Study on Mechanical Properties of Monocoque Chassis for Electric Formula Student using Finite Element Analysis

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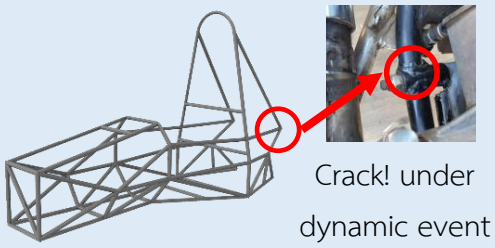
Introduction

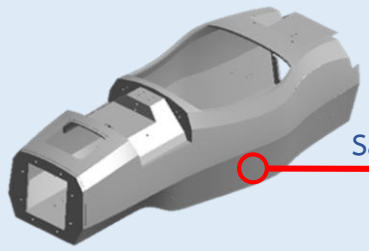
● Steel spaceframe chassis ●



Crack! under dynamic event

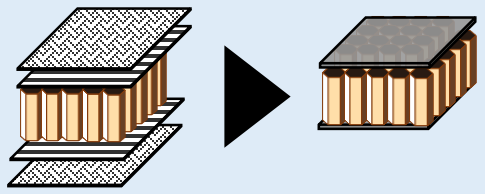
Welding at steel tubes
→ Easier to construct

● Full-body composite monocoque chassis ●



Single piece chassis
→ No stress concentration
Made from carbon fiber reinforced composite
→ High specific strength

Design Idea



UD carbon fiber Woven carbon fiber

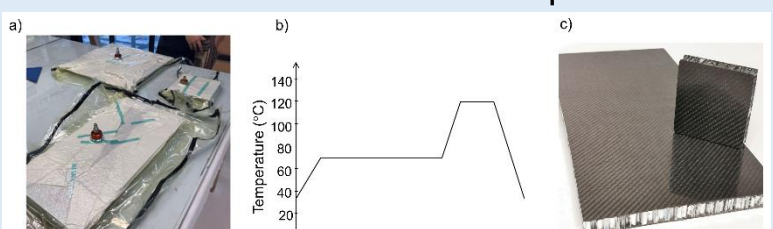
Aluminum honeycomb core

- Protection layer: Woven (Outer)
- Strength layer: UD (Inner)

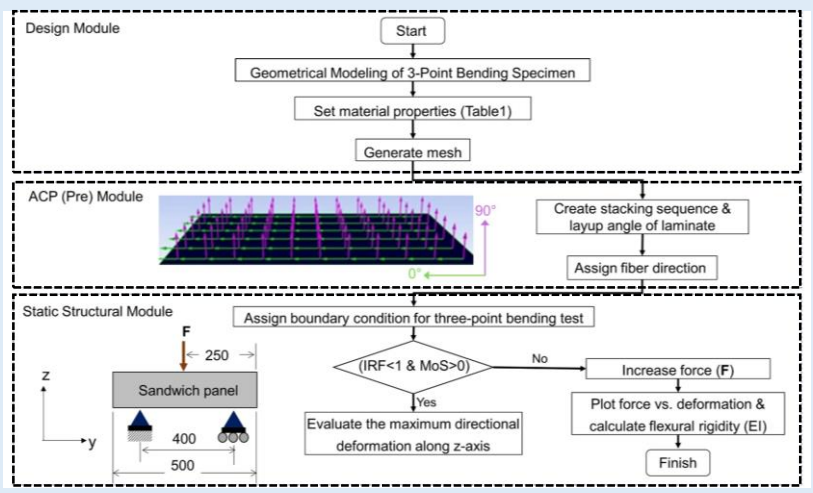
Objective

To design high strength-to-weight ratio of full-body composite monocoque chassis for electric formula student car by optimization of stacking sequences and number of plies of carbon fiber laminate in sandwich panel

