

# **The design and development of a vehicle chassis for a Formula SAE competition car**

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*This dissertation is dedicated with the deepest love to my deceased sister and dog,*

*Anuschka*

*6 / 12 / 2001 – 4 / 08 / 2013*

*A true testimony of God's life-giving love and unfathomable grace*

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## DECLARATION

I, Izak Johannes Fourie, hereby declare that the work contained in this dissertation was produced by myself and is my own, original and unaided work. Some of the information contained in this dissertation has been gained from various journal articles; text books etc, and has been referenced accordingly. The word herein has not been submitted for a degree at another university.

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## ABSTRACT

The Formula SAE is a student based competition organised by SAE International where engineering students from a university design, develop and test a formula-style race car prototype to compete against other universities. The competition car needs to satisfy the competition rules set out by the organisers. The competition strives to stimulate original, creative problem solving together with innovative engineering design practices.

In any race environment, the primary goal is always to be as competitive as possible. Due to the competitive nature of motor sport, vehicle components need to withstand various and severe stresses. The components of a race car vehicle are responsible for the vehicle's handling characteristics and reliability. The chassis is a crucial and integral component of a Formula SAE competition car, primarily responsible for the vehicle's performance characteristics. The chassis is the structural component that accommodates all the other components. A Formula SAE chassis is a structure that requires high torsional stiffness, low weight as well as the necessary strength properties.

In this study, multiple Formula SAE chassis were designed and developed using computer aided design software. Each concept's torsional stiffness, weight and strength properties were tested using finite element analysis software. The different concepts consisted of different design techniques and applications. All the concepts were analysed and assessed, leading to the identification of an acceptable prototype. The prototype was manufactured for experimental tests.

The designed chassis complied with the Formula SAE rules and regulations. The weight, torsional stiffness and strength characteristics of the designed chassis frame were also favourable compared to accepted standards for Formula SAE chassis frames. The manufactured chassis was prepared for experimental tests in order to validate the simulation results produced by the finite element analysis. The torsional stiffness, weight and strength were experimentally determined and the results were compared with the corresponding simulation results. The comparison of the experimental and simulated results enabled the validation of the finite element analysis software.

The study draws conclusions about the use of computer aided design and finite element analysis software as a design tool for the development of a Formula SAE chassis. Closure about the study is provided with general conclusions, recommendations and research possibilities for future studies.

## KEYWORDS

Chassis

Computer aided design

Finite element analysis

Formula SAE

Motorsport

SolidWorks

Space frame

Structures

Torsional stiffness

Vehicle design

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Engineering is not only when solutions meet a problem.

It is when man is in harmony with nature.

It is when  
sciences become reality  
dreams become drawings  
thoughts become things

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## NOMENCLATURE

CAD	Computer Aided Design
CAE	Computer Aided Engineering
COG	Centre of Gravity
CNC	Computer Numerical Control
CS1 (a)	Cockpit Structure 1(a)
CS1 (b)	Cockpit Structure 1(b)
CS2	Cockpit Structure 2
FEA	Finite Element Analysis
FOS	Factor of Safety
FS	Front Structure
FSAE	Formula SAE
RS	Rear Structure
SAE	Society of Automotive Engineers

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## SYMBOLS LIST

A	Area
$A_{\text{inner}}$	Inner area
$A_{\text{outer}}$	Outer area
$D_{\text{inner}}$	Inner diameter
$D_{\text{outer}}$	Outer diameter
E	Young's modulus
F	Force
G	Shear modulus
I	Moment of inertia
$K_{\text{Torsional}}$	Torsional stiffness
k	Strain gauge factor
$L_{\text{chassis}}$	Chassis length
M	Bending moment
P	Applied load
$STR_{\text{MAX}}$	Combined axial & bending stress
$S_y$	Yield strength
$S_{\text{ut}}$	Tensile strength
T	Torsional moment
$U_{\text{EXC}}$	Excited voltage
$U_{\text{OUT}}$	Output voltage
W	Weight
$W_{\text{chassis}}$	Chassis weight
$\Delta$	Translational deflection change
$\varepsilon$	Strain
$\sigma$	Stress
$\theta$	Angular displacement

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