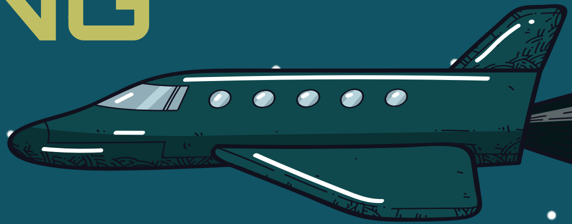
CRASH ANALYSIS OF COMPOSITE AIRCRAFT FUSELAGE UNDER BELLY LANDING



SHARIFAH NADHIRAH BINTI SYED ABD RAHMAN ALQUDSY
DR.JAFFAR SYED MOHAMED ALI,
DR.MOHAMED SULTAN IBRAHIM SHAI DAWOOD

INTRODUCTION

Belly landing crashes:

- ❖ Mechanical failure
- ❖ Human error

Fuselage:

- ❖ Main body of an aircraft
- ❖ Protects passenger

Figure 1: UTair Airlines Boeing 737 hard landing at Usinsk Airport. February 9, 2020[1]

PROBLEM STATEMENT

- ➢ Aircraft structures are designed for crash survival under belly landing.
- ➢ Too risky and expensive to do full-scale drop test.
- ➢ Need to use Finite Element Analysis (FEA) - LS-DYNA to do simulation of crash under belly landing.
  - Can be computationally demanding

OBJECTIVES

- ★ To study and analyse the energy absorption of the fuselage under belly landing.
- ★ To study the effect of composite structure on energy absorption.
- ★ To conduct parametric studies on the effect of different velocities, terrains and materials.

