Design and Analysis of a Smart Composite Beam for Small Wind Turbine Blade

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Outline

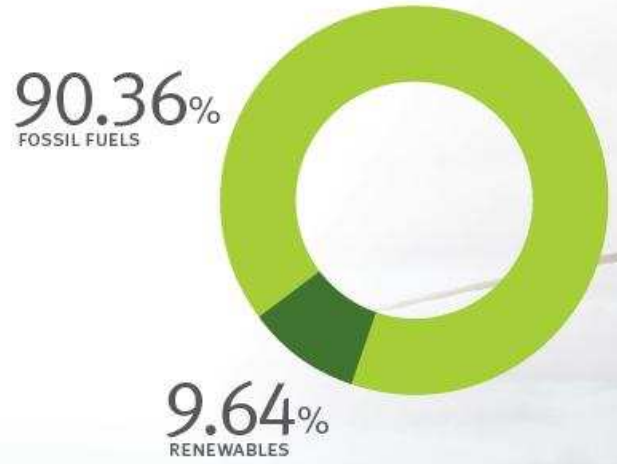
1. Background
   - Wind Energy in Australia
   - Construction of the Wind Blade
   - Aerodynamic of Wind Turbine
2. Load Cases and Design Challenges
   - Inertial, Gravity and Structural Forces Blade Design and Structural Analysis
3. Smart Structures Application
4. Modeling Process and FEA
5. Current Project
6. Conclusion

- global warming and environmental problem

- wind energy is not new technology renewable energy

Australian Renewable Energy Snapshot

Renewable energy rose to 9.6% of the total electricity produced.



- Australian Mandatory Renewable Energy Target: 20 % by 2020 (MRET)
- electricity coming from sources like wind solar and geothermal will be around the same as all of Australia's current household electricity use.

Source: Clean Energy Council Renewable Energy Database,2011

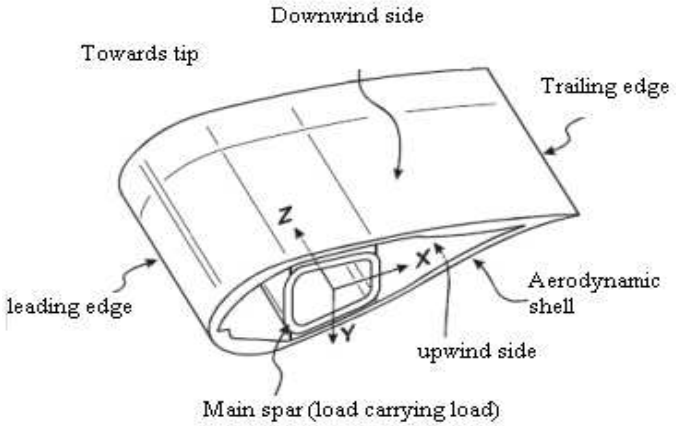
Modern Wind Blade

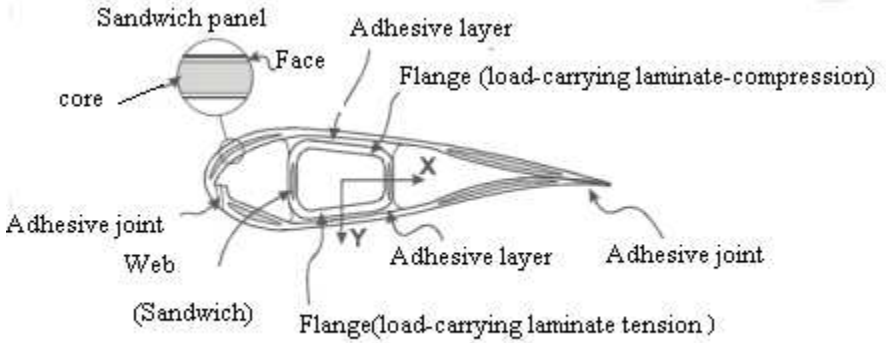
- Modern wind turbines- larger size to generate more electrical power.
- At present, majority of wind turbine blades are constructed with fibre composite materials.
- blades are required to preserve an optimum cross section for aerodynamic efficiency to generate the maximum torque to drive the generators.

Why composite become the only choice ?

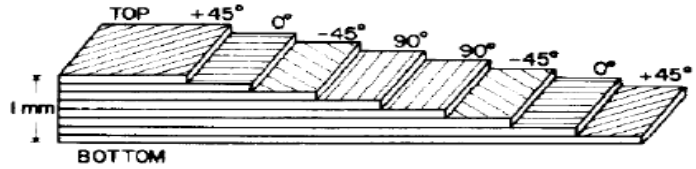
- Light weight
- High strength and stiffness
- Good fatigue strength
- Good design ability
- Good processing ability

