



# Investigation of the compressive behaviour of carbon/glass fibre hybrid composites with 4-point flexural test

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# Outline of the presentation

- Aims of the study
- Specimen configurations and experiment setup
- Result summary
- Conclusion of hybrid composites result under 4-point flexural test
- Future works



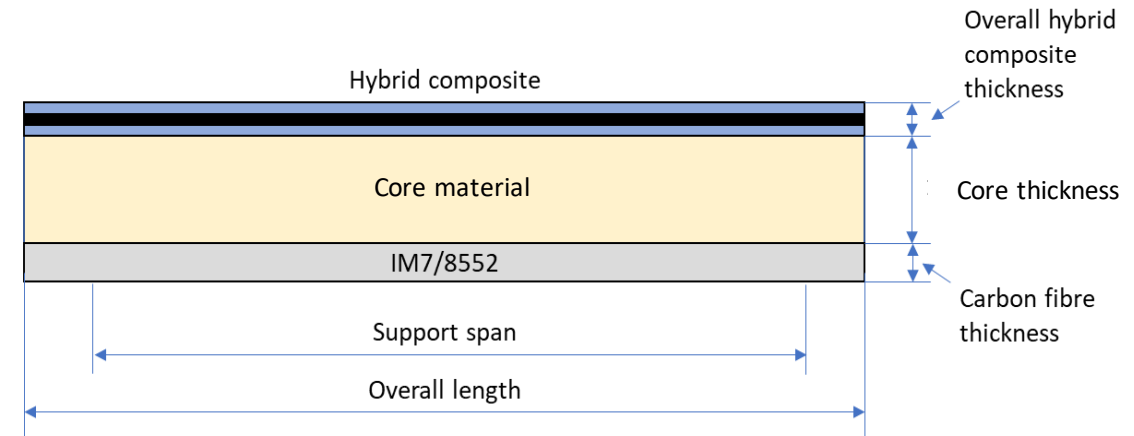
# Aims of the study

- Investigate the compressive failure strain of the glass/high modulus and glass/standard modulus carbon fibre hybrid composites
- Investigate the failure mechanism of hybrid composites with different absolute carbon fibre thicknesses.



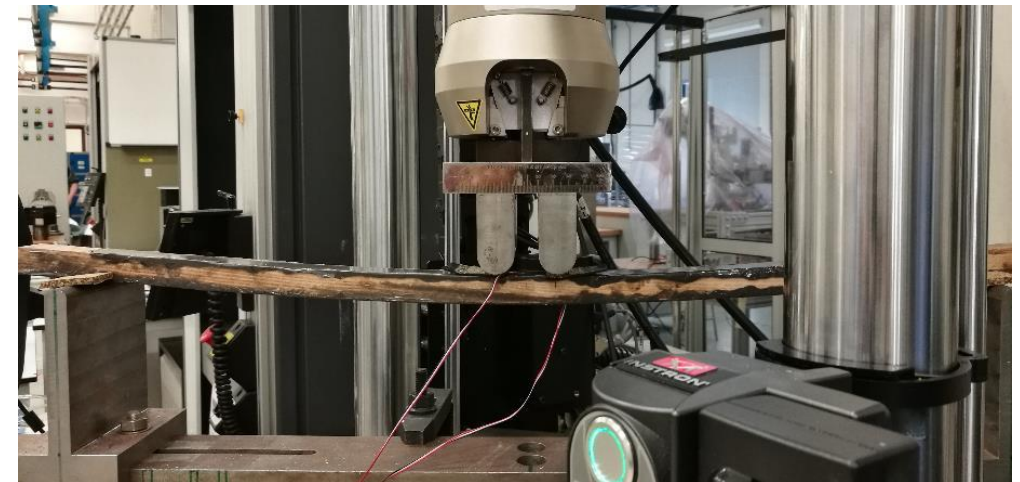
# Specimen configurations and experiment setup