METHODOLOGY

Fuselage Modelling

Length: 1 m
Skin, frames, stringers' thickness: 0.2 cm

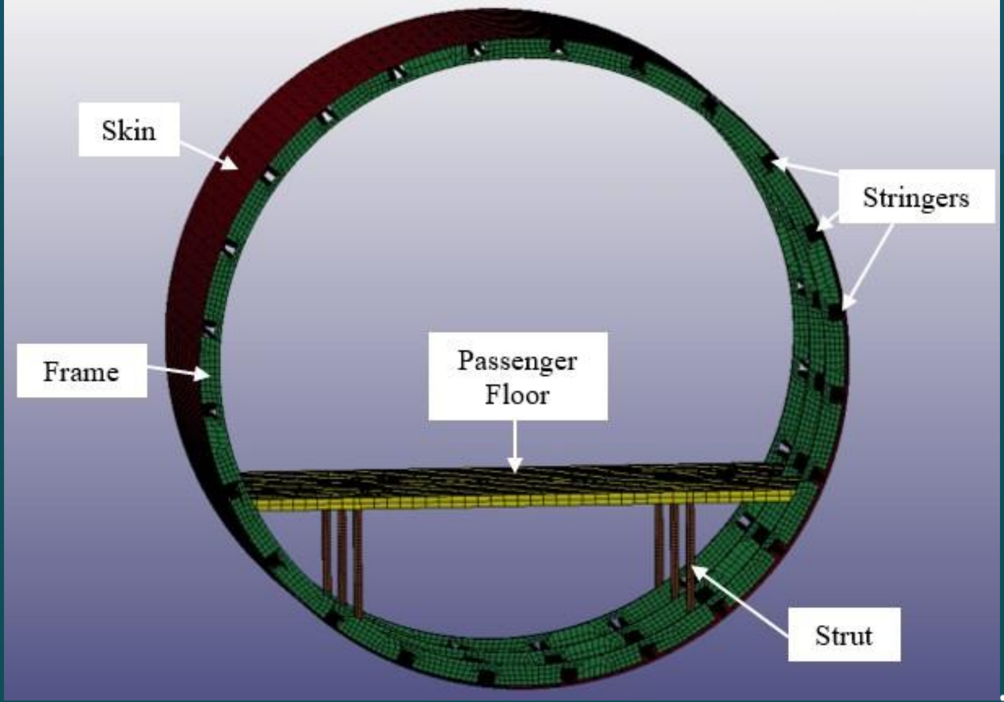


Figure 2: Fuselage components

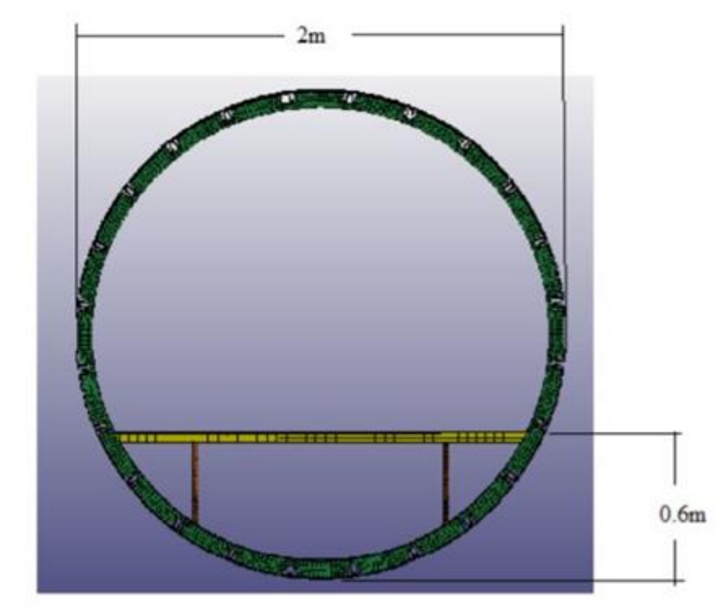


Figure 3: Fuselage dimensions

Material Selection

- Aluminium Materials
  - MAT_098 (simplified johnson-cook) were used for skin, frames, stringers and struts
  - MAT_003 (plastic kinematic) were used for passenger floor

Table 1: Aluminium material properties

Components	Density (kg/m^3)	Elastic Modulus (GPa)
Skin	2796	71
Frame	2796	71
Stringer	2796	71
Strut	2796	71
Passenger Floor	2990	18

Material Selection

- Composite Materials
  - MAT_054 (enhanced composite damage) were used

Table 2: Carbon fiber material properties

Properties	Value
Density (kg/m^3)	1570
Young's modulus – longitudinal direction, E_1 (GPa)	135
Young's modulus – longitudinal direction, E_2 (GPa)	8.8
Poisson's ratio, μ_{12} (GPa)	0.2
Shear modulus of elasticity, G_{12} (GPa)	4.47
Longitudinal tensile strength, X_t (GPa)	1.548
Longitudinal compressive strength, X_c (GPa)	1.226
Transverse tensile strength, Y_c (GPa)	0.218
Transverse compressive strength, Y_t (GPa)	0.0555
Shear strength, G_{12} (GPa)	0.0899

Composite Skin Laminates (8 layers)

Antisymmetric Cross Ply	Unidirectional
• [0/90/0/90/0/90/0/90]	0° 60° 30° 90° 45°
Antisymmetric Angle Ply	**Symmetric Quasi-Isotropic**
• [30/-30/30/-30/30/-30/30/-30] • [45/-45/45/-45/45/-45/45/-45] • [60/-60/60/-60/60/-60/60/-60]	• [90/45/0/-45]s