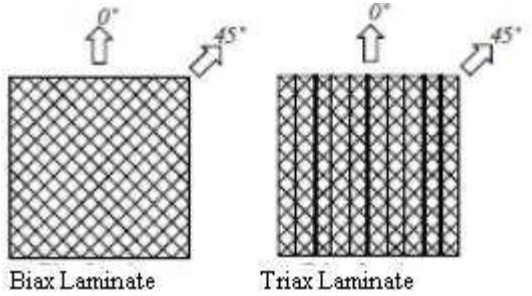
Construction of the Wind Blade



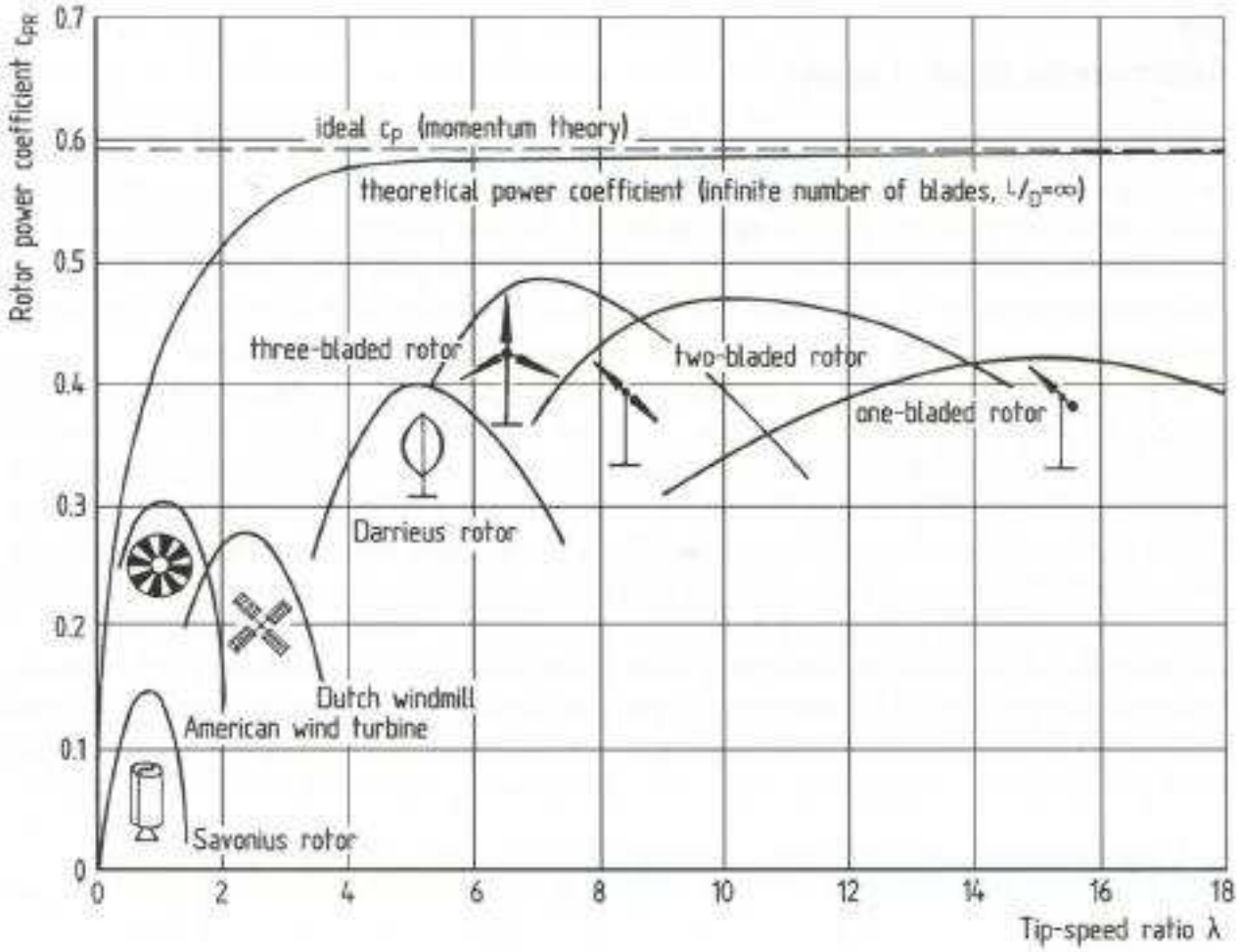


- made in polymer matrix composites, often glued together.
- Such structures may develop a number of possible failure modes





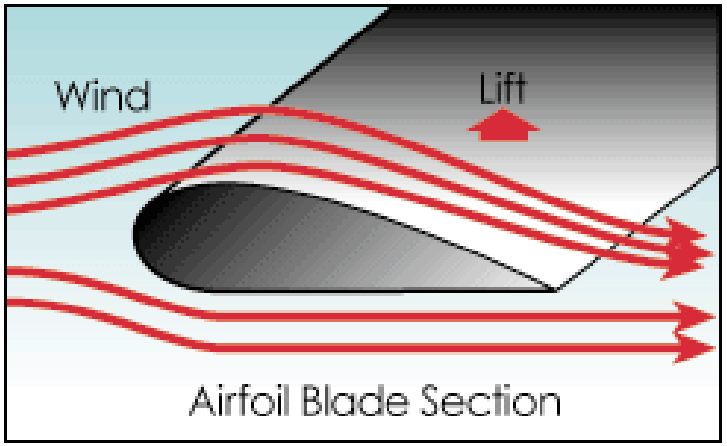
Power Coefficient of the Wind Turbine

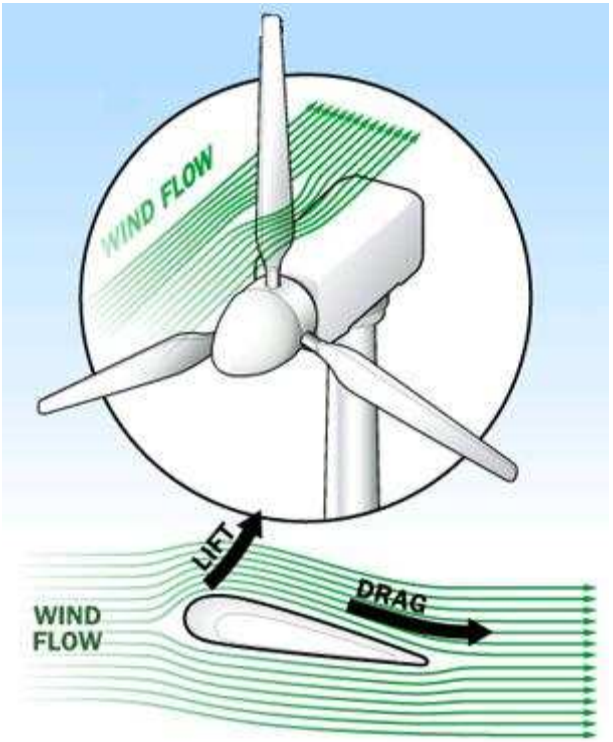


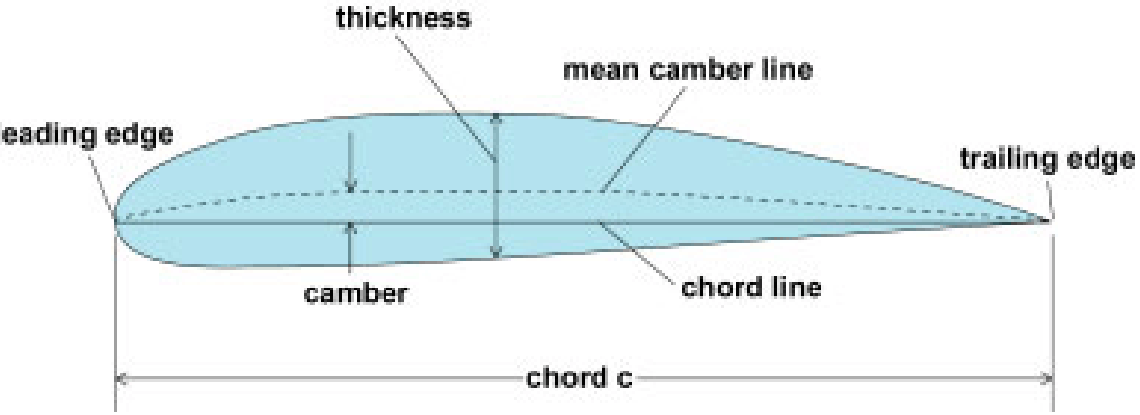
Why blade is very important?

- Interact directly with wind
- A prime mover in the wind turbine system -blade performance.
- It is definitely major component - system efficiency.

