FORMULA: FOLDING OF ORIGAMI-BASED MULTISTABLE LAMINATES

ADMIRE-MCSA ADVANCED MATERIALS POSTDOCTORAL FELLOWSHIP

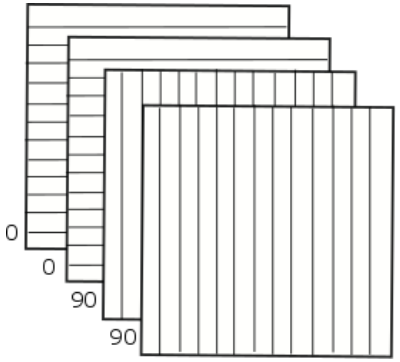
HOST: PROF. PAUL WEAVER, UNIVERSITY OF LIMERICK

Ayan Haldar

04/07/23

PROPOSED DESIGN OF ARCHITECTURED MATERIAL

Multistable Composite Laminates



Unsymmetric Laminates

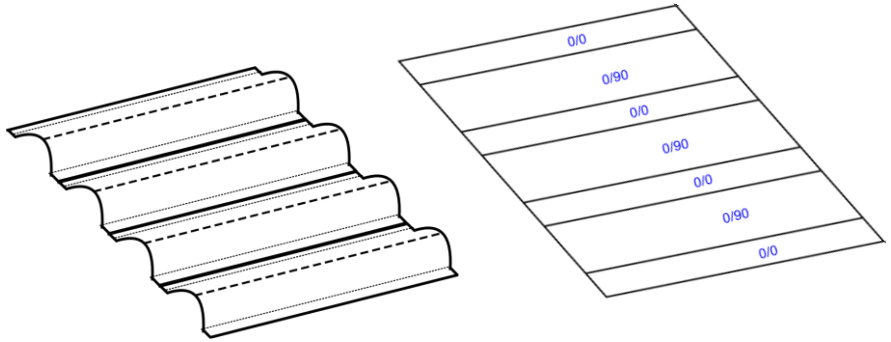
Stable shape-1

At room temperature

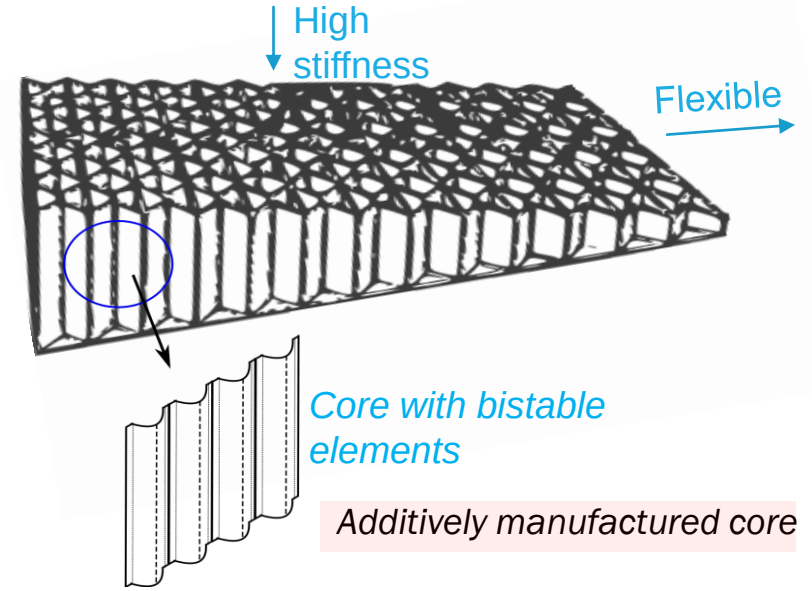
Snap-through

Stable shape-2

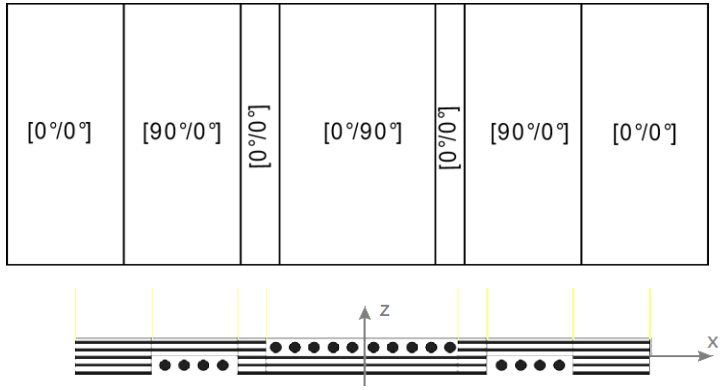
Tessellated Bistable Structure



Designed Core of Wind Turbine Flap