Terrain Modelling

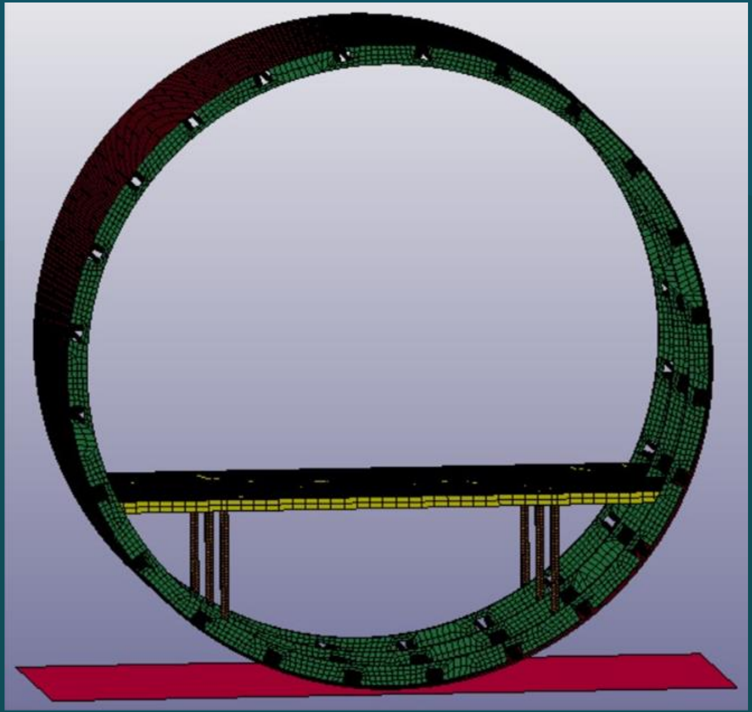


Figure 4: Rigid ground

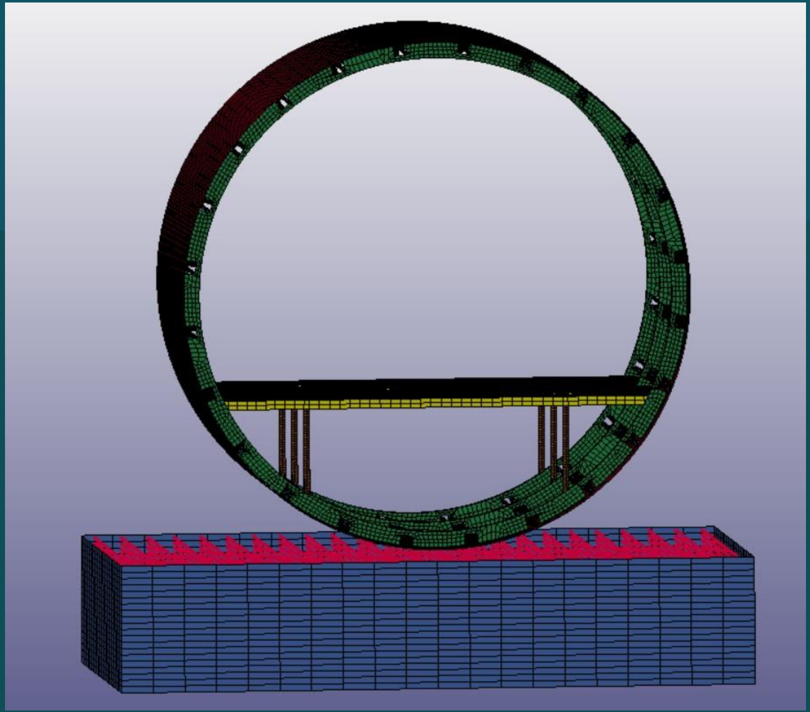
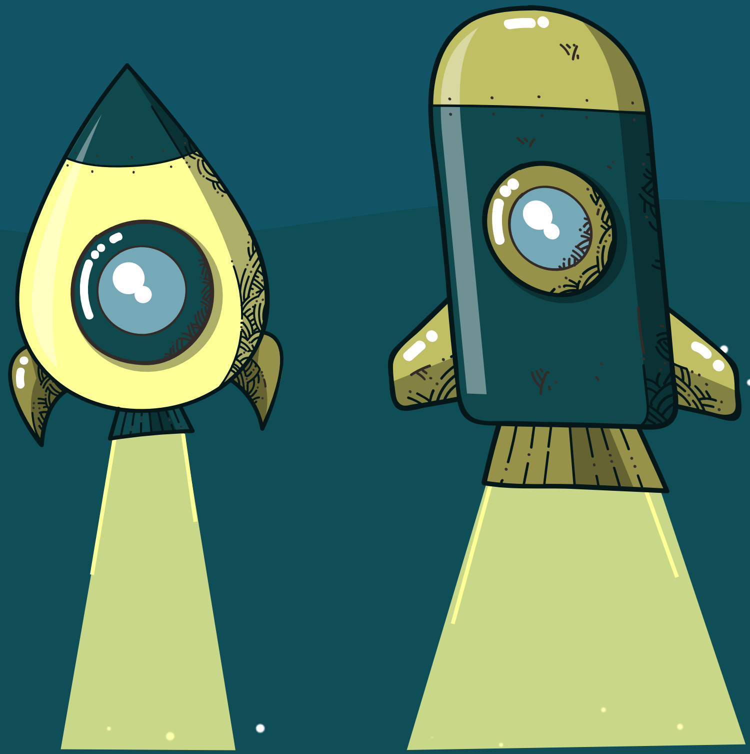