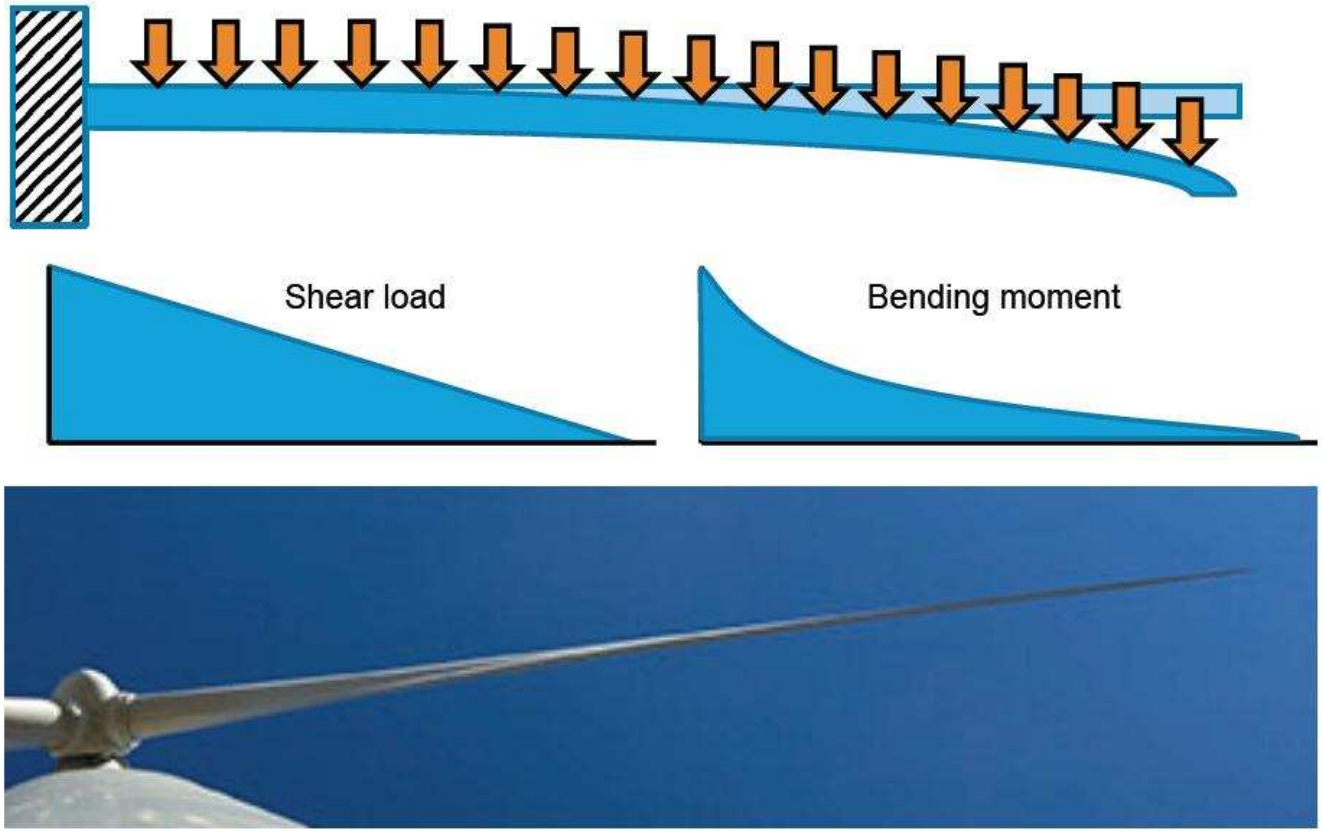
Aerodynamic of Wind Turbine



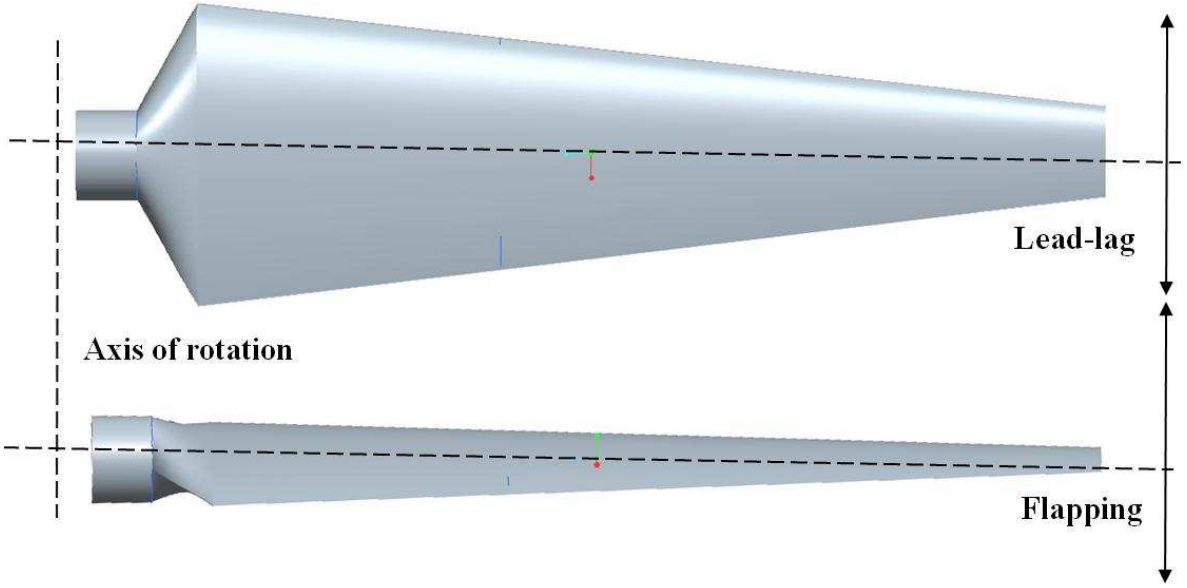


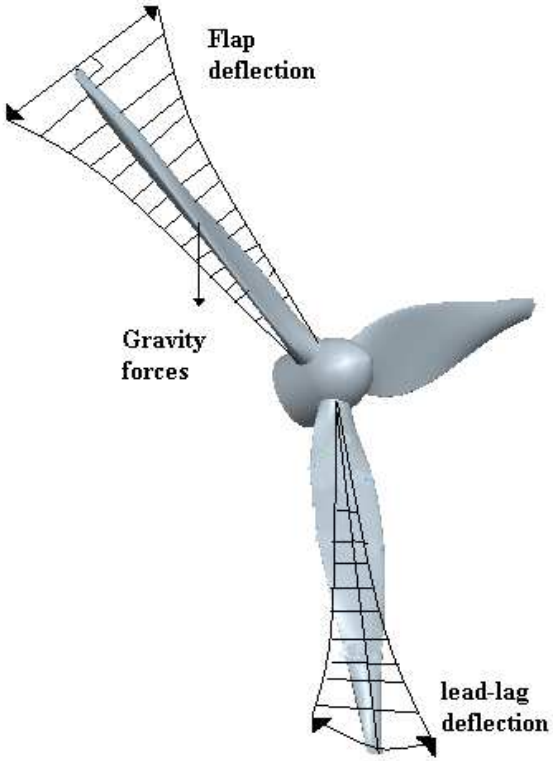


Load cases and design challenges