Sandwich beam configurations	Carbon fibre thickness (mm)
[SG <sub>1</sub> /M55 <sub>1</sub> /SG <sub>1</sub> ]/Ash wood 18 mm/[IM7/8552 <sub>4</sub> ]	0.03
[SG <sub>1</sub> /M55 <sub>2</sub> /SG <sub>1</sub> ]/Ash wood 18 mm/[IM7/8552 <sub>5</sub> ]	0.06
[SG <sub>1</sub> /M55 <sub>16</sub> /SG <sub>1</sub> ]/Ash wood 18 mm/[IM7/8552 <sub>10</sub> ]	0.48
[SG <sub>1</sub> /TC33 <sub>1</sub> /SG <sub>1</sub> ]/PMMA 20 mm/[IM7/8552 <sub>4</sub> ]	0.03
[SG <sub>1</sub> /TC33 <sub>2</sub> /SG <sub>1</sub> ]/PMMA 20 mm/[IM7/8552 <sub>5</sub> ]	0.06
[SG <sub>1</sub> /TC33 <sub>16</sub> /SG <sub>1</sub> ]/PMMA 20 mm/[IM7/8552 <sub>6</sub> ]	0.48



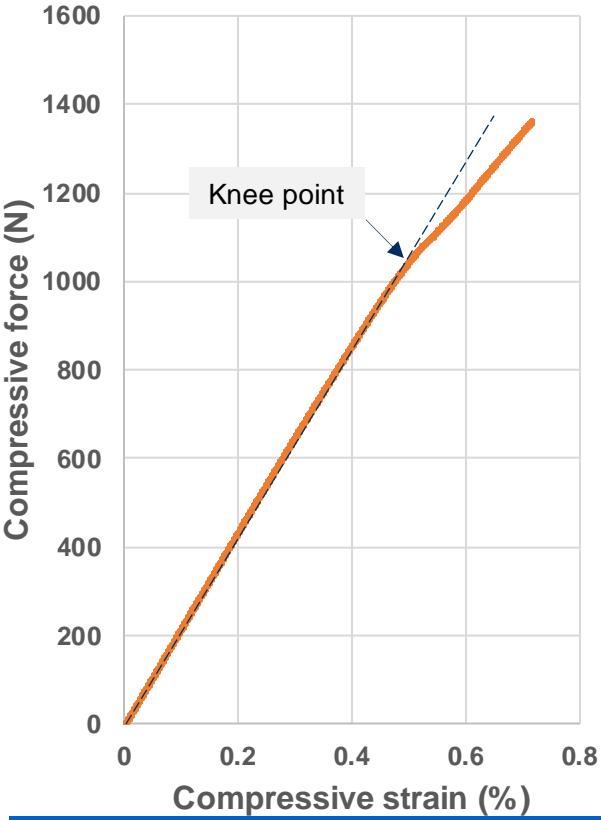
## Experiment setup

- 4-point bending fixture with Instron universal testing machine
  - The larger roller diameter can prevent roller failure from loading noses
- Attach strain gauges on top and bottom skin to measure compressive and tensile strains