Figure 5: Water surface

Boundary Condition

- ❑ Two different velocities:
  - 7 m/s
  - 10 m/s



RESULTS

- Validation on aluminium fuselage drop test on the ground

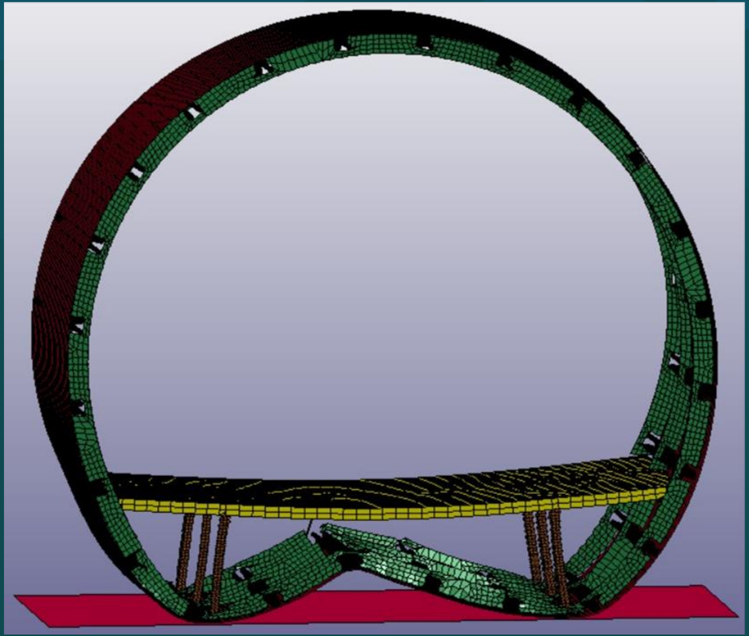


Figure 6: After dropped

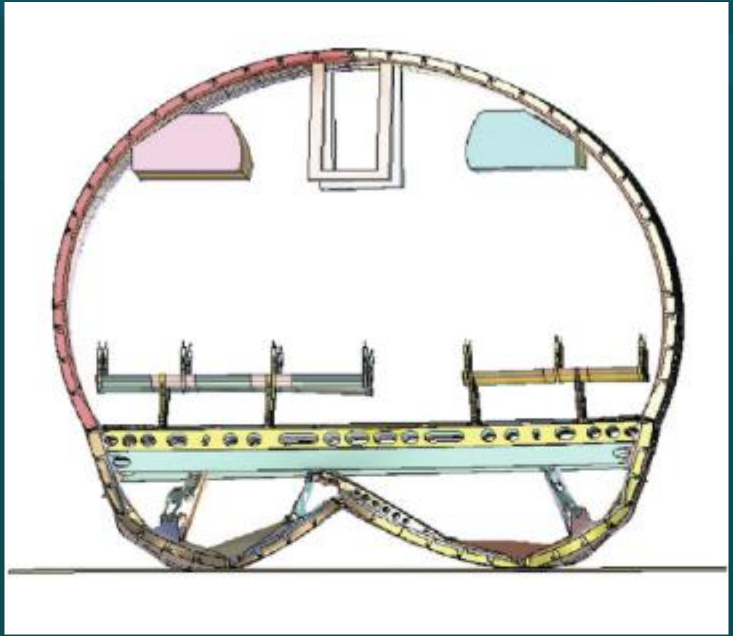


Figure 7: Deformation after impact[2]