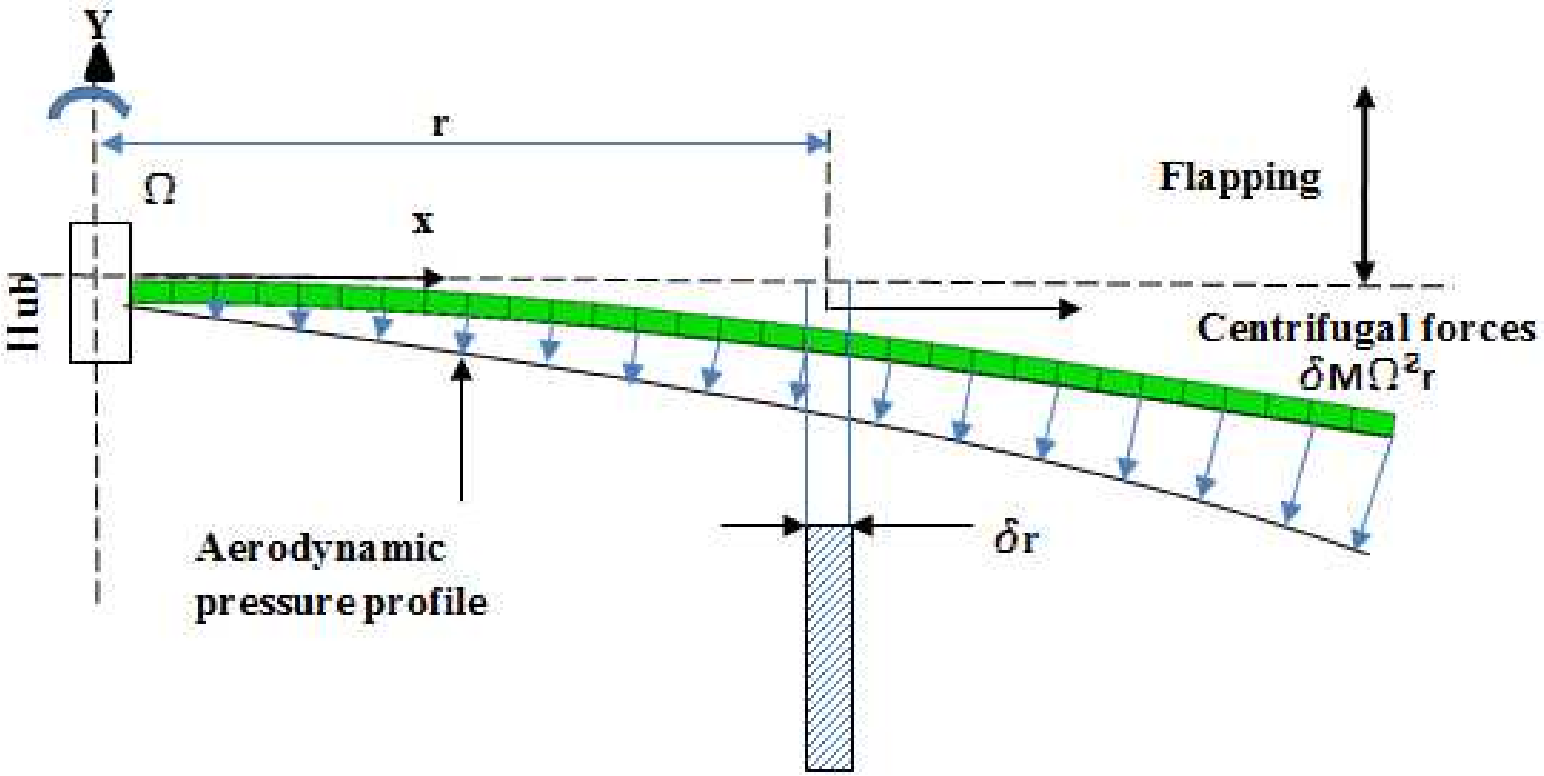


Inertial, Gravity and Structural Forces Blade and Structural Analysis

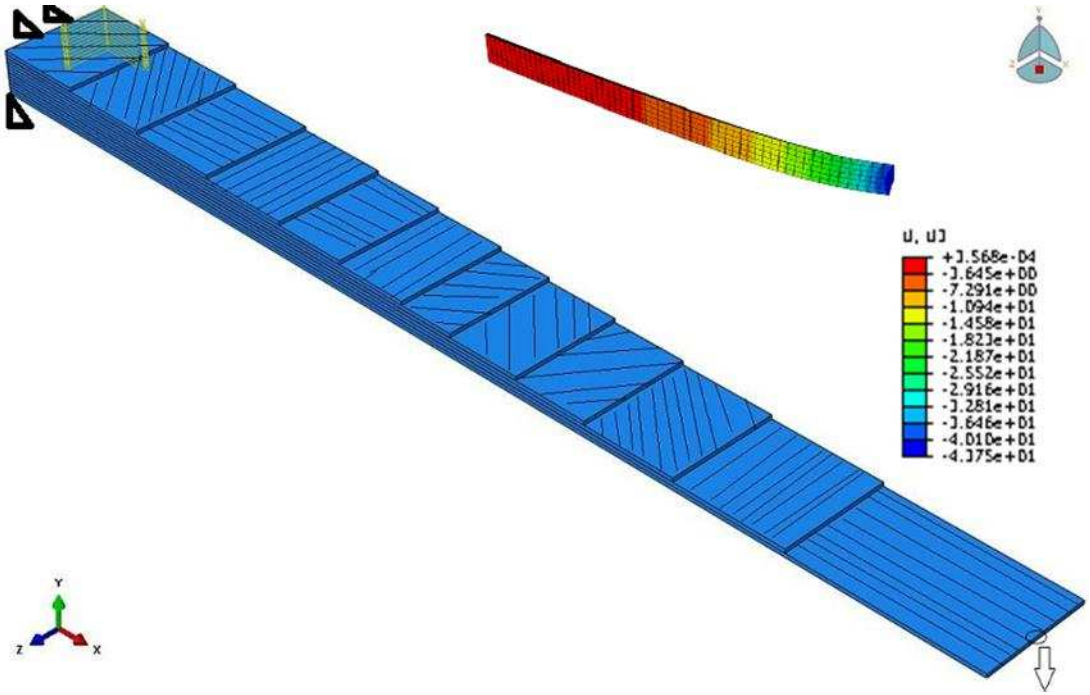




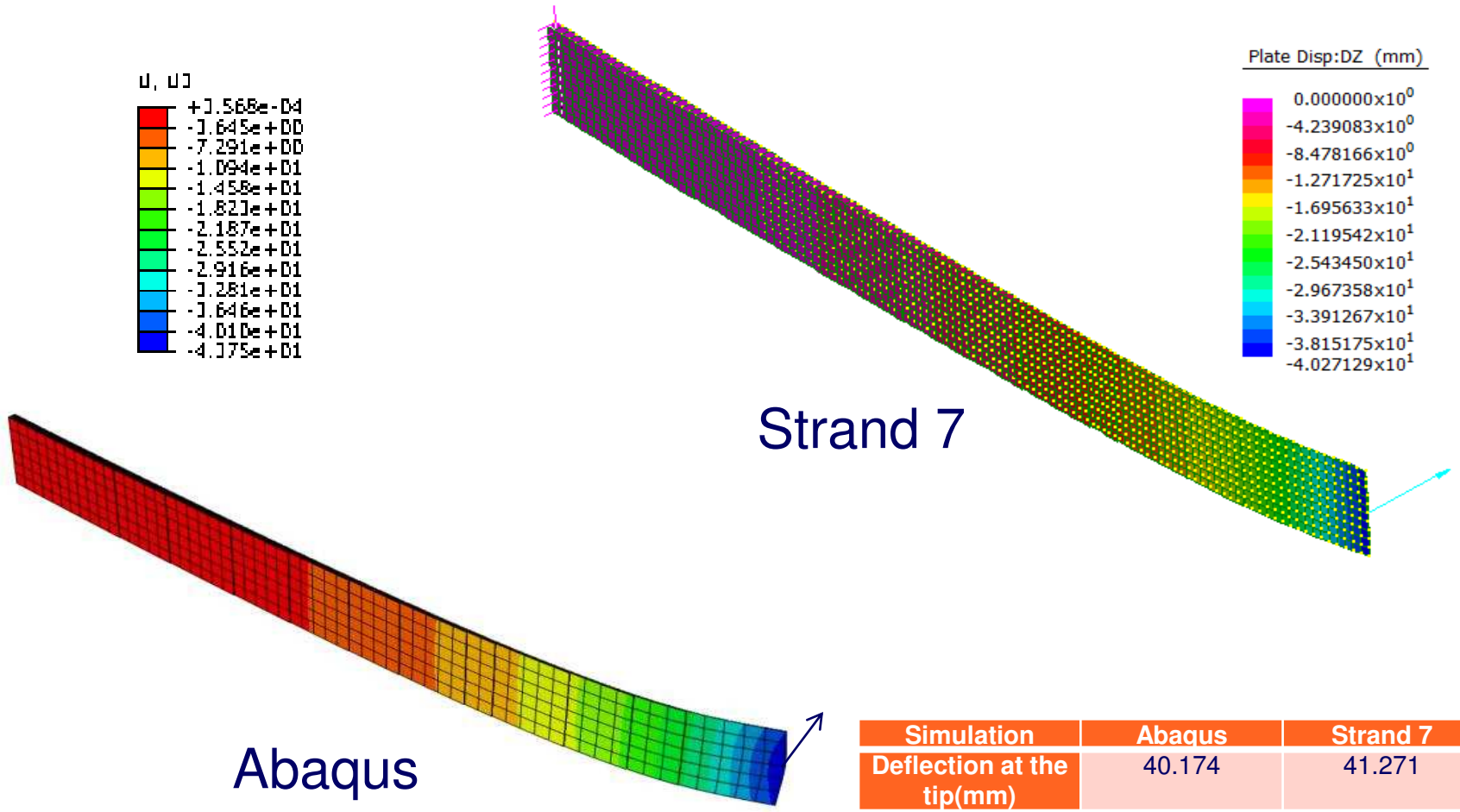
Blade Loading



