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Origami-inspired Design for Manufacture of Curved Composite Structures

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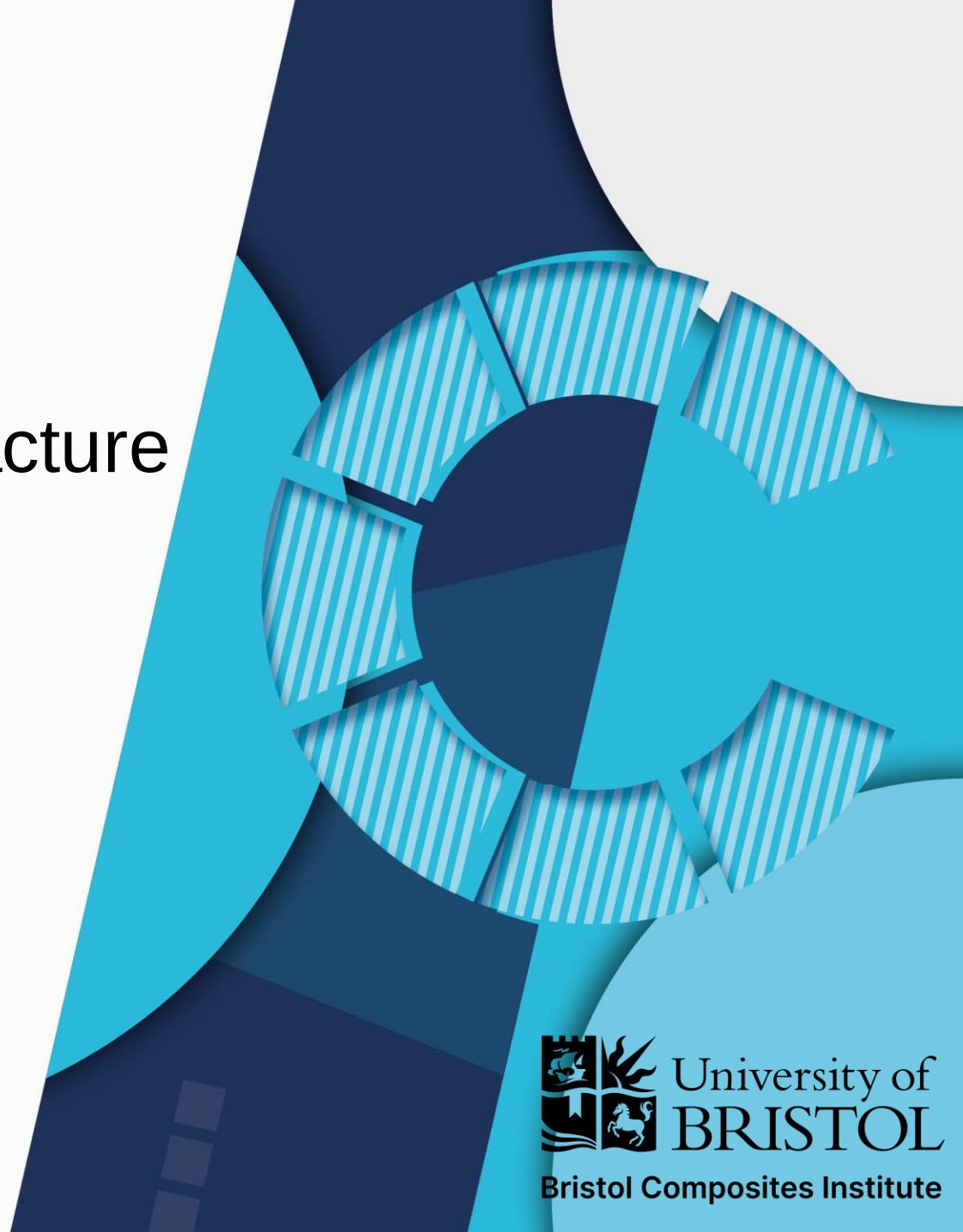

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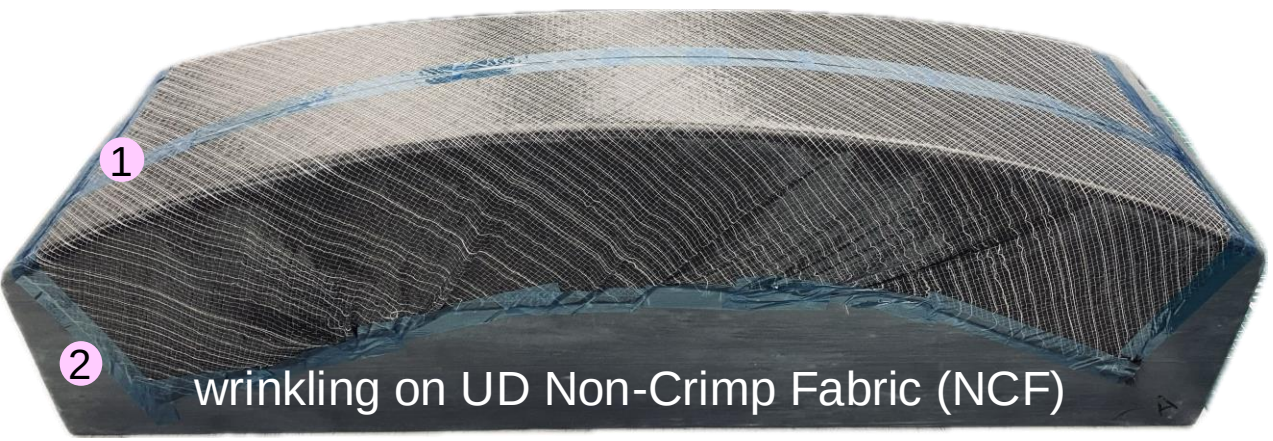
Design for Manufacture of Composites

challenge: complex geometries may lead to **wrinkles**, resulting in reduced mechanical performance

