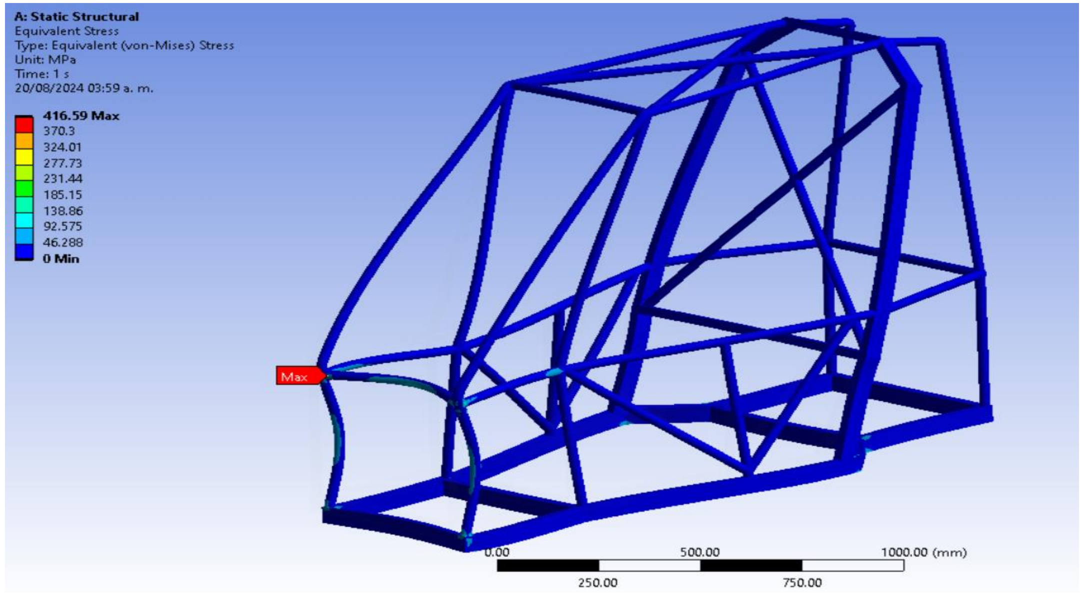


Figure 9. Equivalent Stress in the Front Impact Analysis

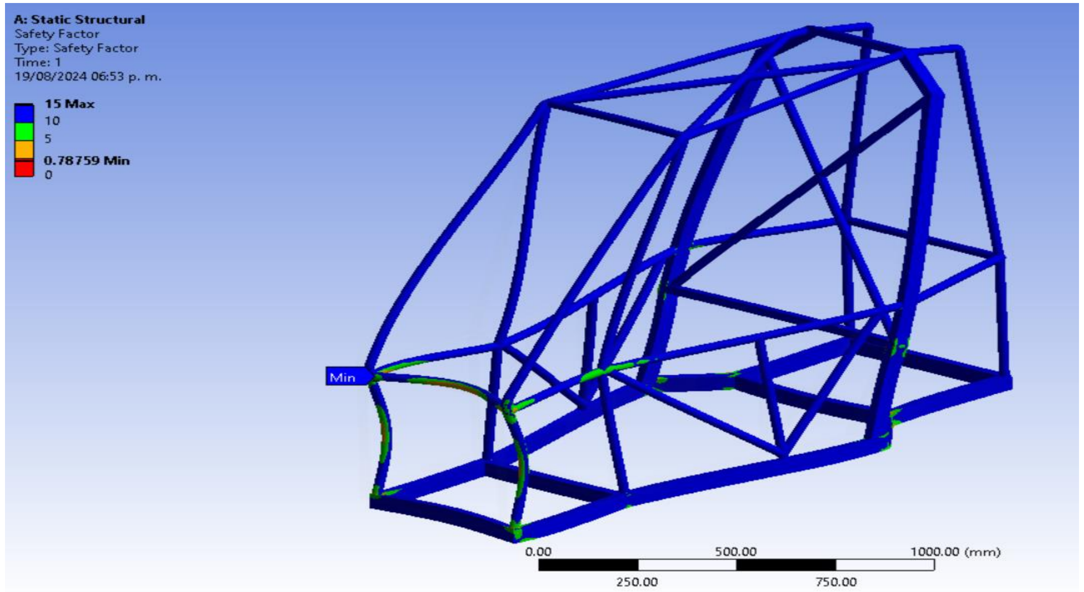


Figure 10. Safety Factor According to the Von Mises Criterion in the Front Impact Analysis

Source Author's own contribution

Results

Rear Impact Analysis

In the rear impact analysis, the chassis's resistance to longitudinal forces typical of a rear collision was evaluated. To simulate this type of impact, boundary conditions were applied that restricted the movement of the chassis at the front, while longitudinal loads were applied at the rear to represent the force of a rear-end collision with a magnitude of 4G. The maximum Von Mises stress recorded in the rear impact areas was 240.47 MPa. This value, as illustrated in Figure 13, shows how the stress is distributed in critical areas With the recorded stress value, a safety factor of 1.364 was calculated. This result, shown in Figure 14, indicates that the chassis can withstand rear impacts without significant damage