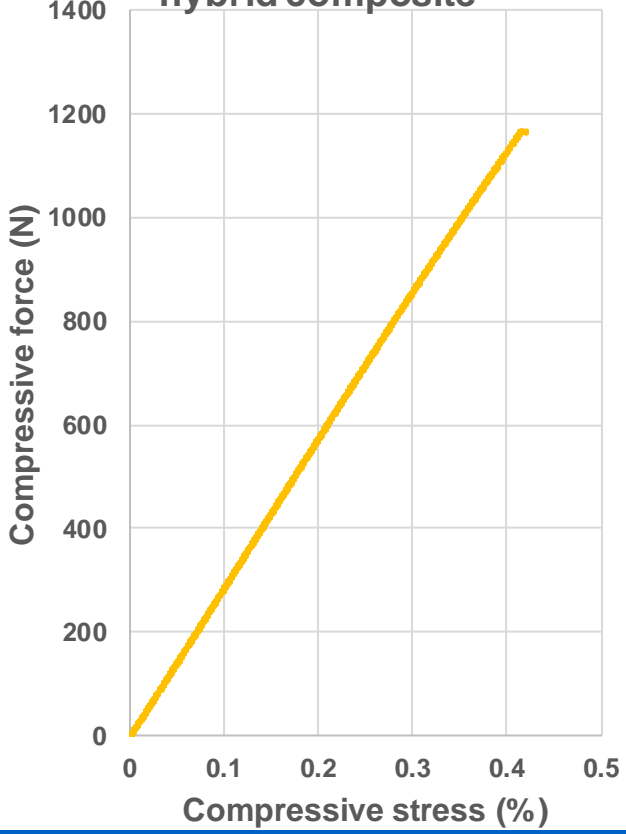


# Result summary: SG<sub>1</sub>/M55<sub>n</sub>/SG<sub>1</sub>

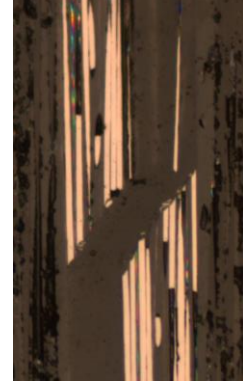
Compressive load-compressive strain response of SG<sub>1</sub>/M55<sub>1</sub>/SG<sub>1</sub> hybrid composite



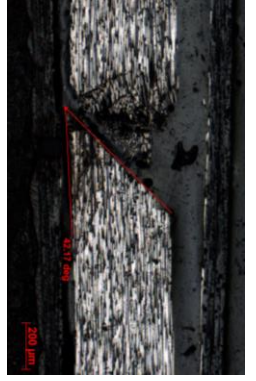
Compressive force-compressive strain response of SG<sub>1</sub>/M55<sub>2</sub>/SG<sub>1</sub> hybrid composite



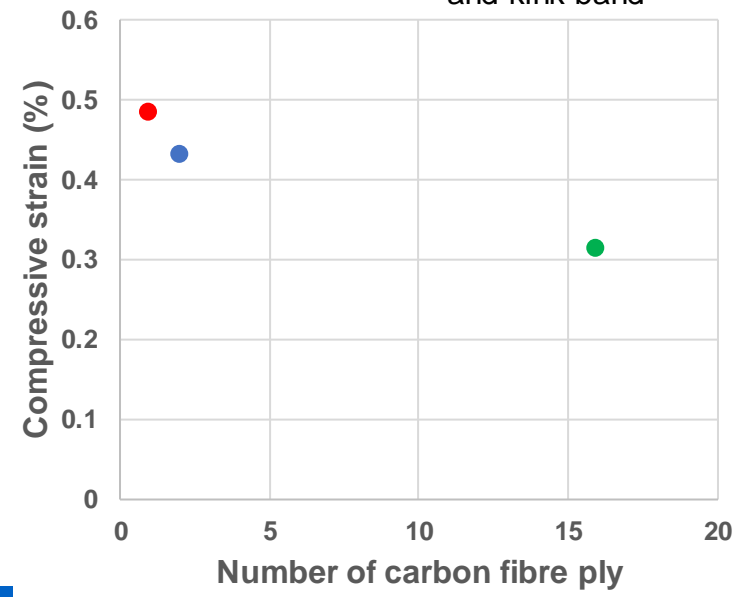
SG<sub>1</sub>/M55<sub>1</sub>/SG<sub>1</sub>  
Fibre fracture



SG<sub>1</sub>/M55<sub>2</sub>/SG<sub>1</sub>  
Fibre fracture and kink band



SG<sub>1</sub>/M55<sub>16</sub>/SG<sub>1</sub>  
Kink band



- SG(1)/M55(1)/SG(1)
- SG(1)/M55(2)/SG(1)
- SG(1)/M55(16)/SG(1)