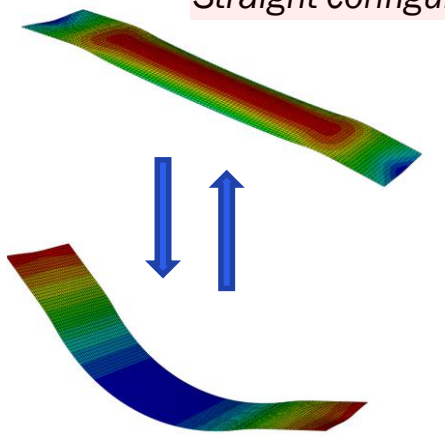


Additively manufactured core



Rectangular Laminates

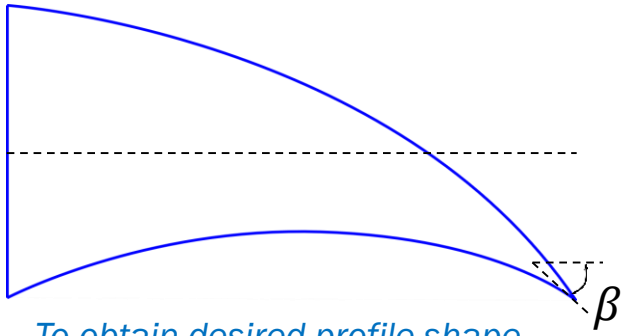
Straight configuration



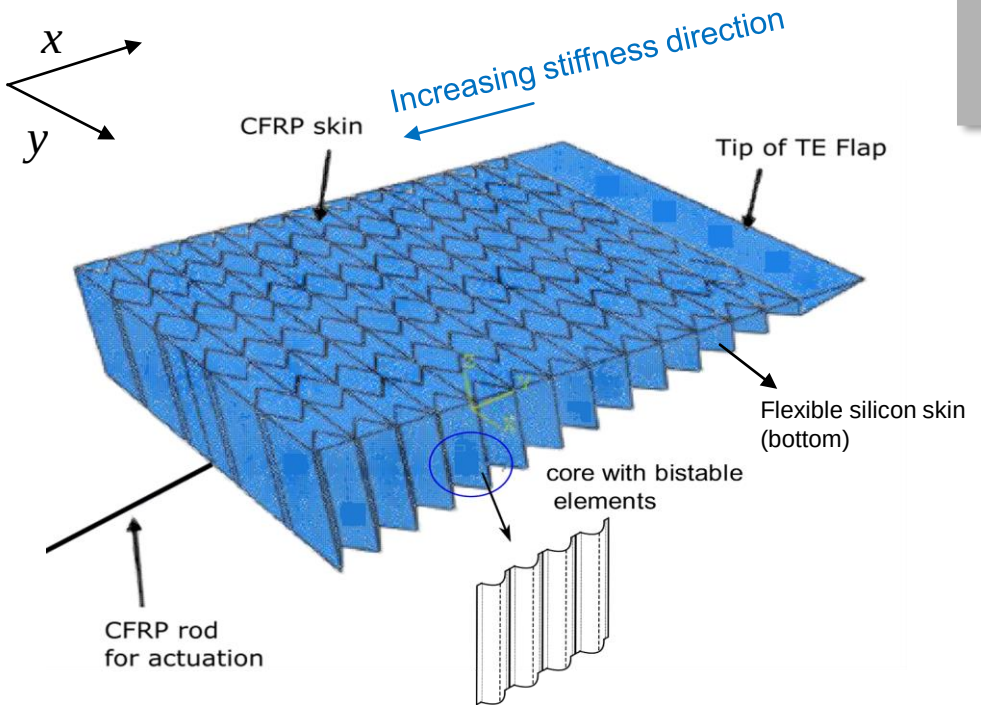
Folded configuration

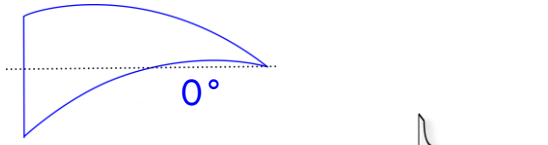
Using Carbon fiber reinforced composites additively manufactured using MarkedForge 3

DESIGN OF MORPHING FLAP

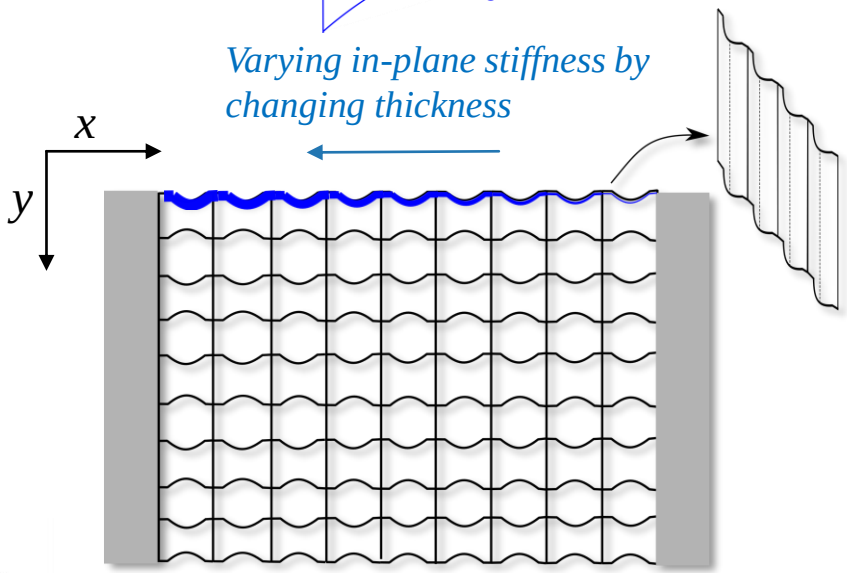


To obtain desired profile shape

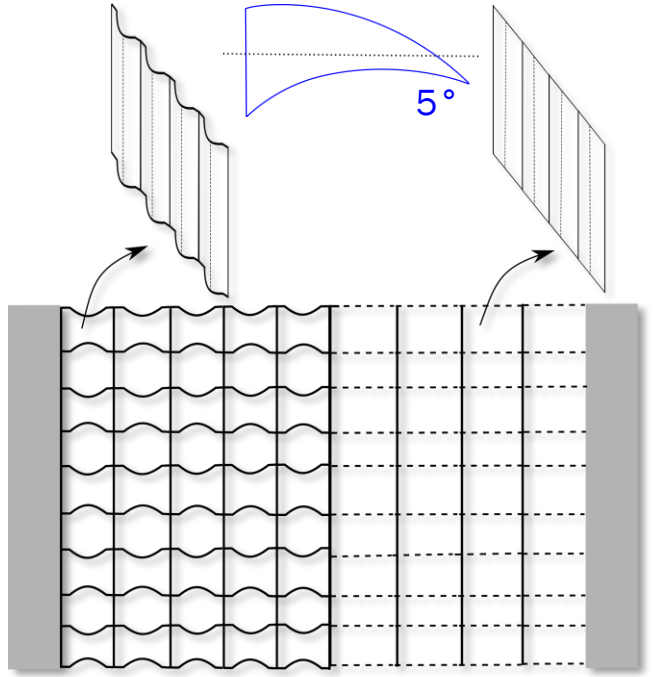




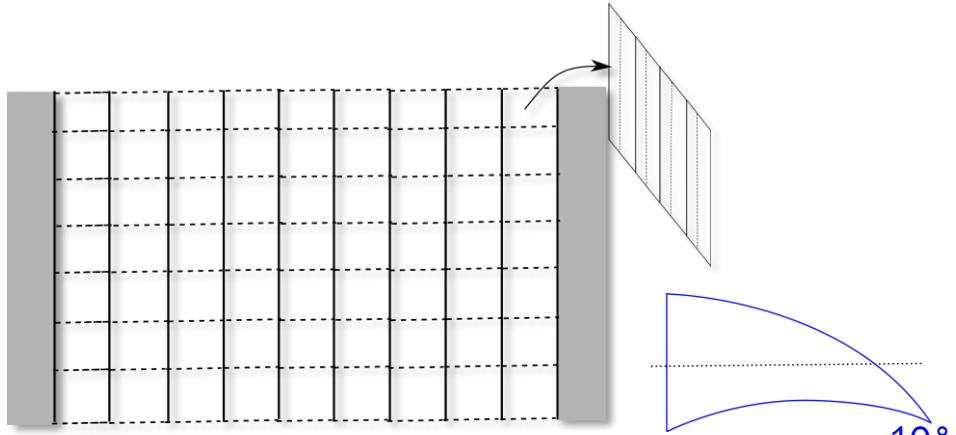
Varying in-plane stiffness by changing thickness