Modeling Process and FEA (contd)



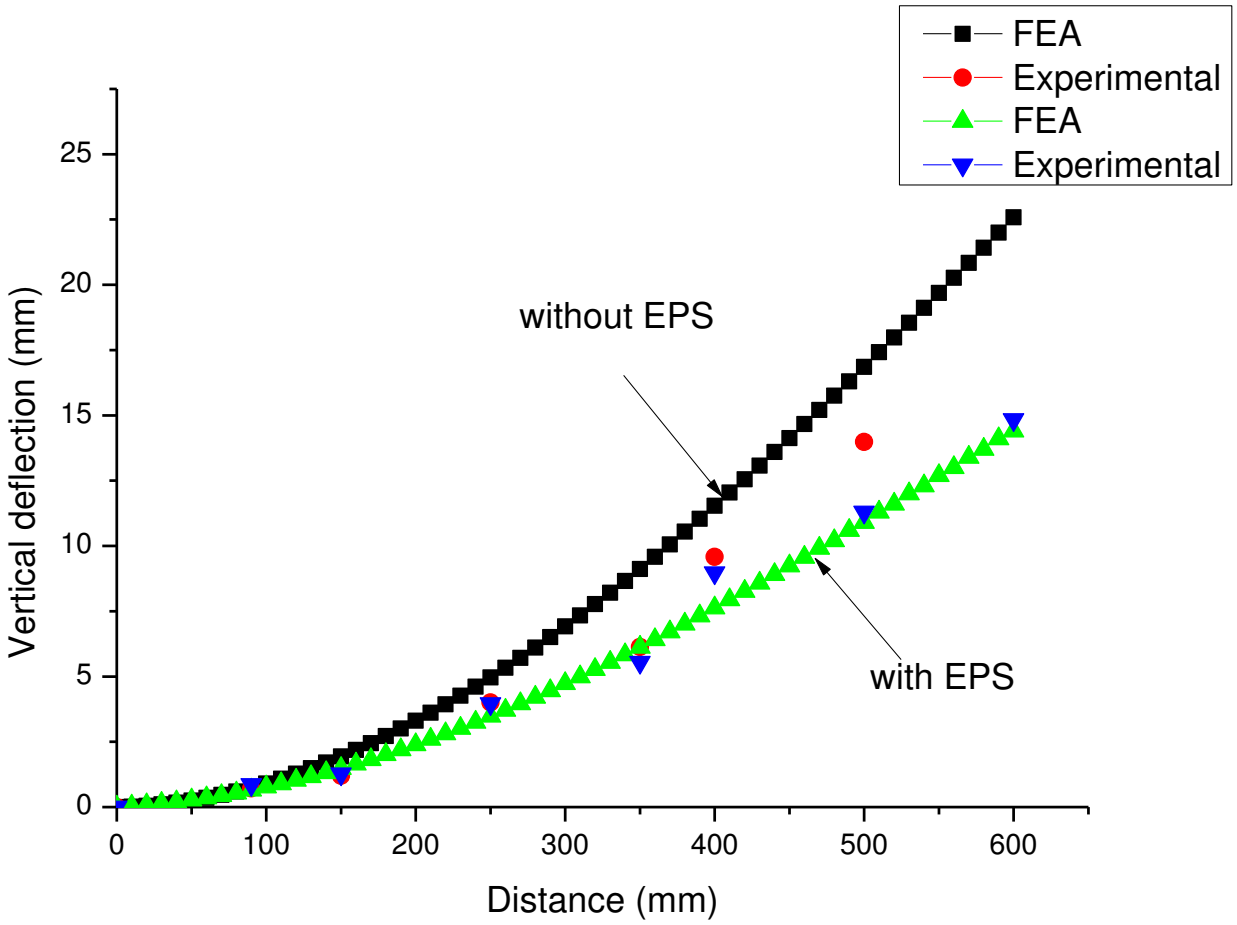
Comparison of FEA



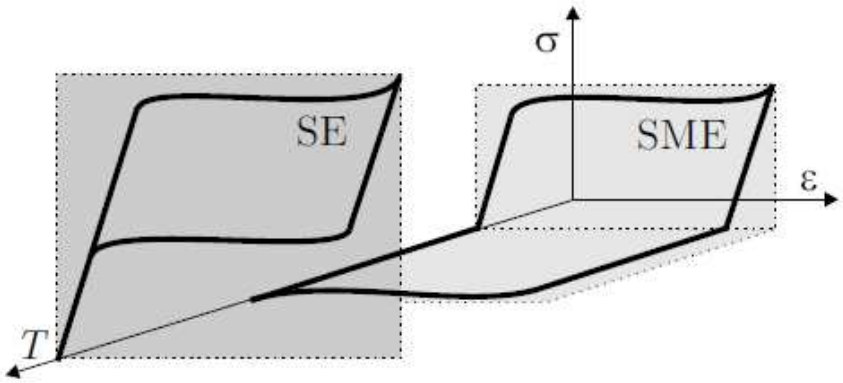
Simulation	Abaqus	Strand 7
Deflection at the tip(mm)	40.174	41.271