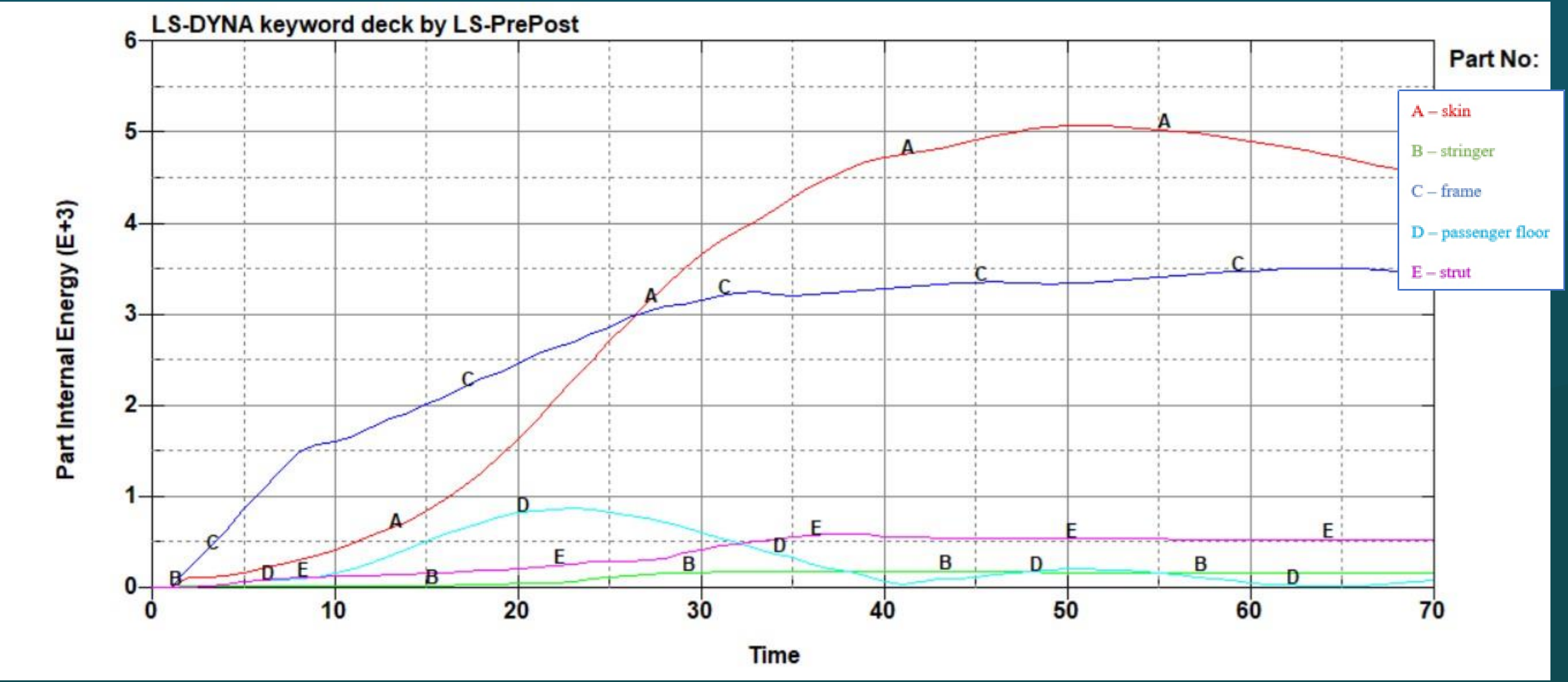


Figure 8: Graph of part internal energy for aluminium fuselage with impact velocity of 10 m/s