Folded configuration

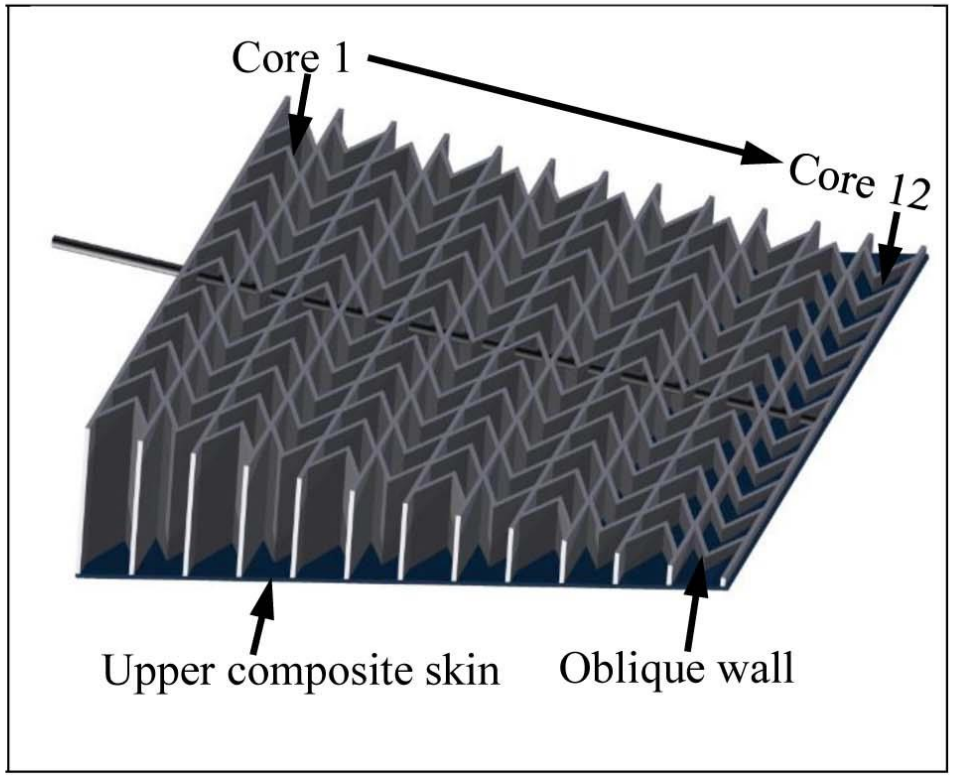


Half retracted configuration

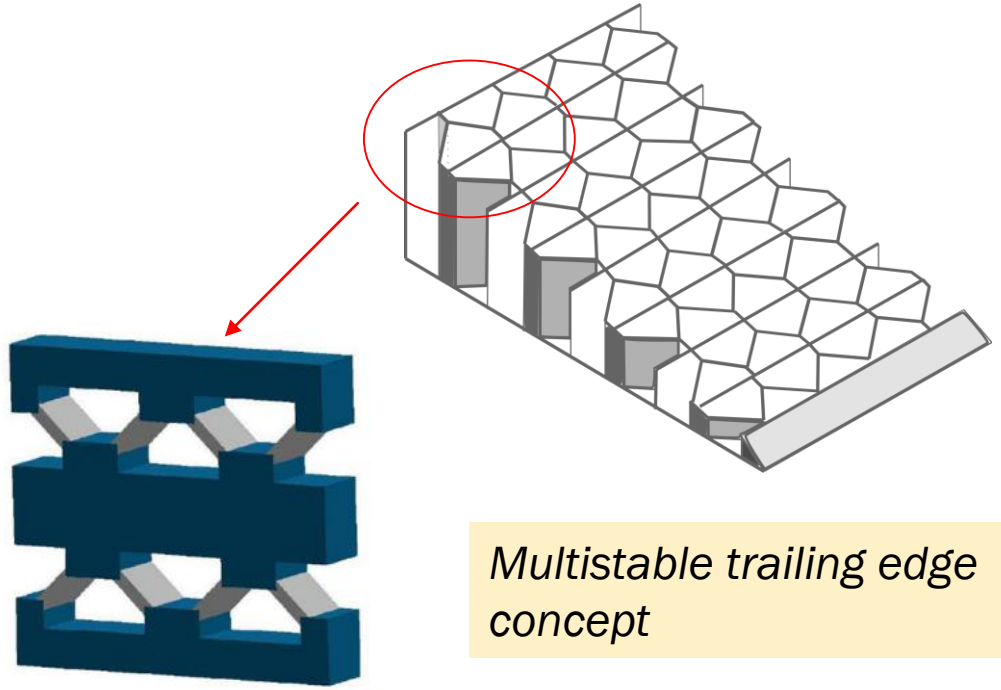


Full retracted configuration

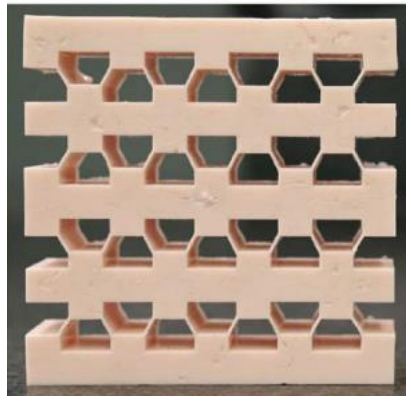
STRATEGY - A

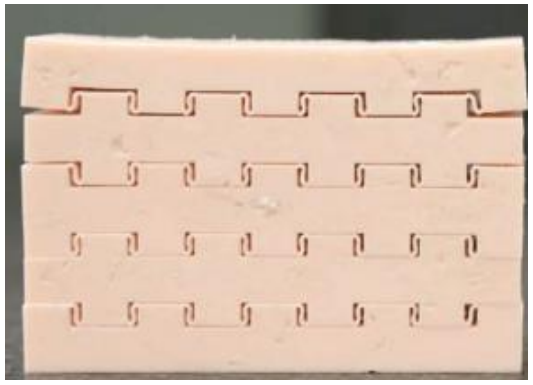


ZPR trailing edge (Qing et al.)