**Failure is shifted from small carbon fragmentations to single crack with kink band.**



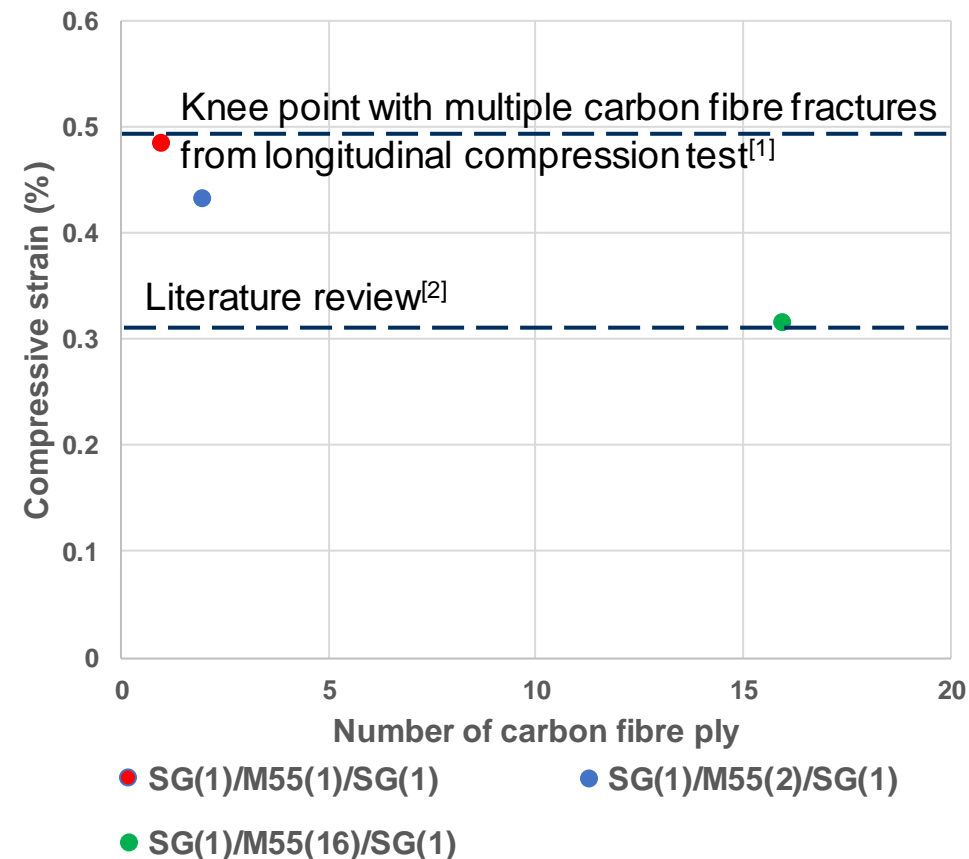
# Result summary: SG<sub>1</sub>/M55<sub>n</sub>/SG<sub>1</sub>

Specimen configuration	Knee-point compressive strain (%)	Failure compressive strain (%)	Failure compressive force (N)	Failure mode
SG/M55 <sub>1</sub> /SG	0.484 (3)	-	1800 (10)	Small carbon fragmentation
SG/M55 <sub>2</sub> /SG	-	0.431 (2)	1135 (3)	Limited carbon fragmentation
SG/M55 <sub>16</sub> /SG	-	0.314 (3)	1859 (5)	Single angled crack and delamination

Remark: number in the bracket represented to the coefficient of variation (CV)