Fabrication of sandwich panel



Finite element model

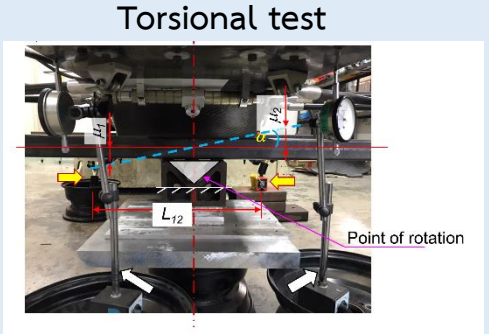


Mechanical tests

3 Point bending

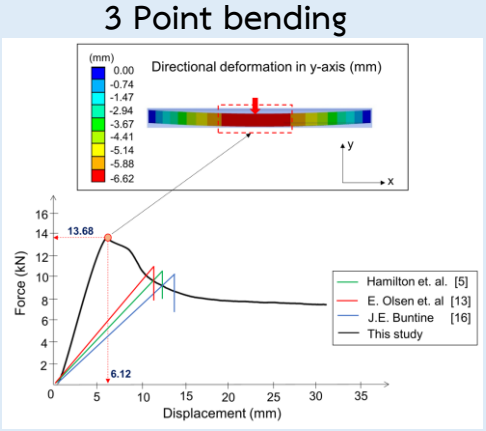
Perimeter shear

Torsional test

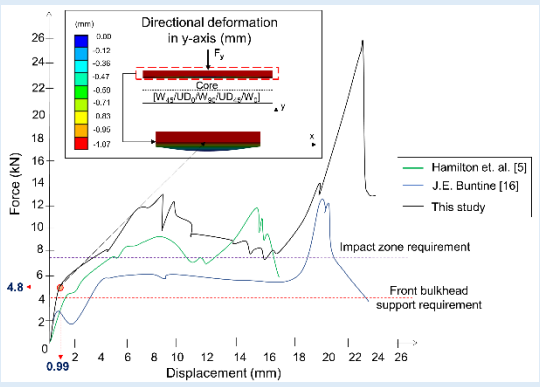


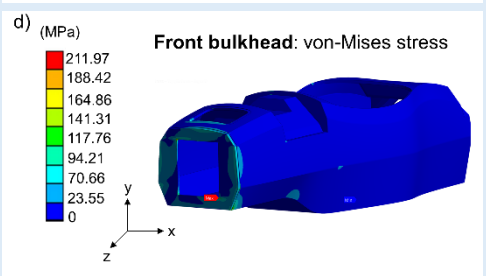
Results & Discussion

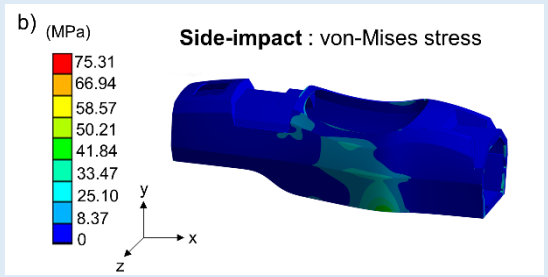
3 Point bending



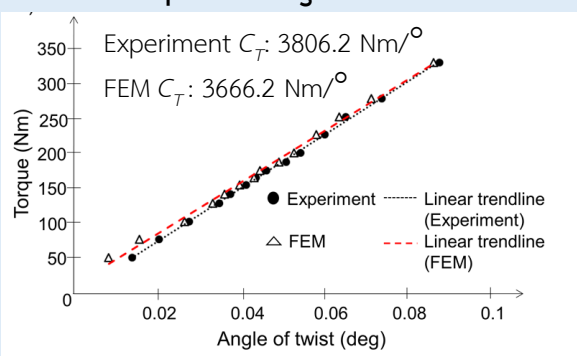
Perimeter shear







Torque & Angle of twist



Torque (T) : $T = Fr$

Angle of twist (α)

$$\alpha = \tan^{-1}\left(\frac{\mu_1 + \mu_2}{L_{12}}\right)$$

Torsional stiffness (C_T)

$$T = C_T \alpha$$

Summary

The proposed stacking sequence of carbon fiber plies; $W45/UD0/W90/UD45/W0/core]_{sym}$, shows

(i) the highest deflection force at similar displacement under 3point bending and perimeter shear tests, respectively

(ii) The highest 25 MPa of stress contributes 6.12 and 0.99 mm under side-impact and front bulkhead, respectively, which were below the maximum allowable 25 mm regarding FSAE rules.

(iii) Moderate CT → Higher accuracy during cornering

References: [1] FSAE rules (2019) [2] Hamilton et al, *SAE Tech. paper* (2015)., [3] E. Olsen et al, *IJRSI* (2016)., [4] J.E. Buntine, Bachelor thesis, UNSW (2018).