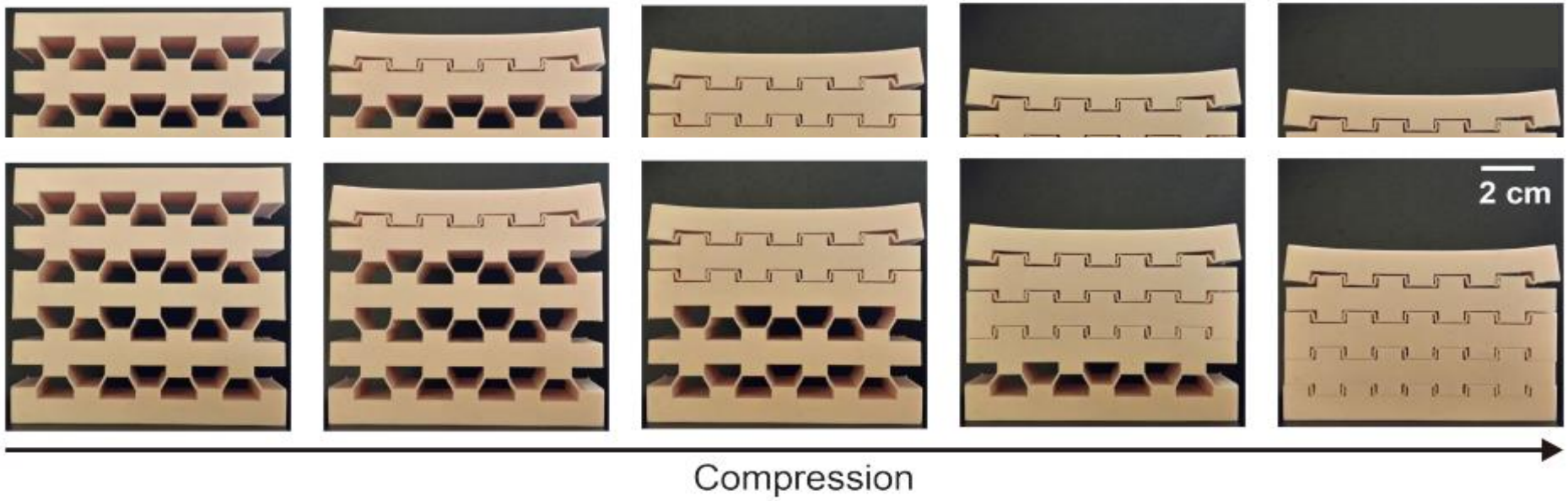


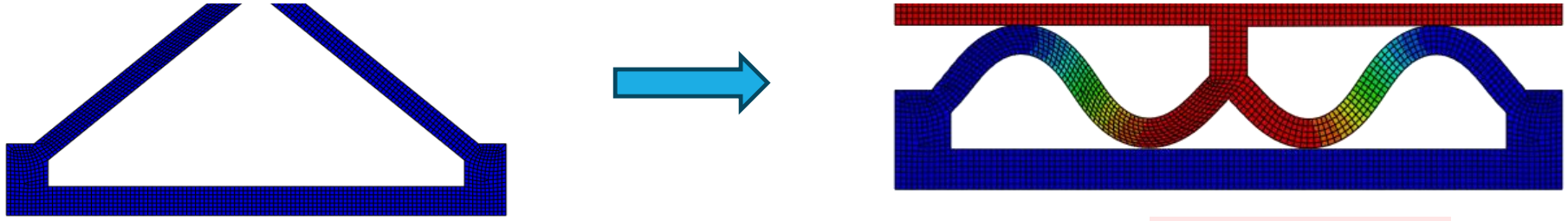
Multistable trailing edge concept





LOCKING AT MULTIPLE STABLE SHAPES

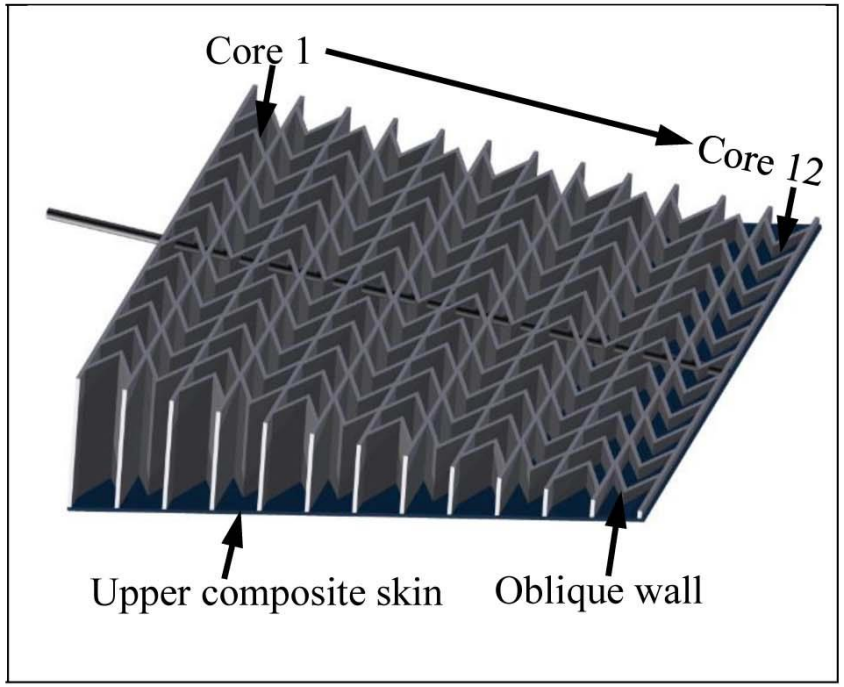




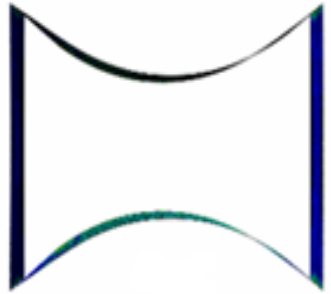
Stable shape 1

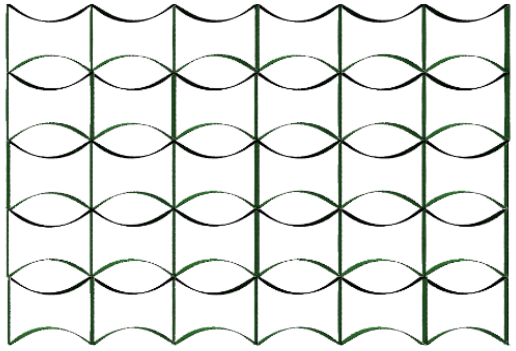
Stable shape 2

STRATEGY - B

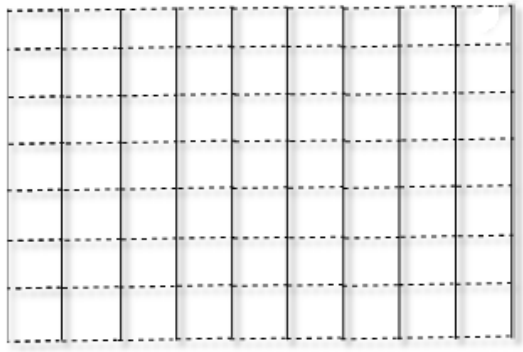


ZPR trailing edge (Qing et al.)