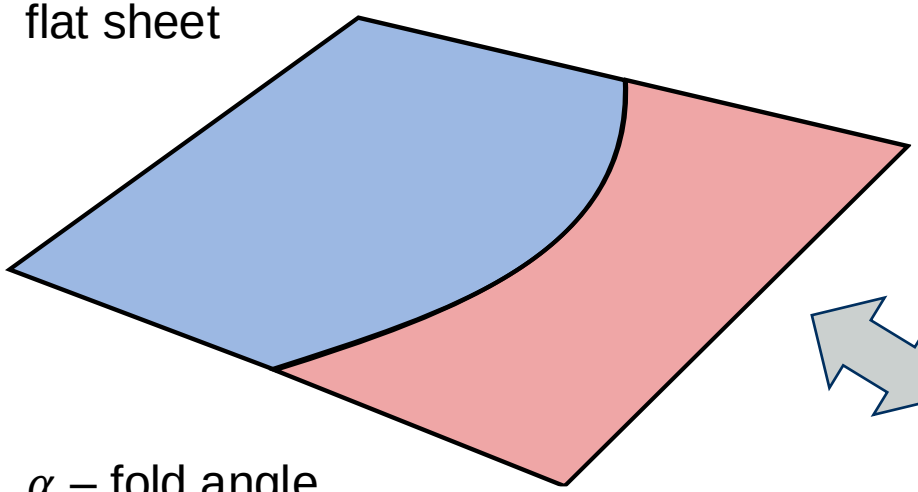
solution: create composite components that are fundamentally **designed for manufacture**

origami-inspired design for complex curved geometries with inherently **minimal defects**