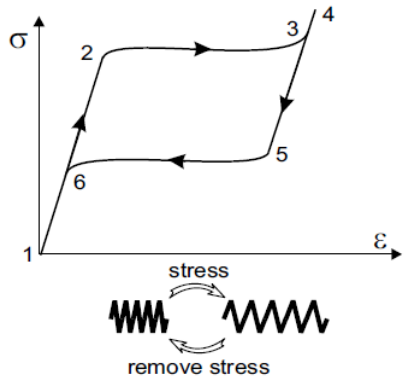
~2 % different

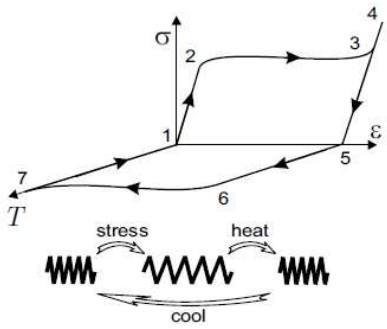
Result

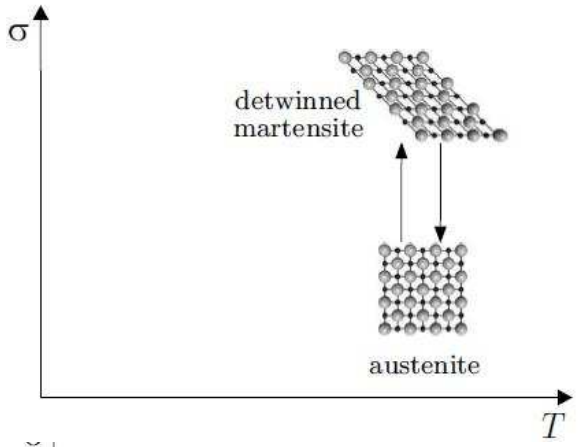

FEA
Experimental
FEA
Experimental
without EPS
with EPS
Vertical deflection (mm)
Distance (mm)
0
5
10
15
20
25
0
100
200
300
400
500
600