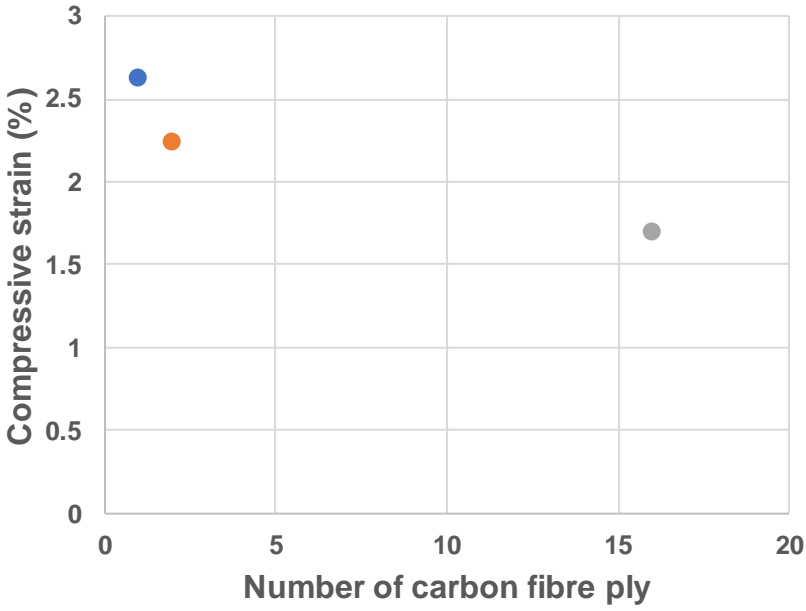
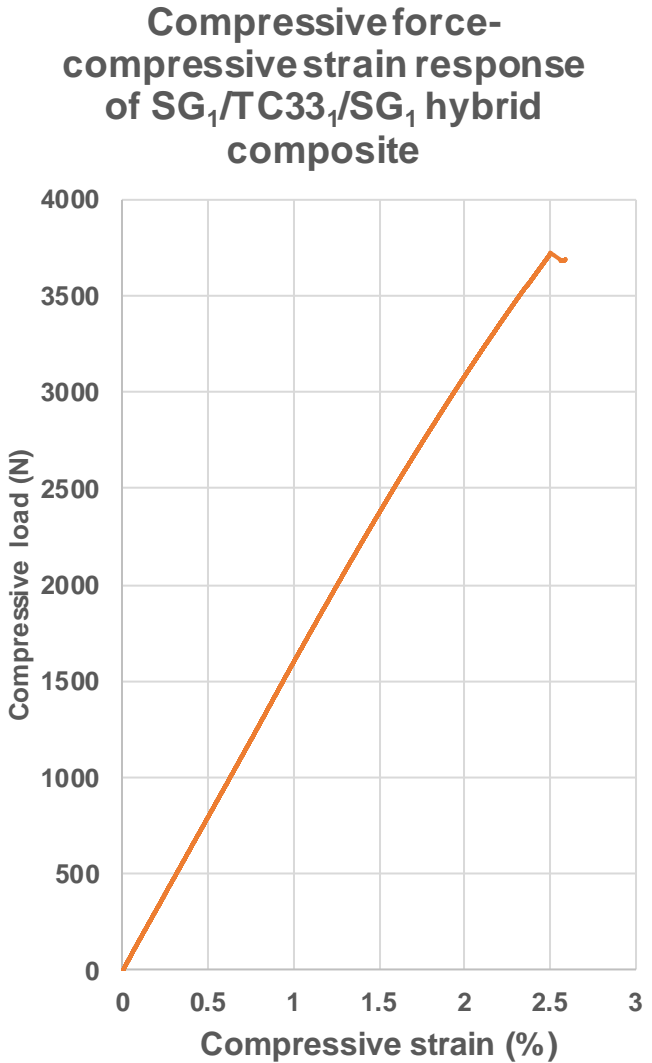
- Single ply case created small carbon fragmentation which is similar to previous study<sup>[1]</sup>
- Double ply case shows limited carbon fragmentation, followed by a single fracture.
- 16 ply case shows single fracture with similar compressive strain compared to previous study<sup>[2]</sup>