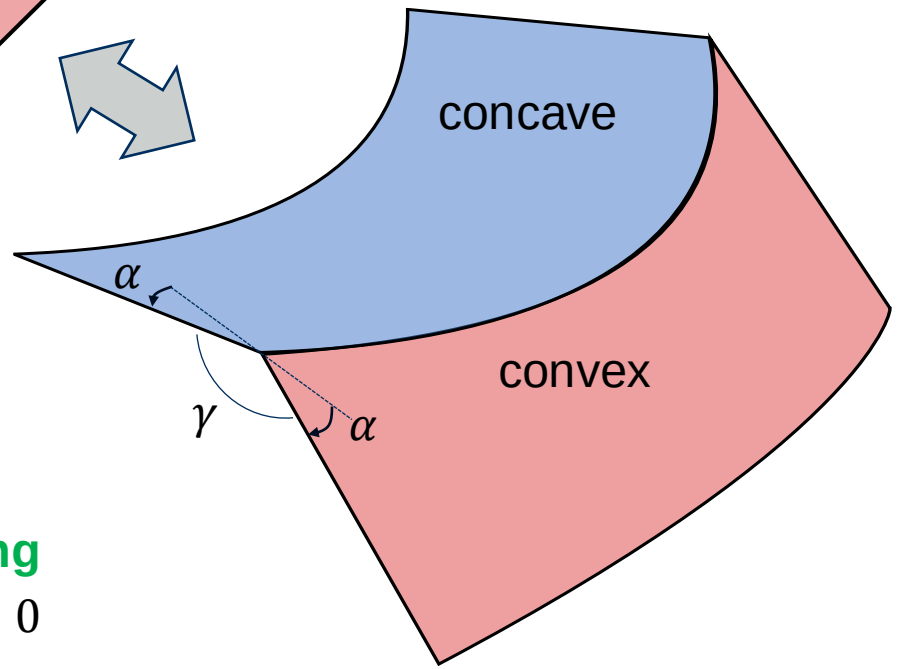


Curved-Crease Origami

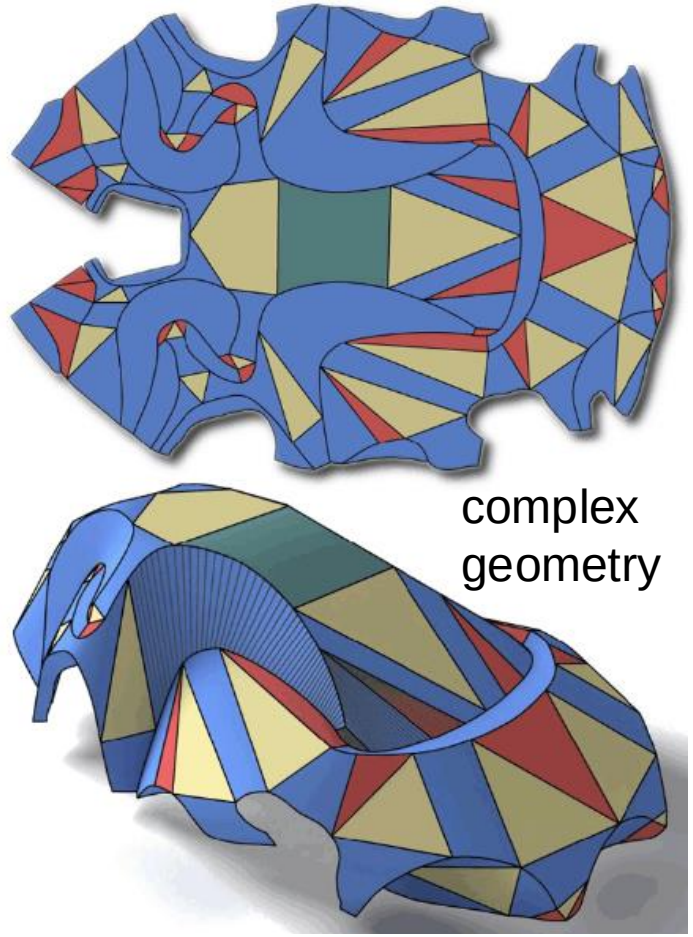
flat sheet



α – fold angle
γ – dihedral angle



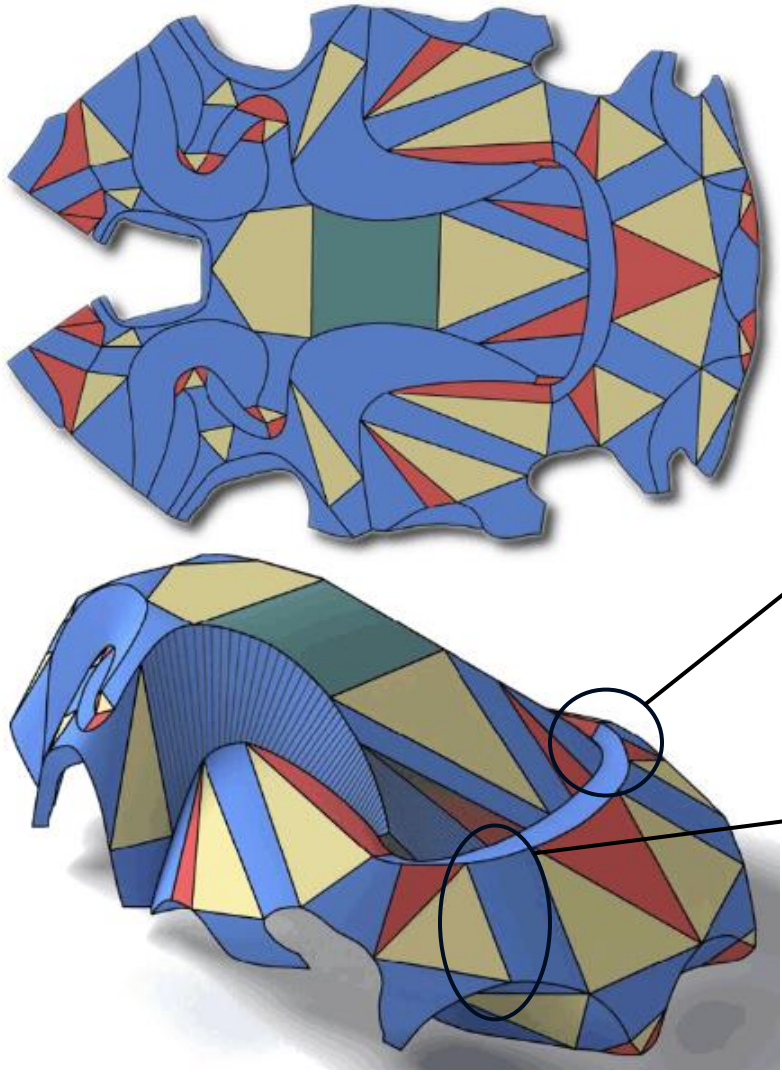
developable surface
folding: **no stretching or shearing**
Gaussian curvature $K = \kappa_1 \cdot \kappa_2 = 0$



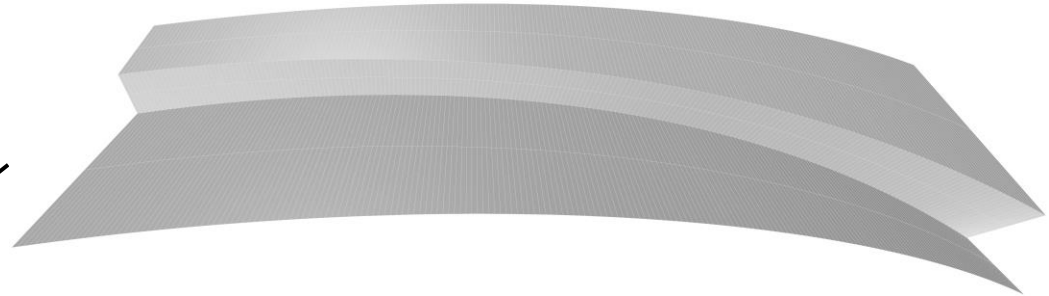
complex geometry

Kilian, M., Flöry, S., Chen, Z., Mitra, N. J., Sheffer, A., & Pottmann, H. (2008). Curved folding. ACM transactions on graphics (TOG), 27(3), 1-9.