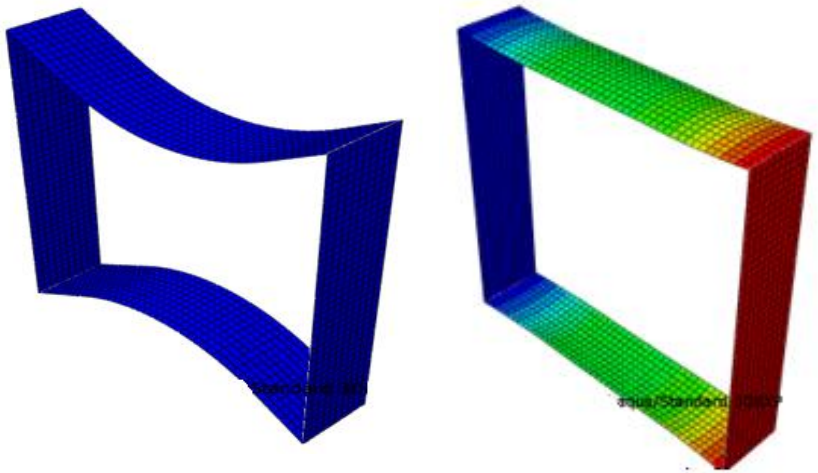


Min plate length of 200 mm for substantial deformation for a flap

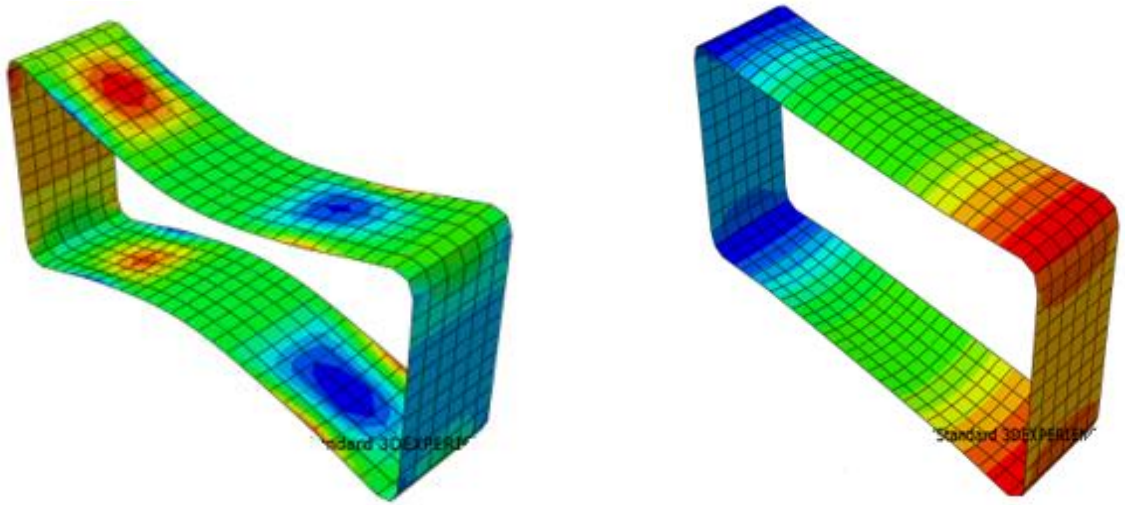


Hinges cause issue in manufacturing or scalability

STRATEGY – B (IMPROVED DESIGN)