- Validation on aluminium fuselage drop test on water

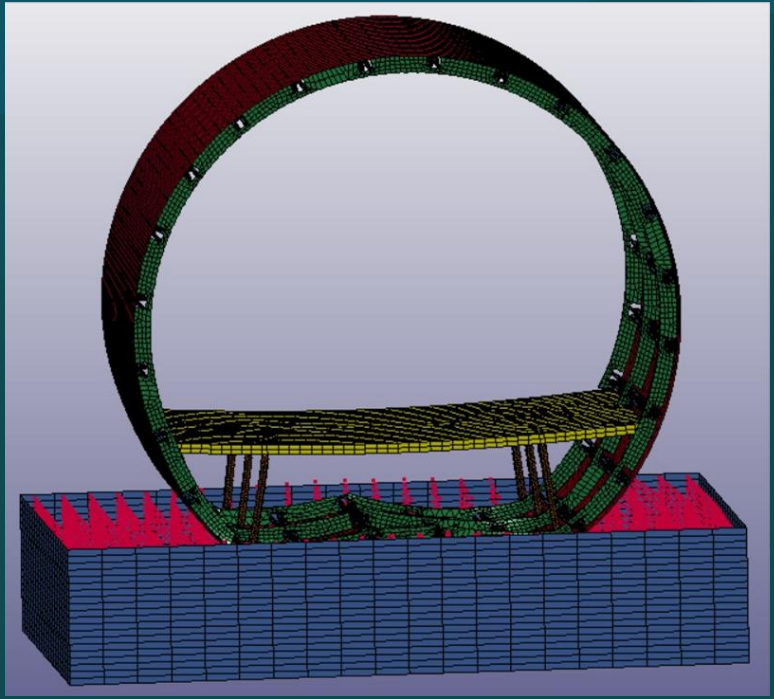


Figure 9: After dropped

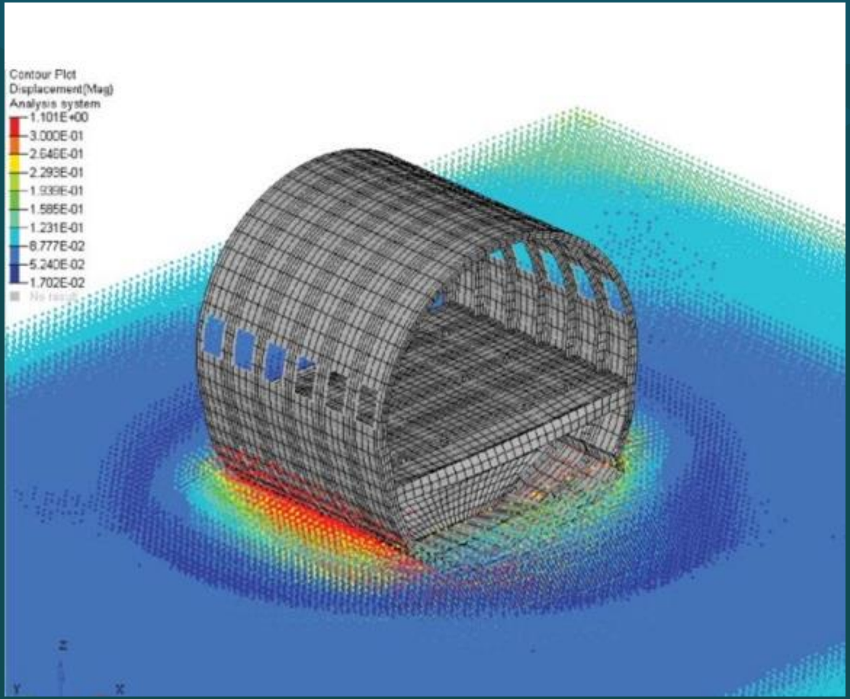


Figure 10: Behaviour of fuselage section[3]