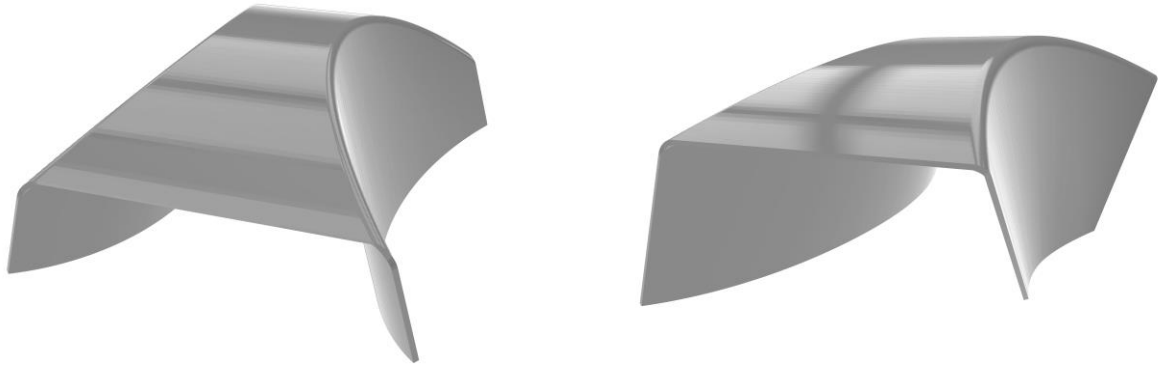
Multiple Folds and Building Blocks



Mountain + Valley fold

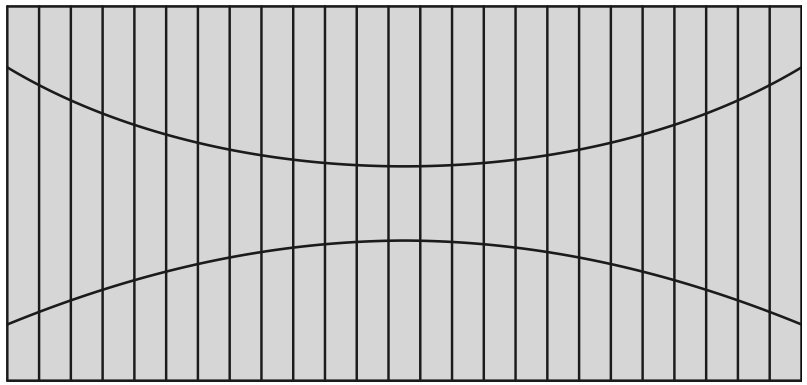


Mountain + Mountain fold

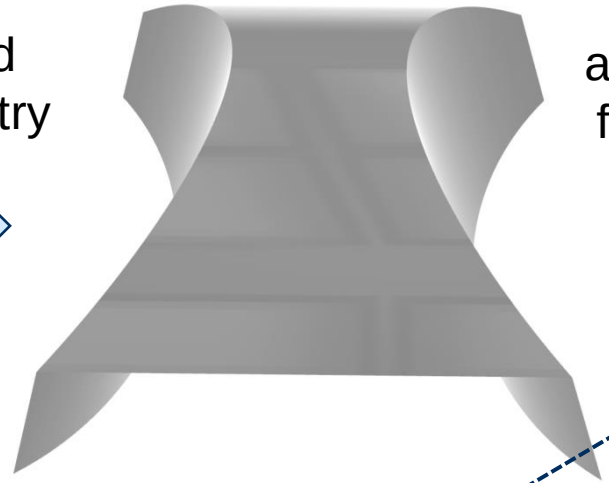


Kilian, M., Flöry, S., Chen, Z., Mitra, N. J., Sheffer, A., & Pottmann, H. (2008). Curved folding. ACM transactions on graphics (TOG), 27(3), 1-9.

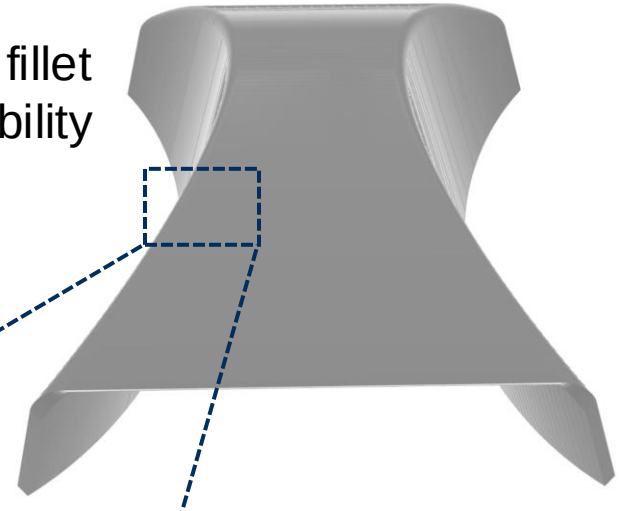
Methodology : Curved-Crease Origami Moulds