## Compressive strain-number of carbon fibre ply trend



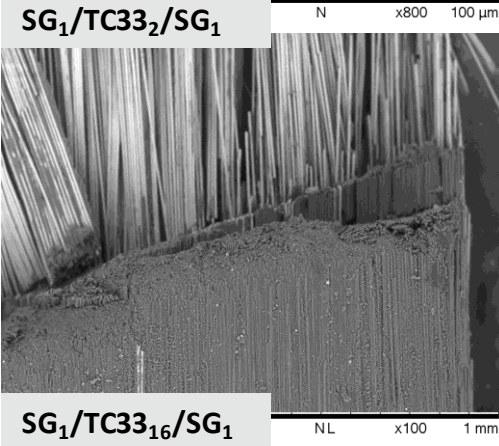
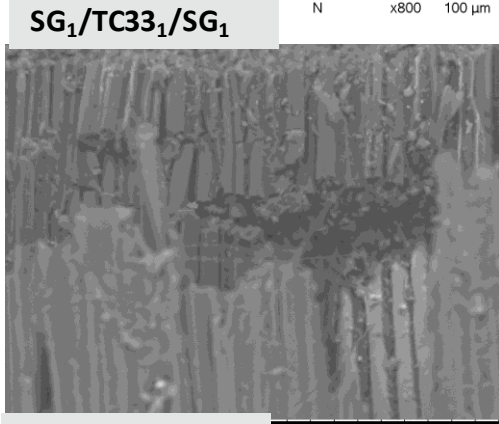
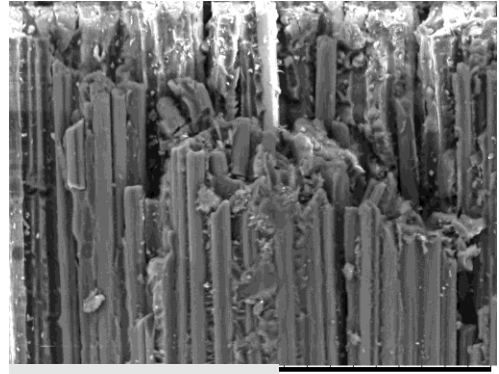
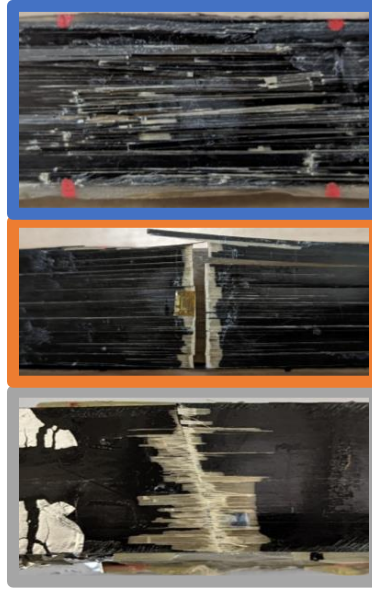