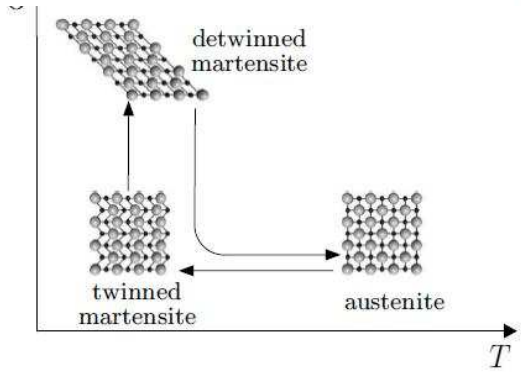
SMA Behaviour



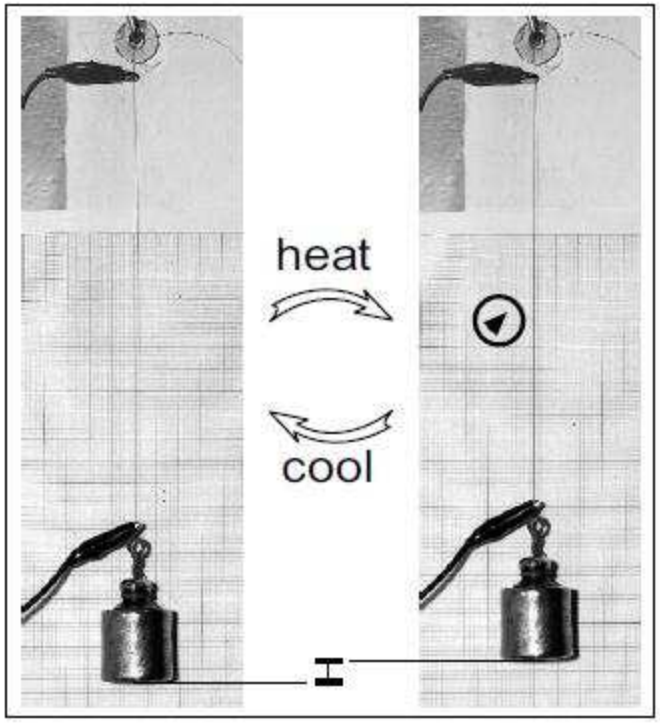






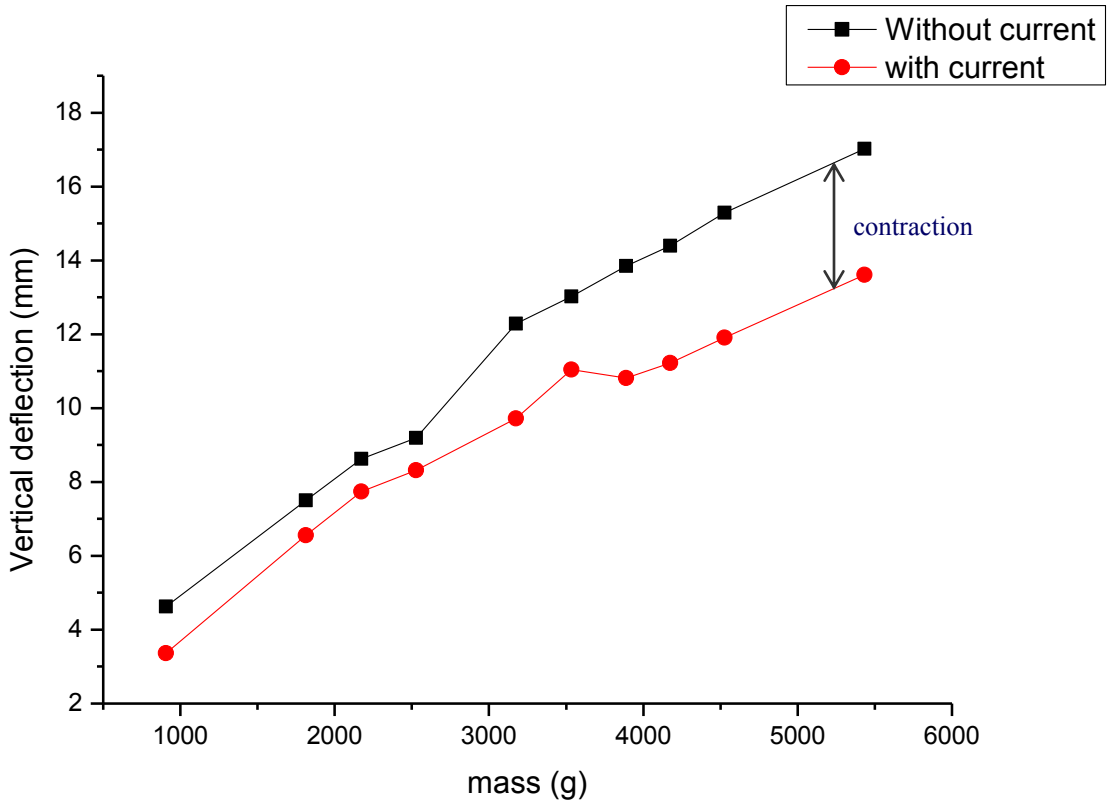


Shape memory effect and superelasticity

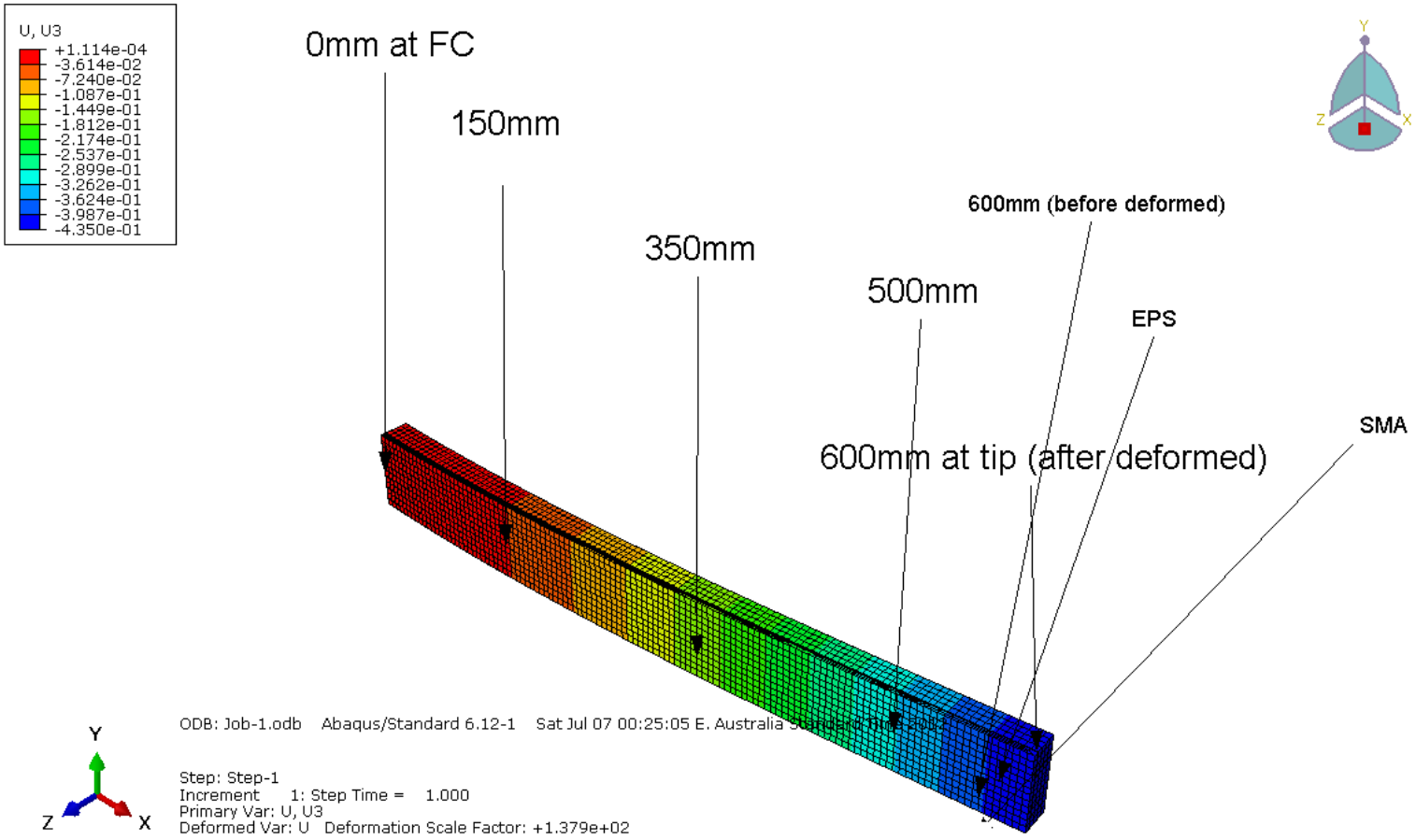


Shape recovery under applied load

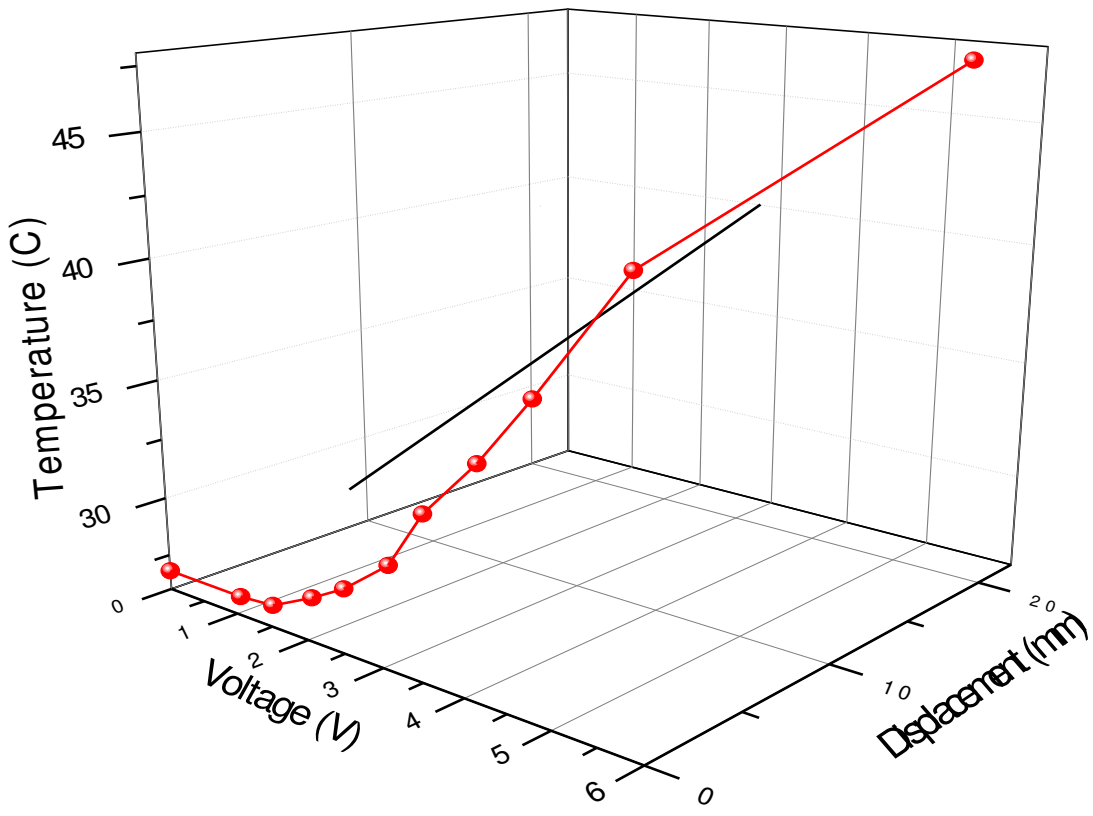
Experimental on Load Test



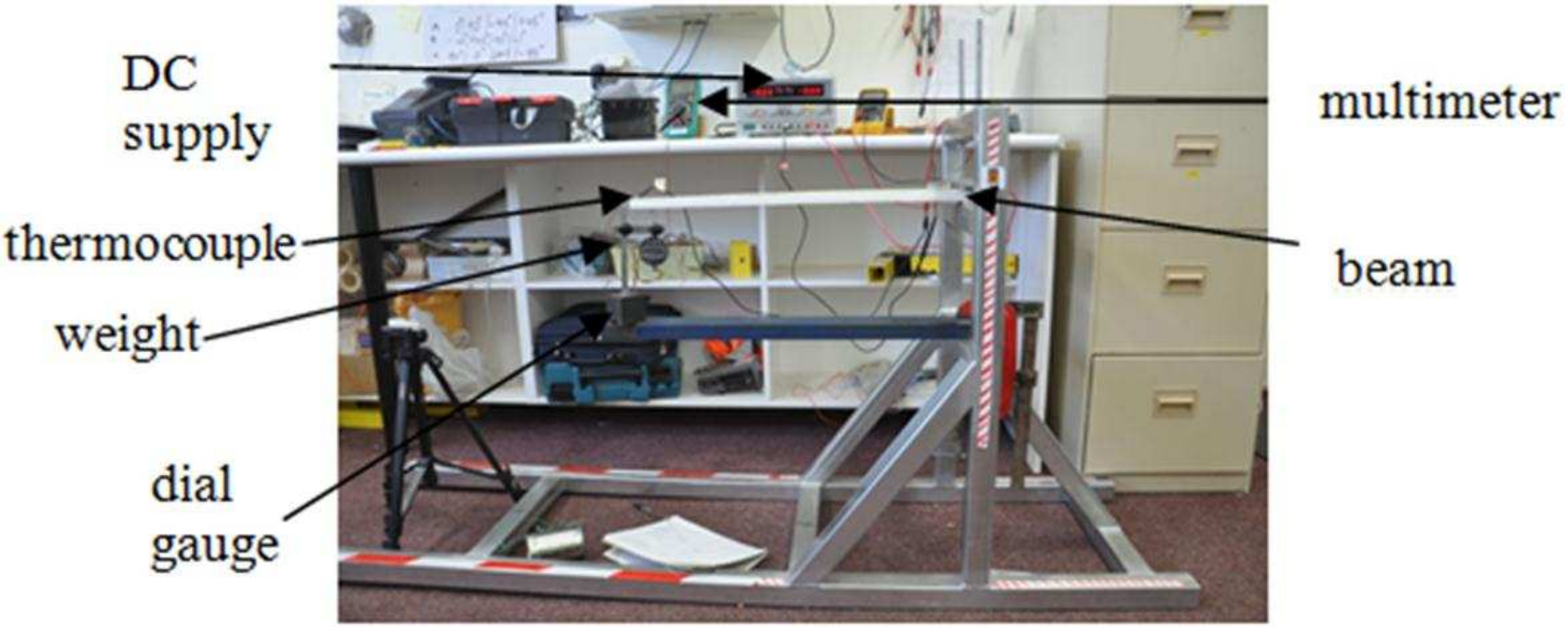
FEA with SMA and EPS



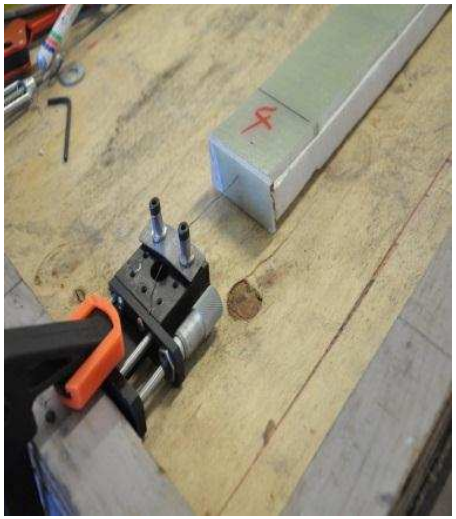
Relationship between voltage, temperature and contract displacement

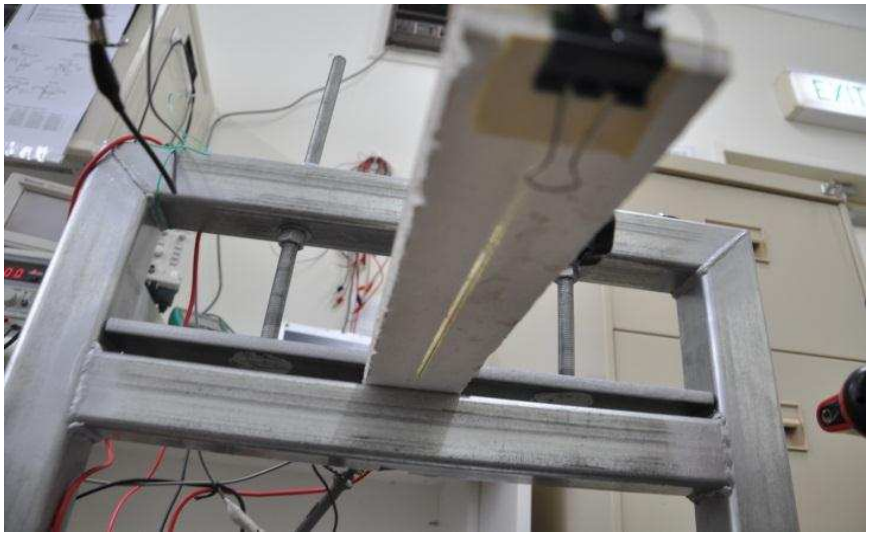