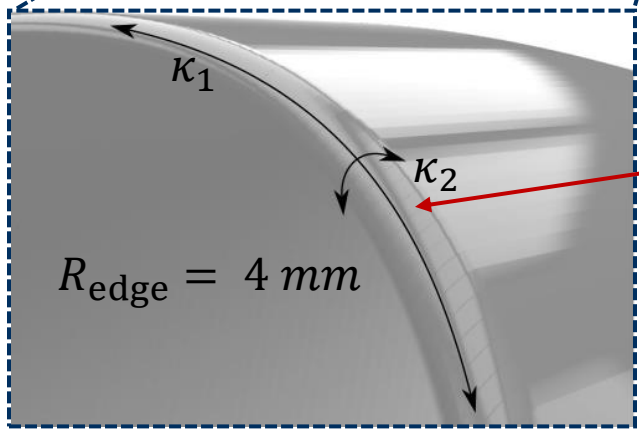
folded geometry



add edge fillet for formability

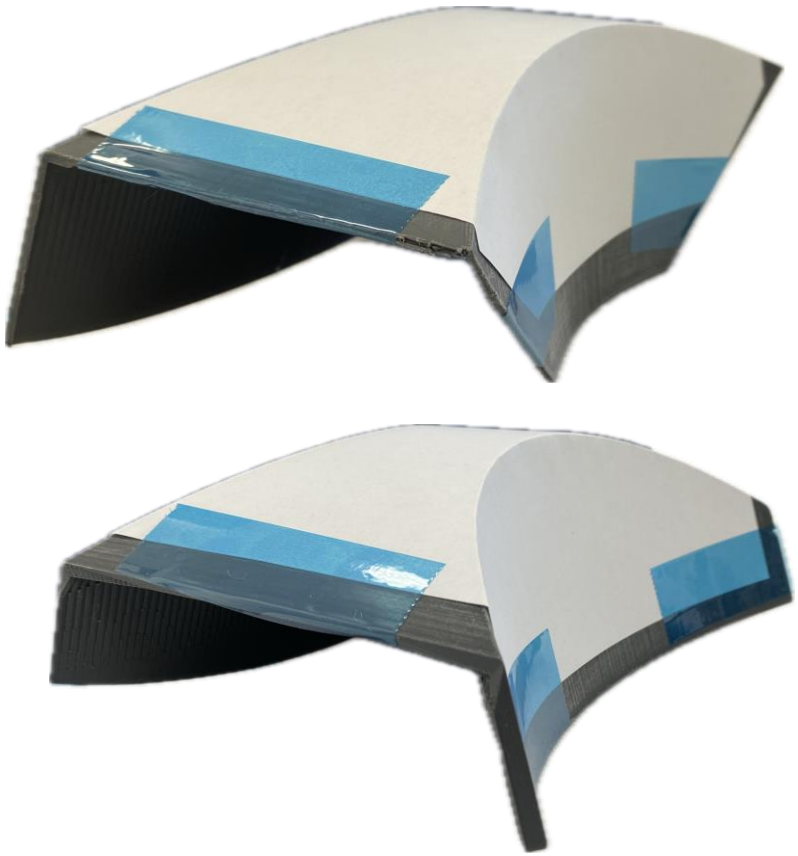


forming



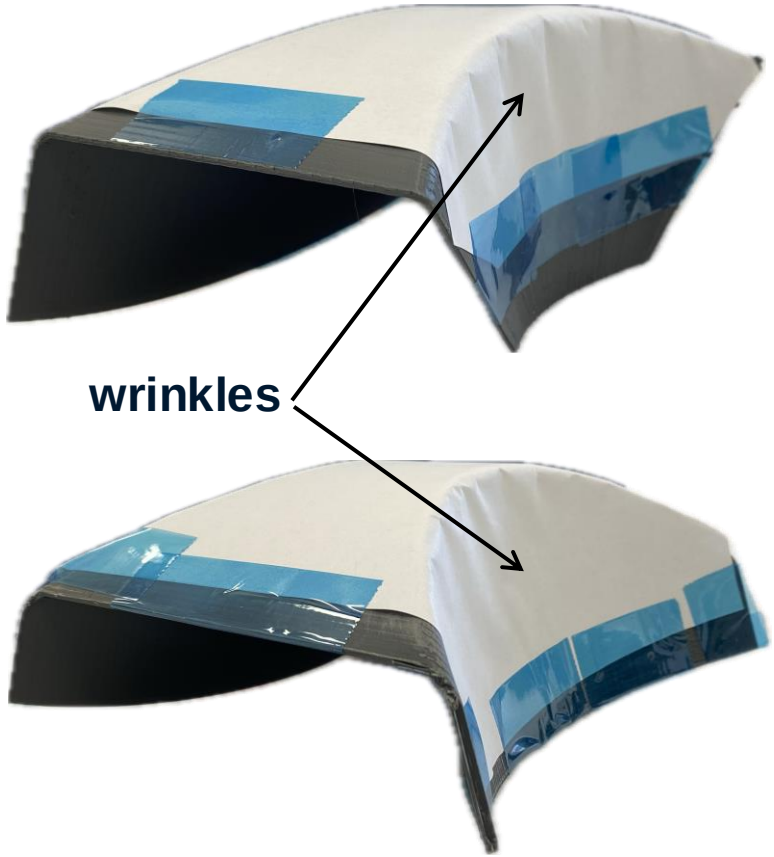
doubly-curved (non-developable)