RESULTS

For composite skin laminates

Unidirectional Laminates

Energy absorption comparison

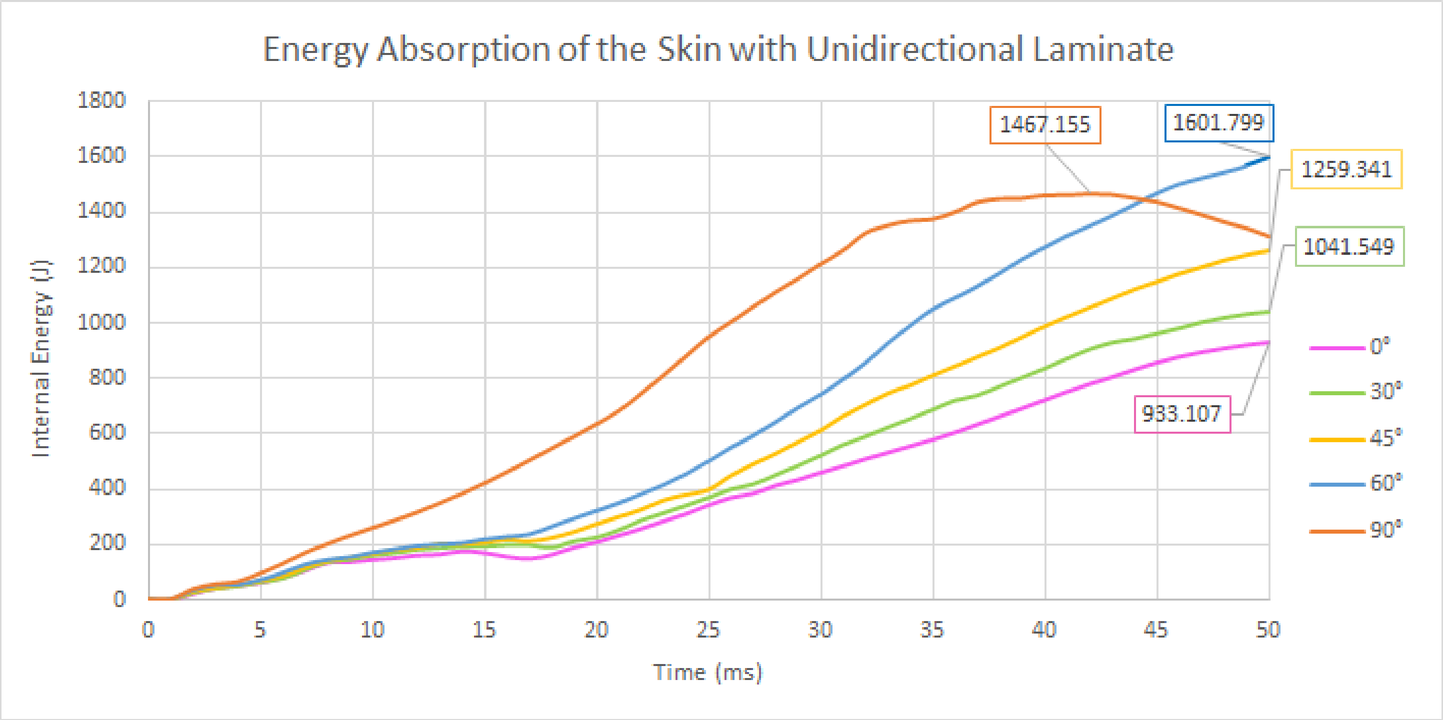


Figure 15: Graph of internal energy of the skin for unidirectional laminates

Effect of different materials

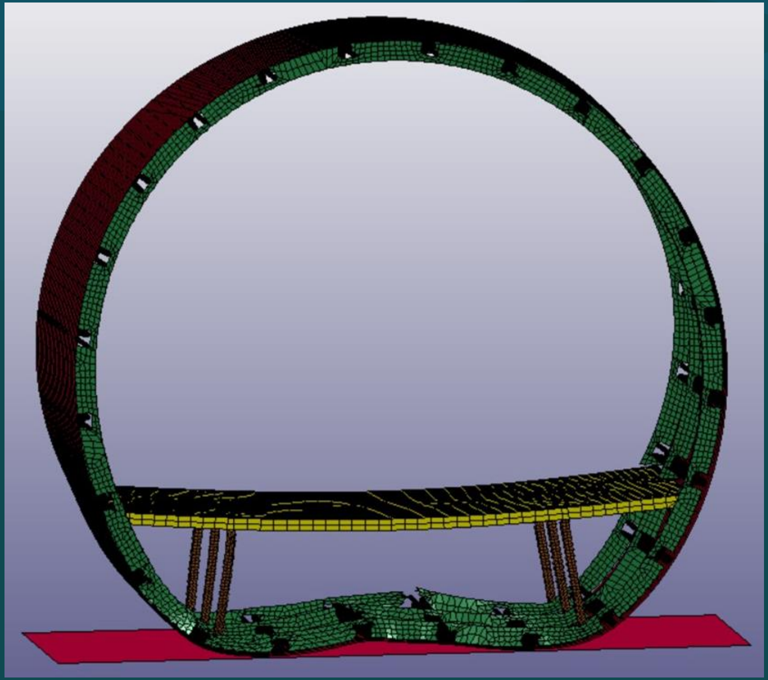


Figure 22: Aluminium fuselage

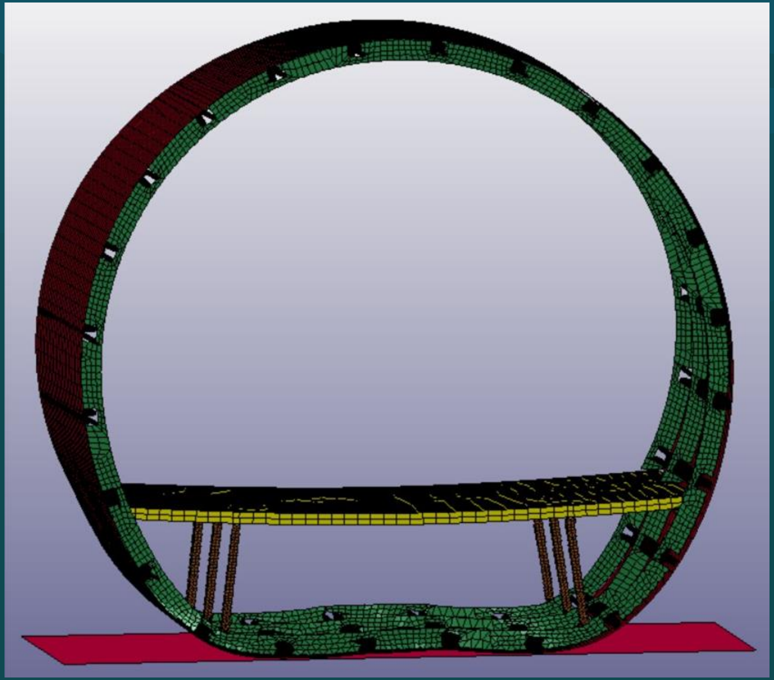


Figure 23: Composite fuselage

CONCLUSION

- Aluminium vs composite
  - Aluminium absorbs higher energy than carbon fiber
- Aluminium fuselage
  - Energy absorption varies in different parameters.
  - Frames and skin absorbs the most energy.
- Composite fuselage
  - Frames absorbs the most energy followed by the skin, the passenger floor, struts and stringers.
  - Symmetric quasi-isotropic laminates have a good energy absorbing process.

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