Current work

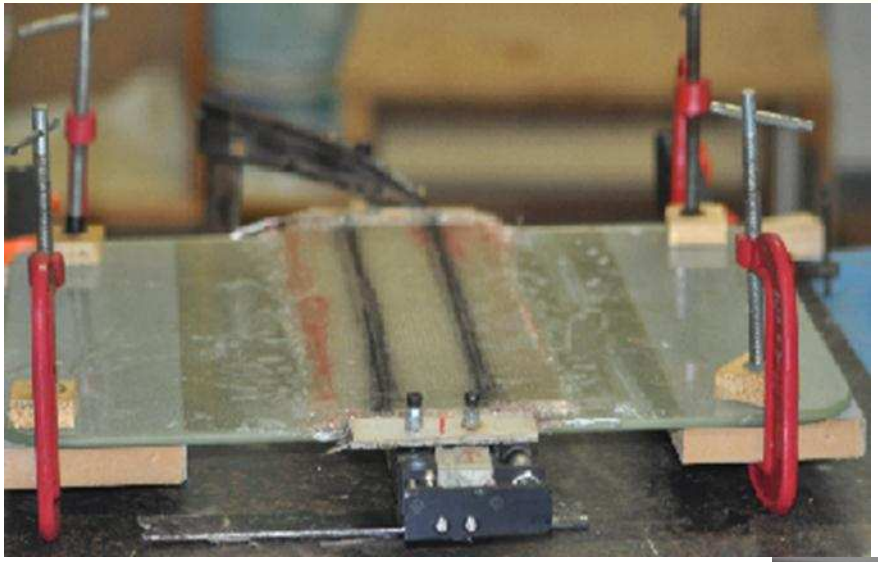


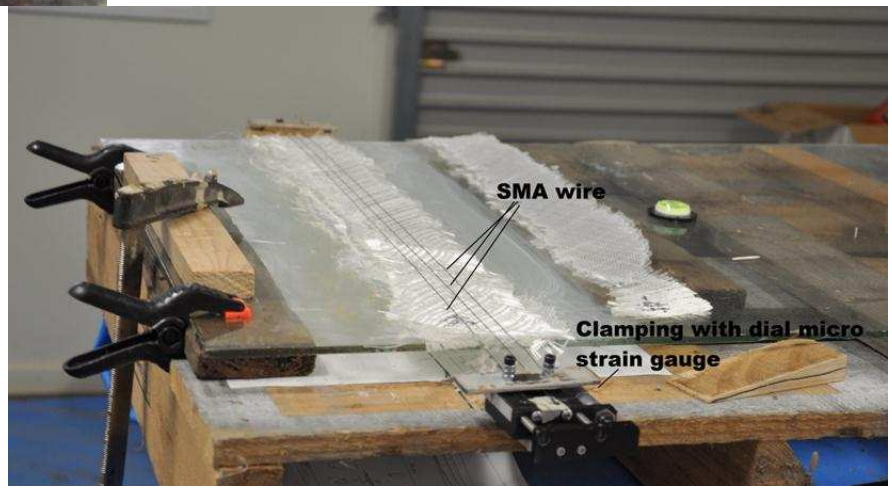
Problem Encountered





Specimen Fabrication





Conclusion

- Current findings and results of the previously described numerical simulation and its correlation with experimental results, the following summary may be drawn.

- Finite element analysis using ABAQUS is able to predict satisfactory deflection compared with the experimental works.

- The SMA which is embedded in composite will be expected to alleviate the deflection.

THANK YOU