Folding

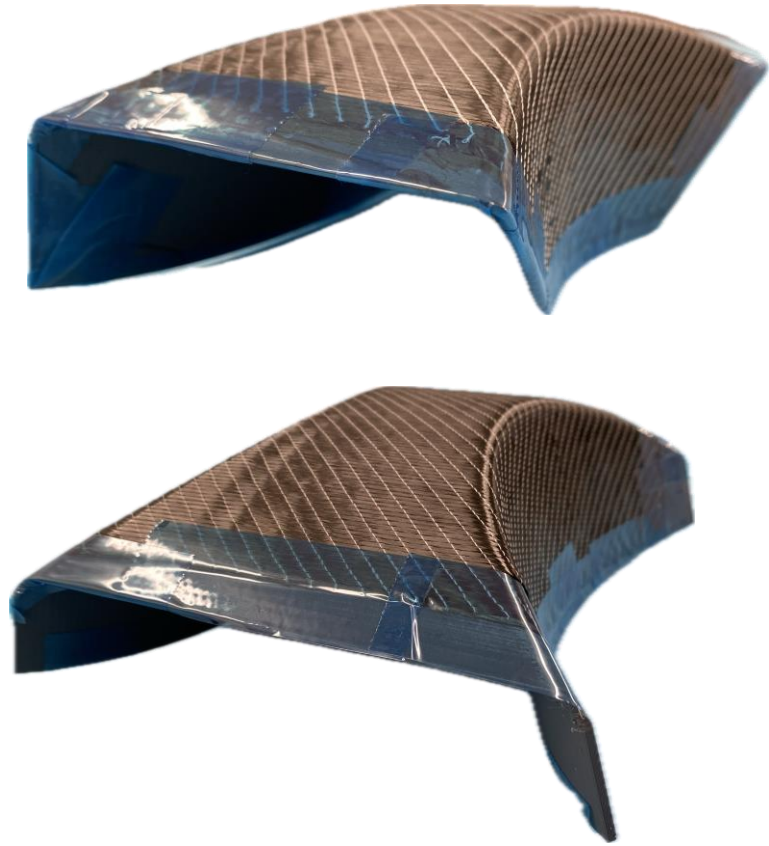


no wrinkling on developable curved-crease origami geometry

Forming



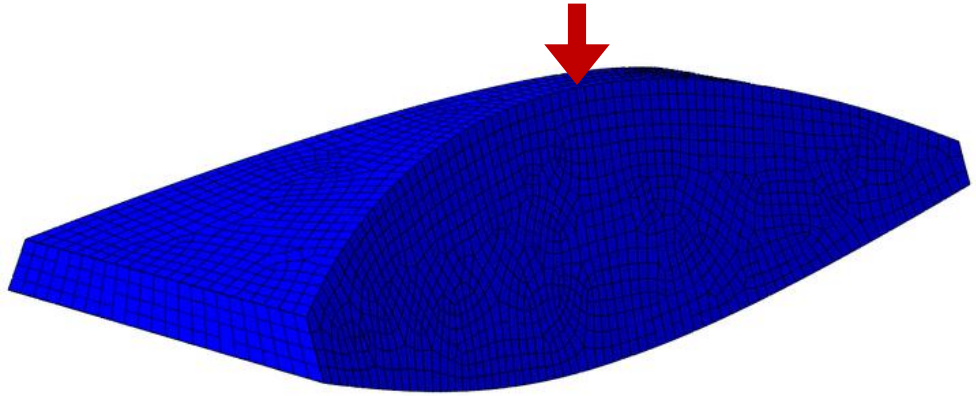
non-developable edge results in **wrinkling**