# Result summary: SG<sub>1</sub>/TC33<sub>n</sub>/SG<sub>1</sub>

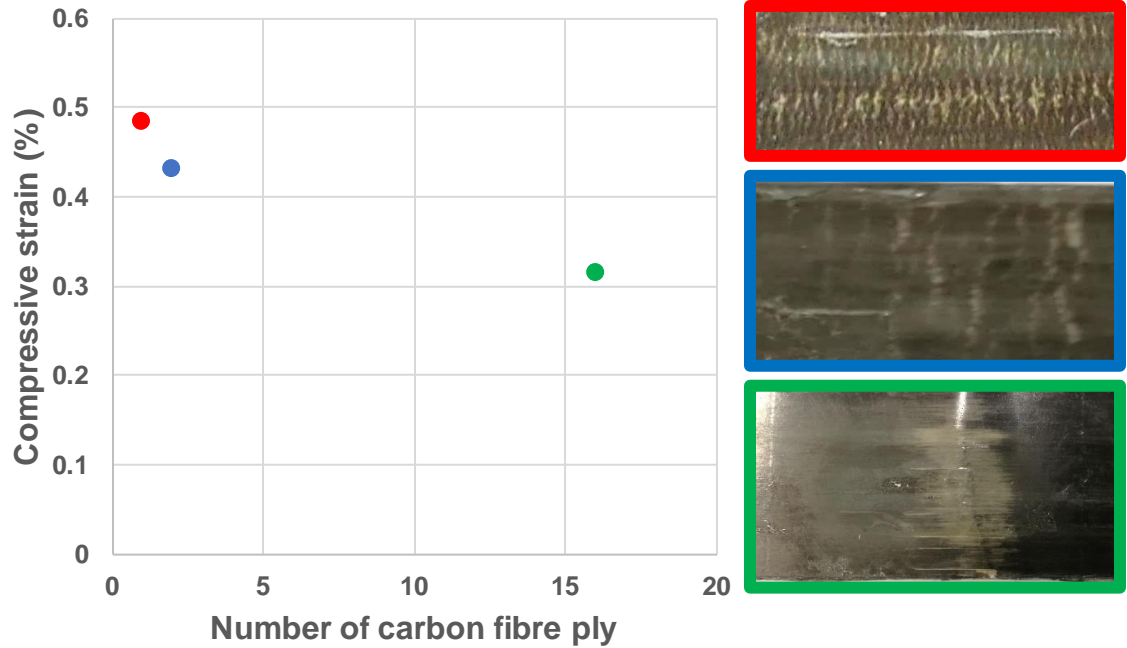


- SG(1)/TC33(1)/SG(1)
- SG(1)/TC33(2)/SG(1)
- SG(1)/TC33(16)/SG(1)

**Overall failure is kink band with slightly non-linear load-strain response.**

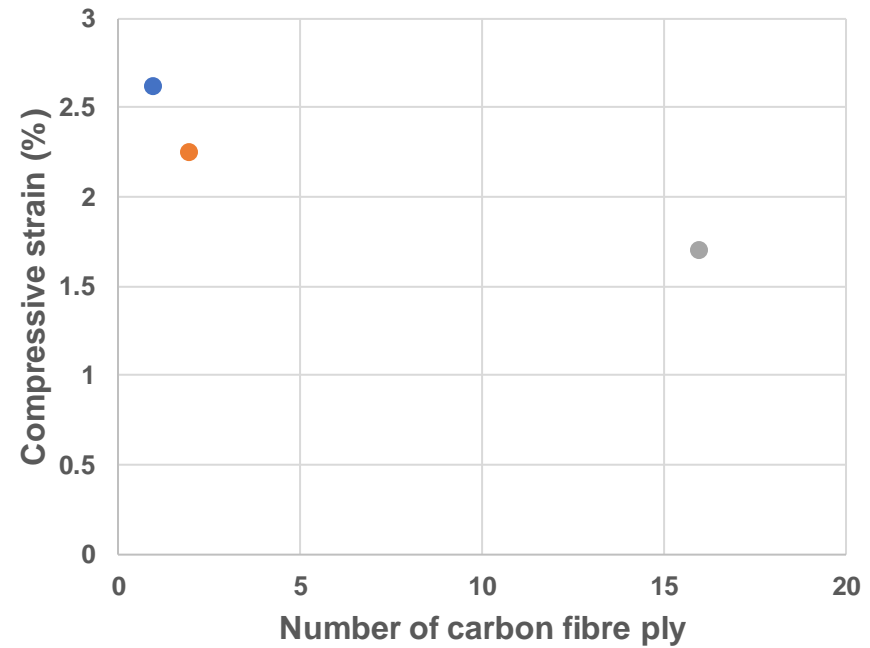


# Conclusion of hybrid composites result under 4-point flexural test



- SG(1)/M55(1)/SG(1)
- SG(1)/M55(2)/SG(1)
- SG(1)/M55(16)/SG(1)

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- SG(1)/TC33(1)/SG(1)
- SG(1)/TC33(2)/SG(1)
- SG(1)/TC33(16)/SG(1)

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- Compressive behaviour and failure strain are affected by the thickness of low strain fibre material or the ratio to the thickness of high strain fibre material including fibre types.
- The proper high strain/low strain hybrid system could increase the compressive performance.





# Future works

- Study the compressive failure characteristics of carbon-carbon fibre hybrid composites.
- Develop an understanding of the compressive failure of hybrid composites.
- Create damage mode maps under compressive loading



# References

- [1] P. Suwarta, G. Czél, M. Fotouhi, J. Rycerz, and M. R. Wisnom, “Pseudo-ductility of unidirectional thin ply hybrid composites in longitudinal compression,” 33rd Tech. Conf. Am. Soc. Compos. 2018, vol. 2, pp. 1032–1041, 2018.
- [2] O. Montagnier and C. Hochard, “Compression characterization of high-modulus carbon fibers,” *J. Compos. Mater.*, vol. 39, no. 1, pp. 35–49, 2005.





# Thank you for your attention

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