With hinges at the corners

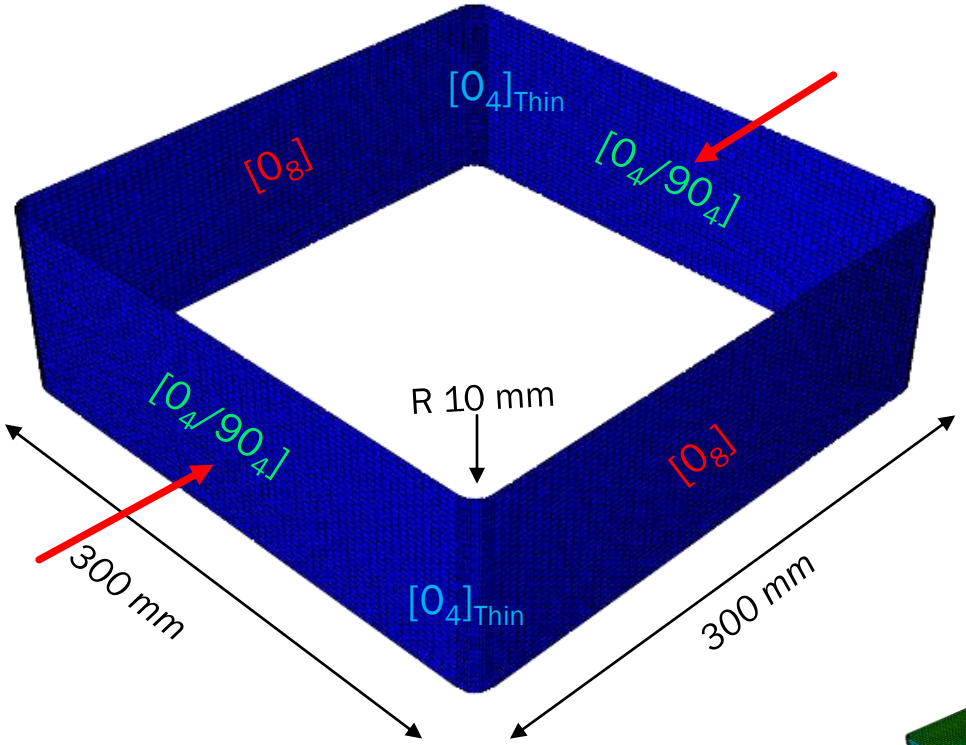


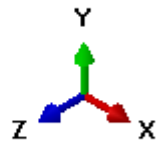
Monolithic structure

$[0]_2$ layers are the corners

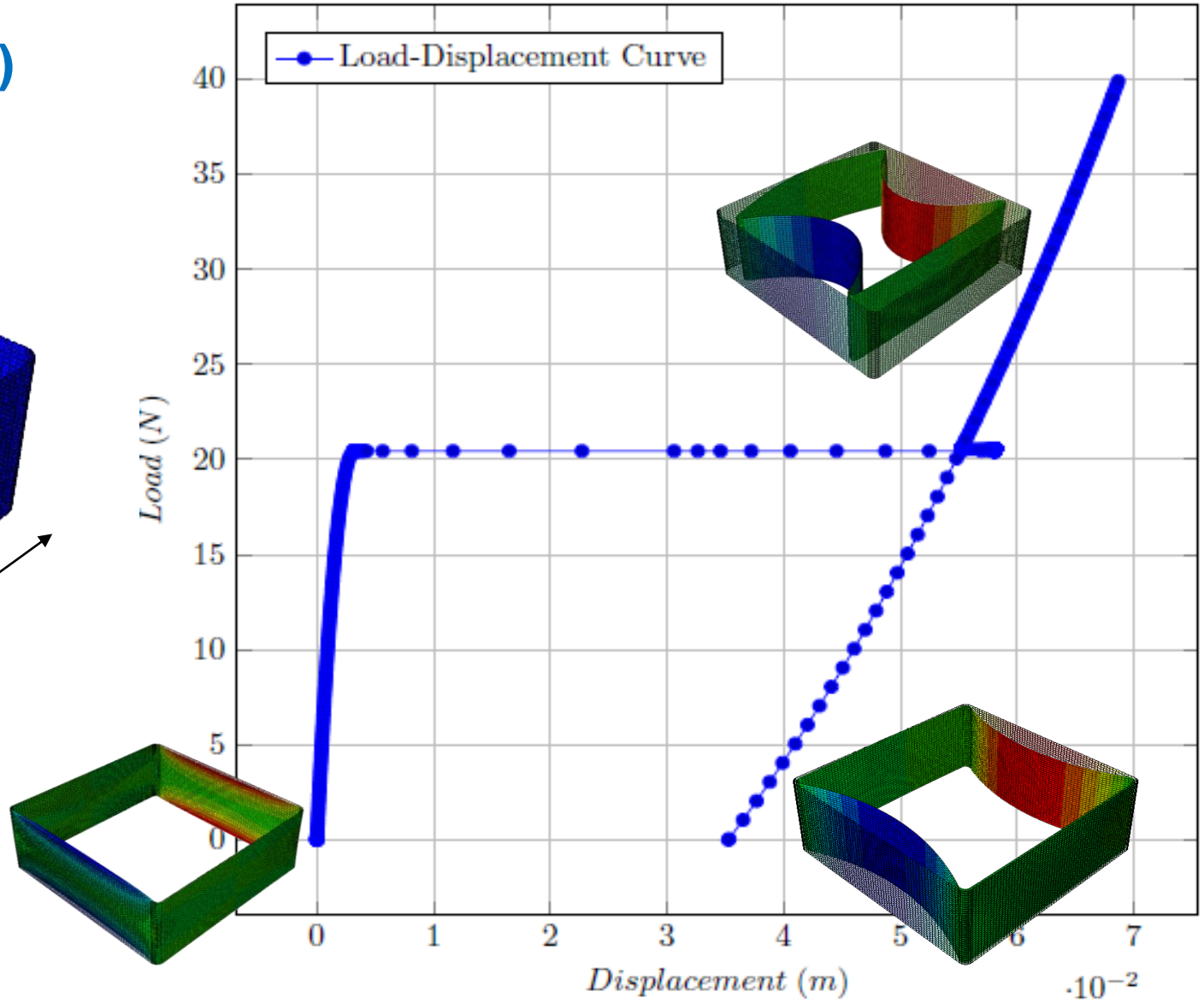
DESIGN OF UNIT CELL
EXPLORING BISTABILITY (R10)