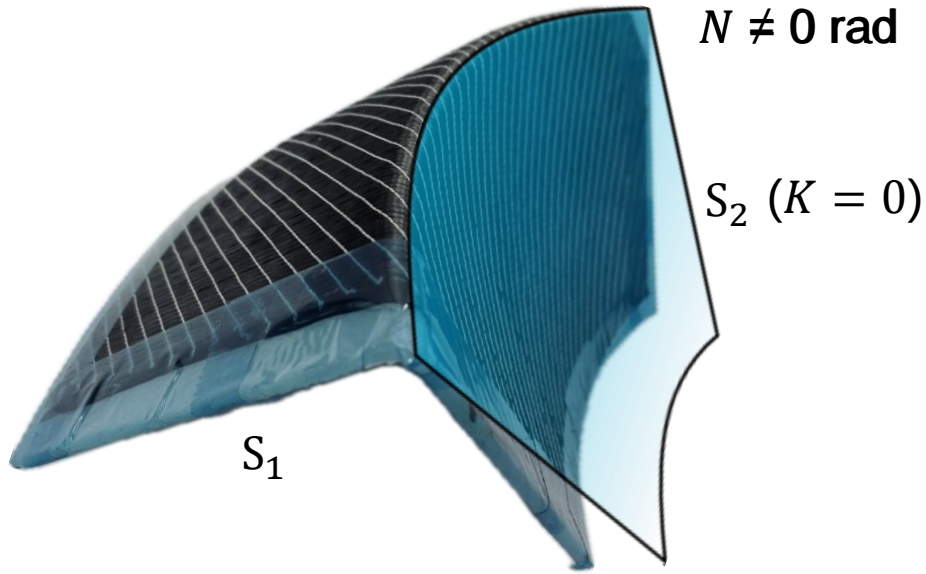


Biaxial NCF (0/90) forms **without defects**

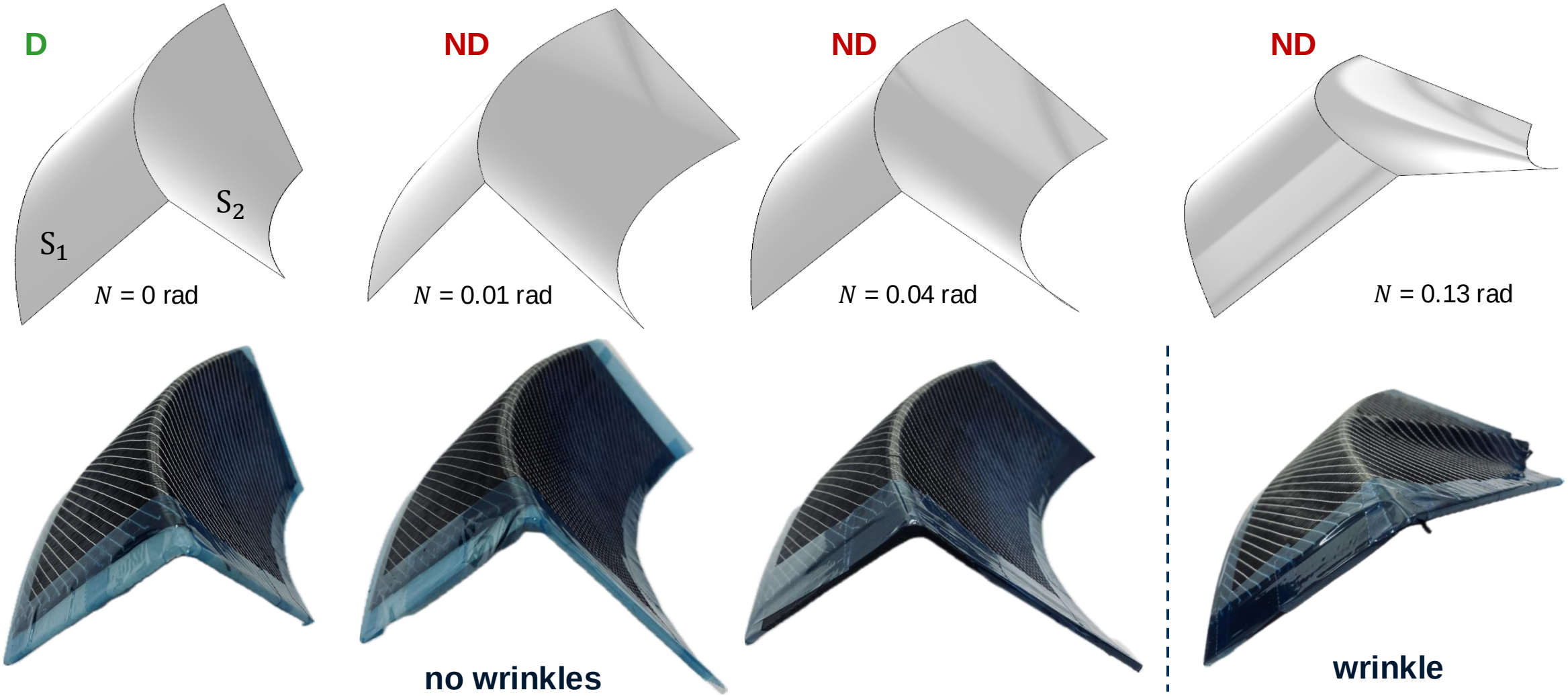
Expanding Design Space – Beyond Origami

- Origami geometries **minimise defects**; however, may not fully meet structural or design requirements
- NCF shearability allows for **non-developability at the crease**
- systematically deviate from origami geometries to **expand the design space**





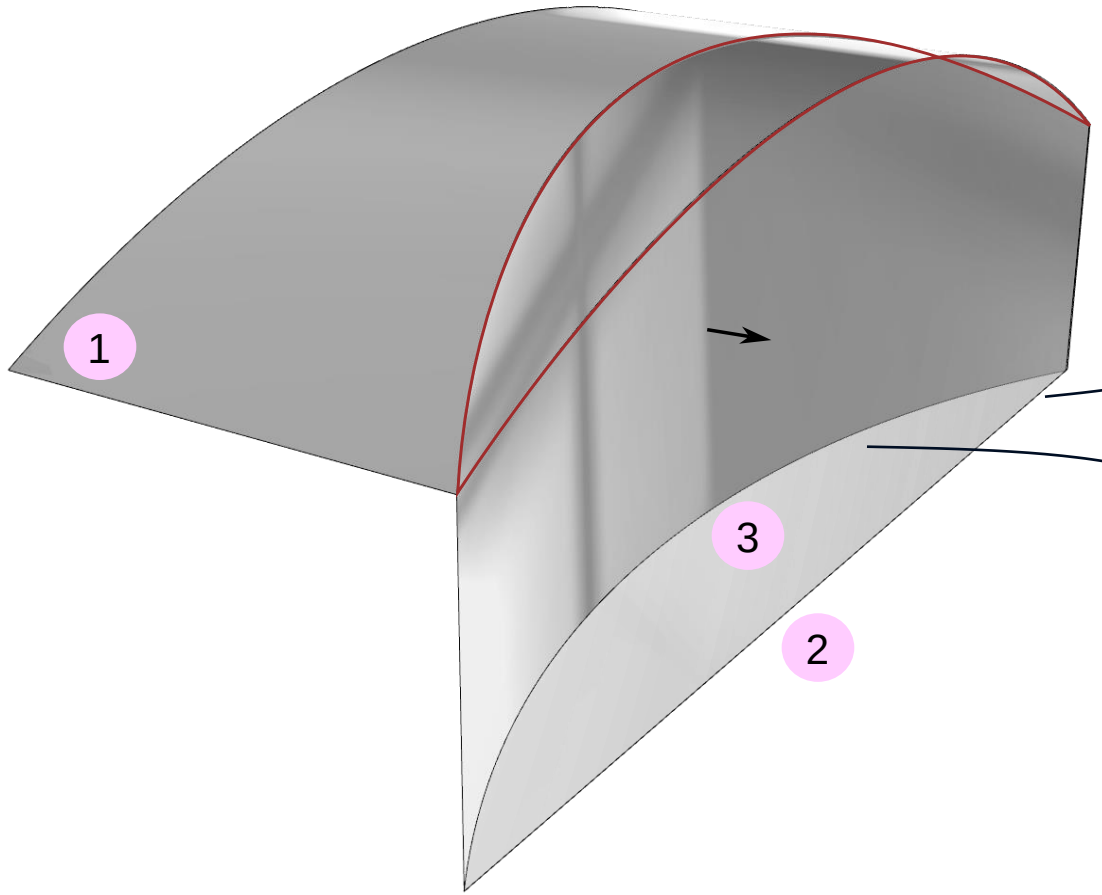
Non-Developable Crease joining Developable Surfaces