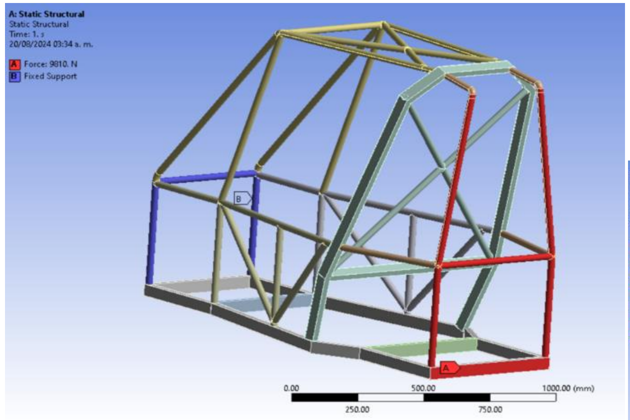


Figure 11. Equivalent Stress in the Rear Impact

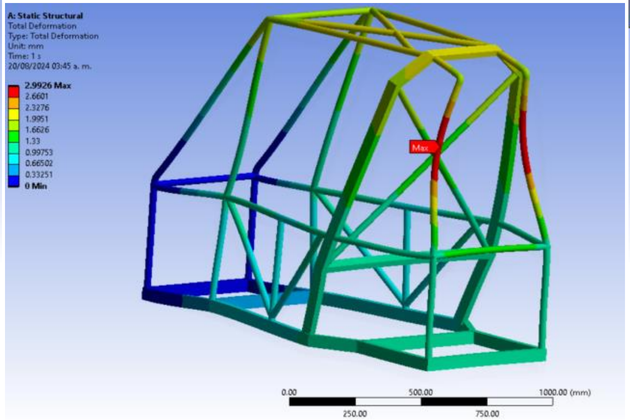


Figure 12. Total Deformation in the Rear Impact

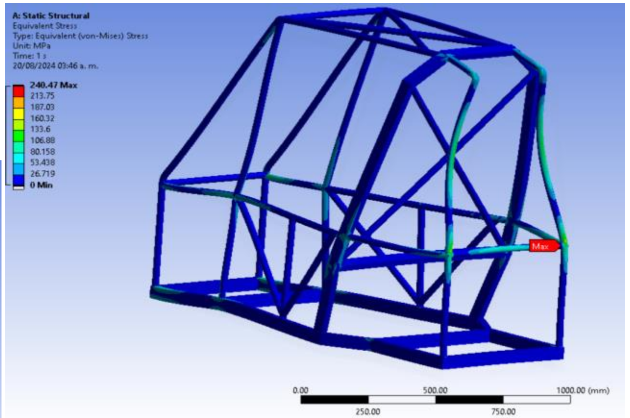


Figure 13. Equivalent Stress in the Rear Impact Analysis

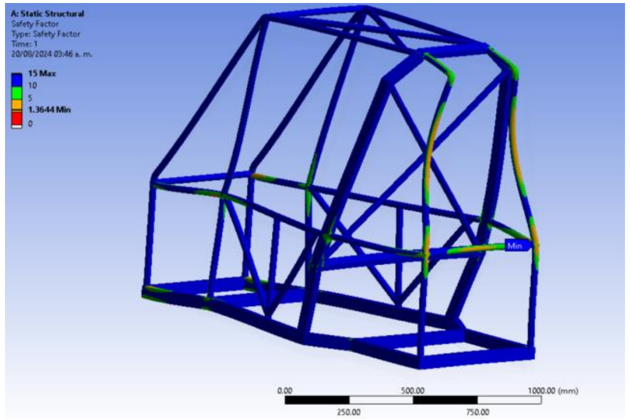


Figure 14. Safety Factor According to the Von Mises Criterion in the Rear Impact Analysis

Source Author's own contribution

Conclusions

The BAJA SAE vehicle chassis needs a more robust structural design to ensure safety and integrity in extreme frontal impact conditions. The AISI 1020 steel chassis does not meet the expected safety requirements.

To address these challenges, the possibilityof modifying the material in the front part of the chassis was evaluated, considering, for example, replacing AISI 1020 steel with AISI 1045 steel, whichhas a yield strength of 530 MPa.

Additionally, a design optimization methodology will be applied that considers key variables of strength and weight.

The implementation of design optimization, along with the possible modification of the material in the front part, is a crucial step to improve the chassis's integrity in frontal impacts, applying an approach based on strength and weight to meet the strict safety standards of the BAJA SAE competition.

References

Baja SAE. (2024). Baja SAE Rules 2024. Society of Automotive Engineers.

Bhandari, V. B. (2021). Design of Machine Elements. McGraw Hill Education. ISBN: 9789390177479

Beer, F. P., Johnston, E. R., & DeWolf, J. T. (2020). Mechanics of Materials. McGraw-Hill Education. ISBN: 9781260113273

Hibbeler, R. C. (2020). Engineering Mechanics: Statics & Dynamics (14th ed.) Pearson. ISBN: 9780136912378

Logan, D. L. (2016). A First Course in the Finite Element Method. Cengage Learning. ISBN: 9781337342407

Budynas, R. G., & Nisbett, K. J. (2024). Shigley's Mechanical Engineering Design ISE (11th ed.). McGraw Hill Education. ISBN: 9781260577112

Cross, N. (2021). Engineering design methods: Strategies for product design (5th ed.). John Wiley & Sons. ISBN: 978-1-119-72440-7

Pahl, G., Beitz, W., Feldhusen, J., & Grote, K.-H. (2007). Engineering Design: A Systematic Approach (3rd ed.). Springer. https://doi.org/10.1007/978-1-84628-319-2

ECORFAN®