R10 8S 8U 4C

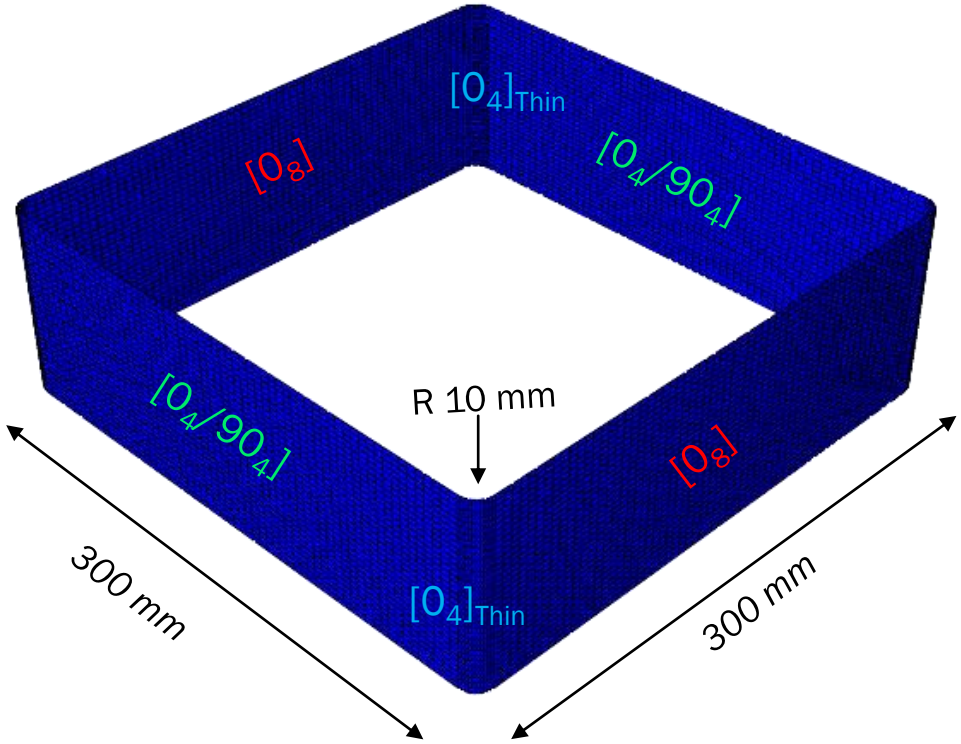


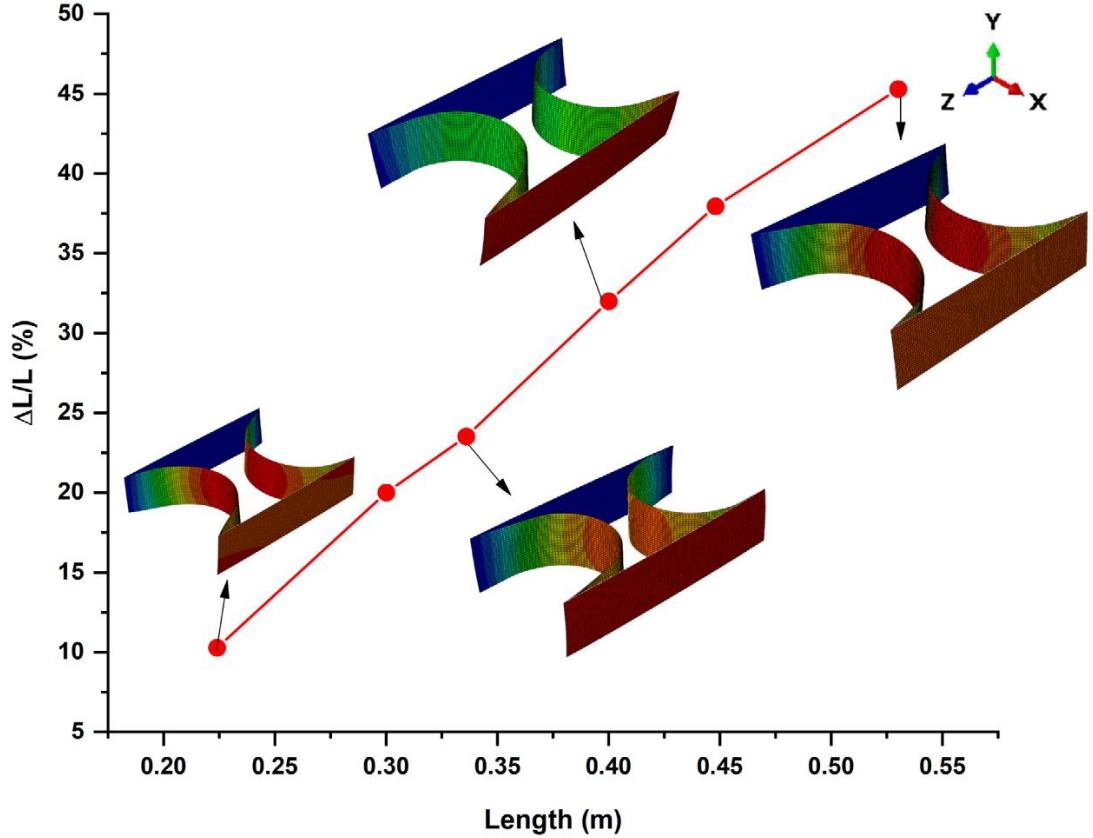


*Contour indicates U_z



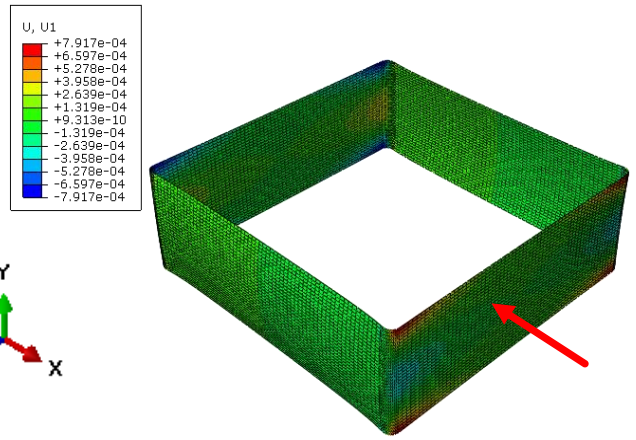
DESIGN OF UNIT CELL
EXPLORING BISTABILITY (R10)



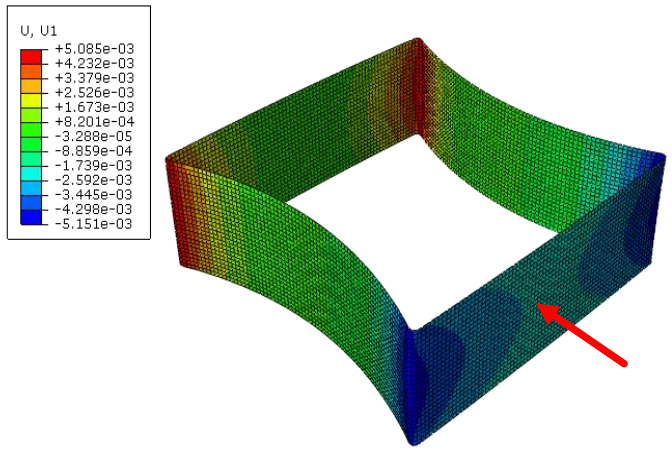


*Contour indicates U_z

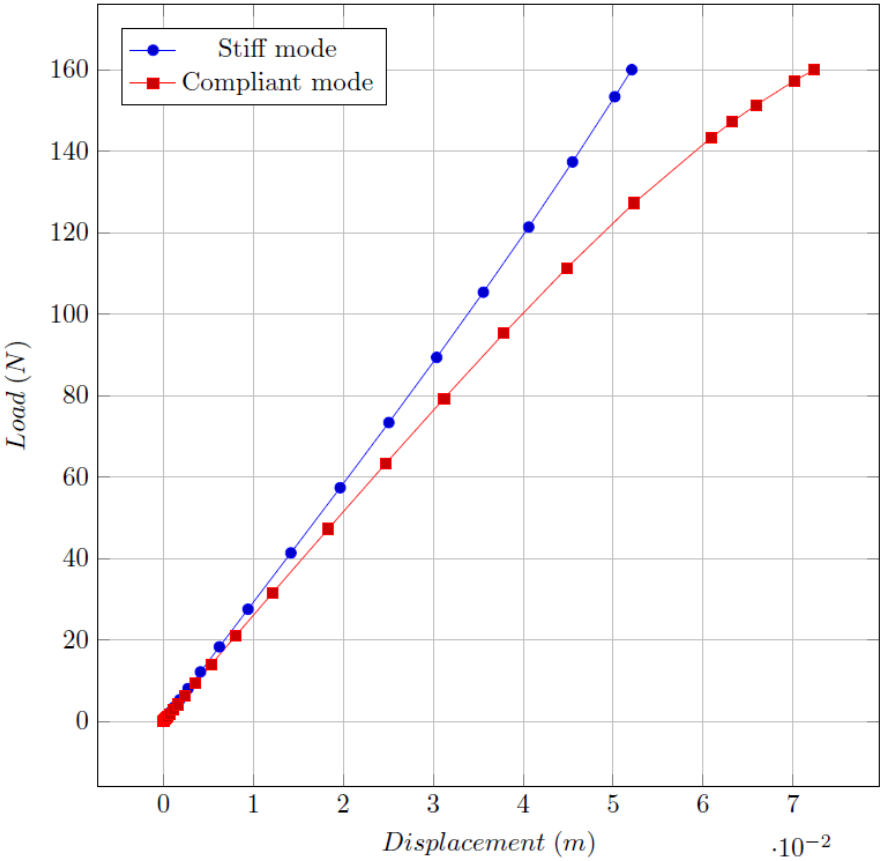
STIFFNESS TAILORING (R10 8S 8U 4C)