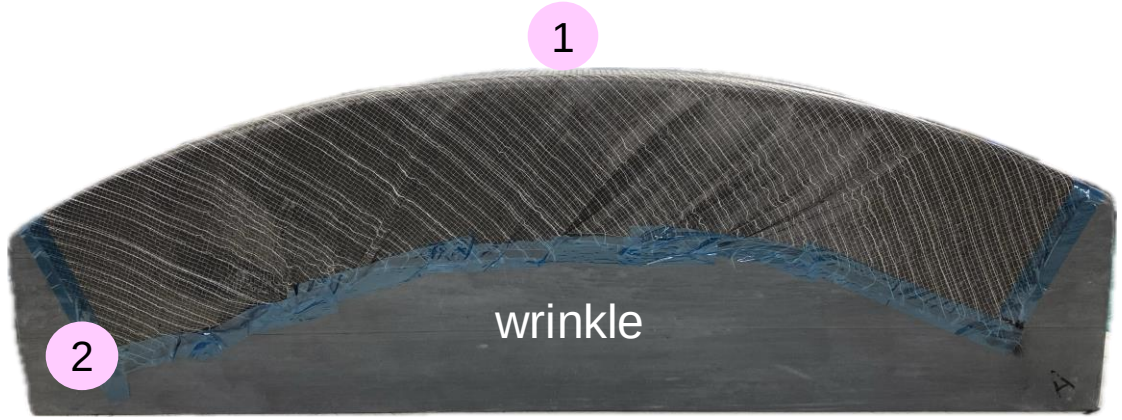
D – Developable – no shearing or stretching
ND – Non-Developable – shearing, stretching

N – non-developability metric

Conclusion and Current Work



ND

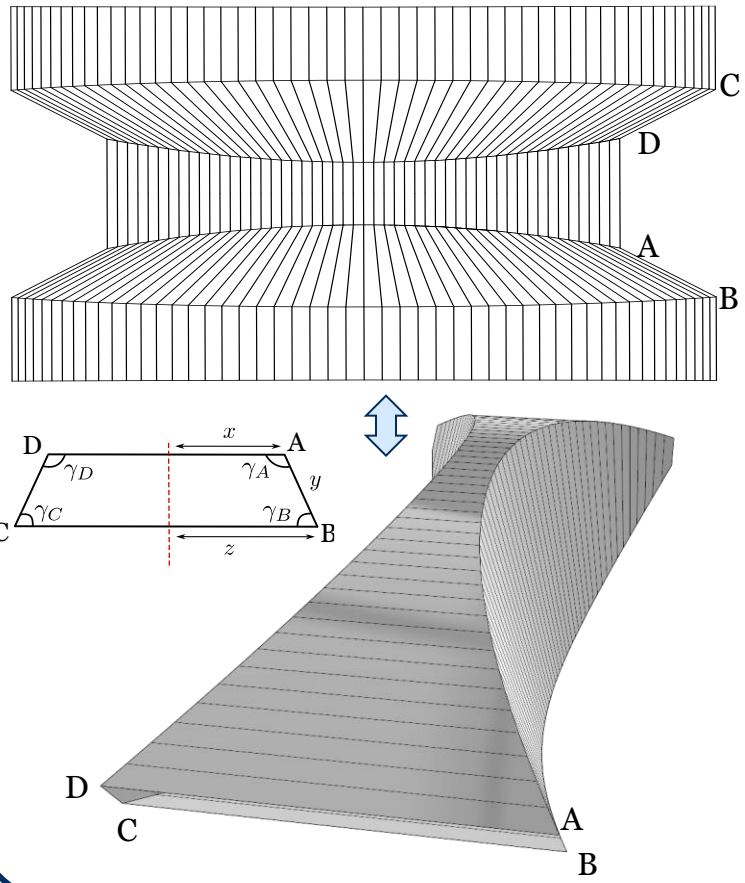


D

How closely can surface 3 match surface 2 without wrinkles, considering fabric shearability?

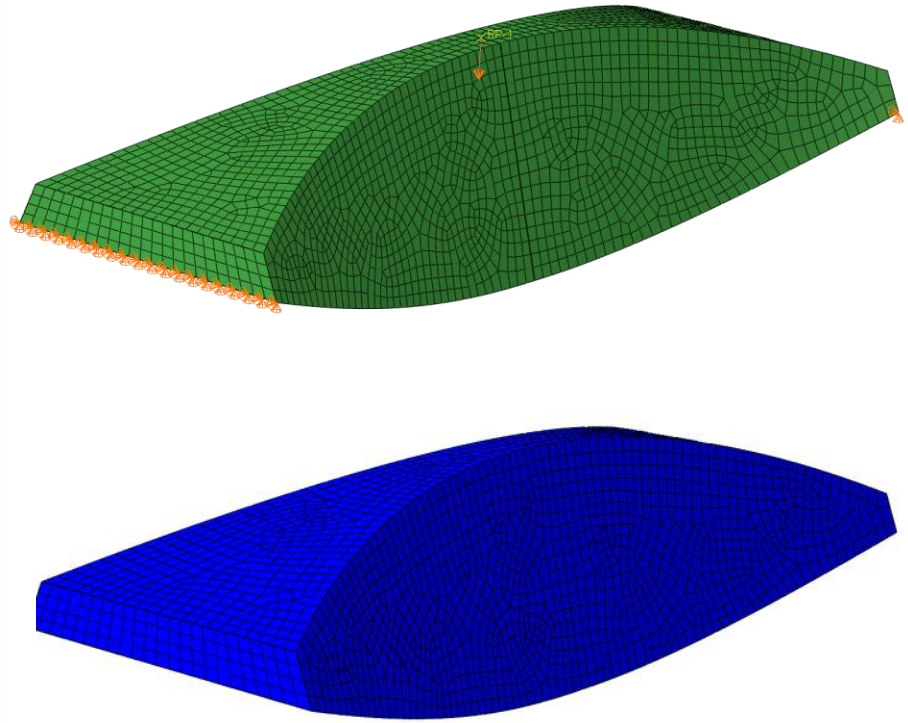
Current Work : Parametric Design and Optimisation

Geometry Generation



Structural Optimisation

Structural Analysis



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Thank you

Q&A ?

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