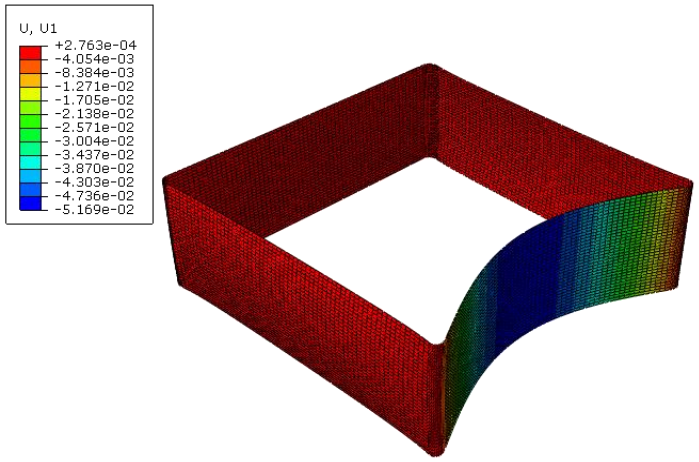


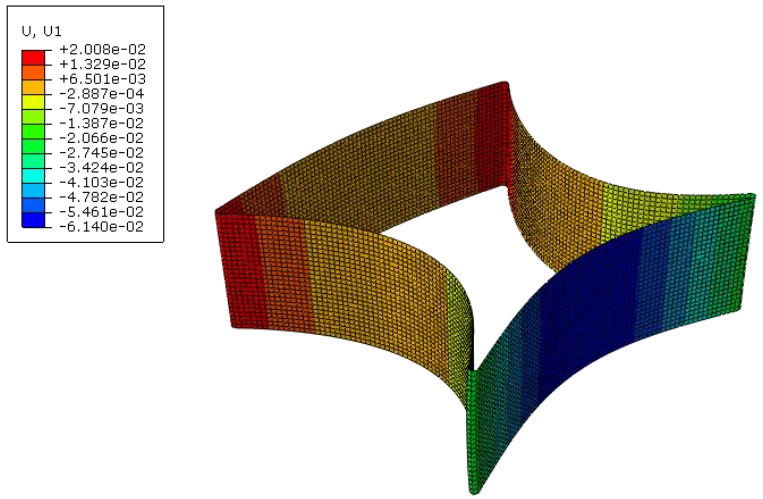
Stiff mode



Compliant mode

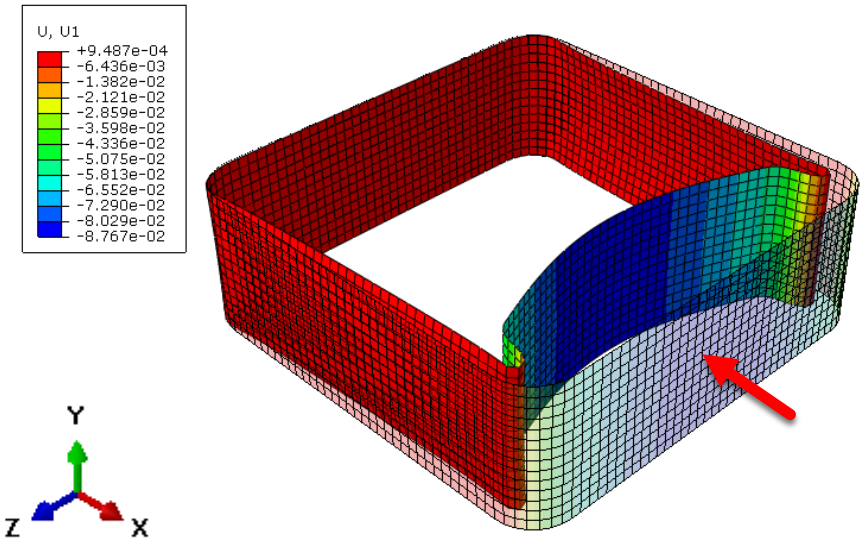




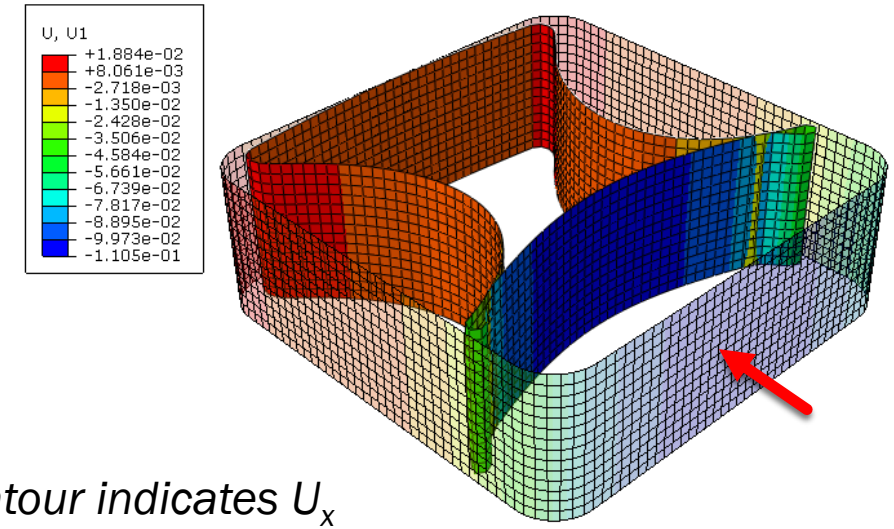


**Contour indicates U_x*

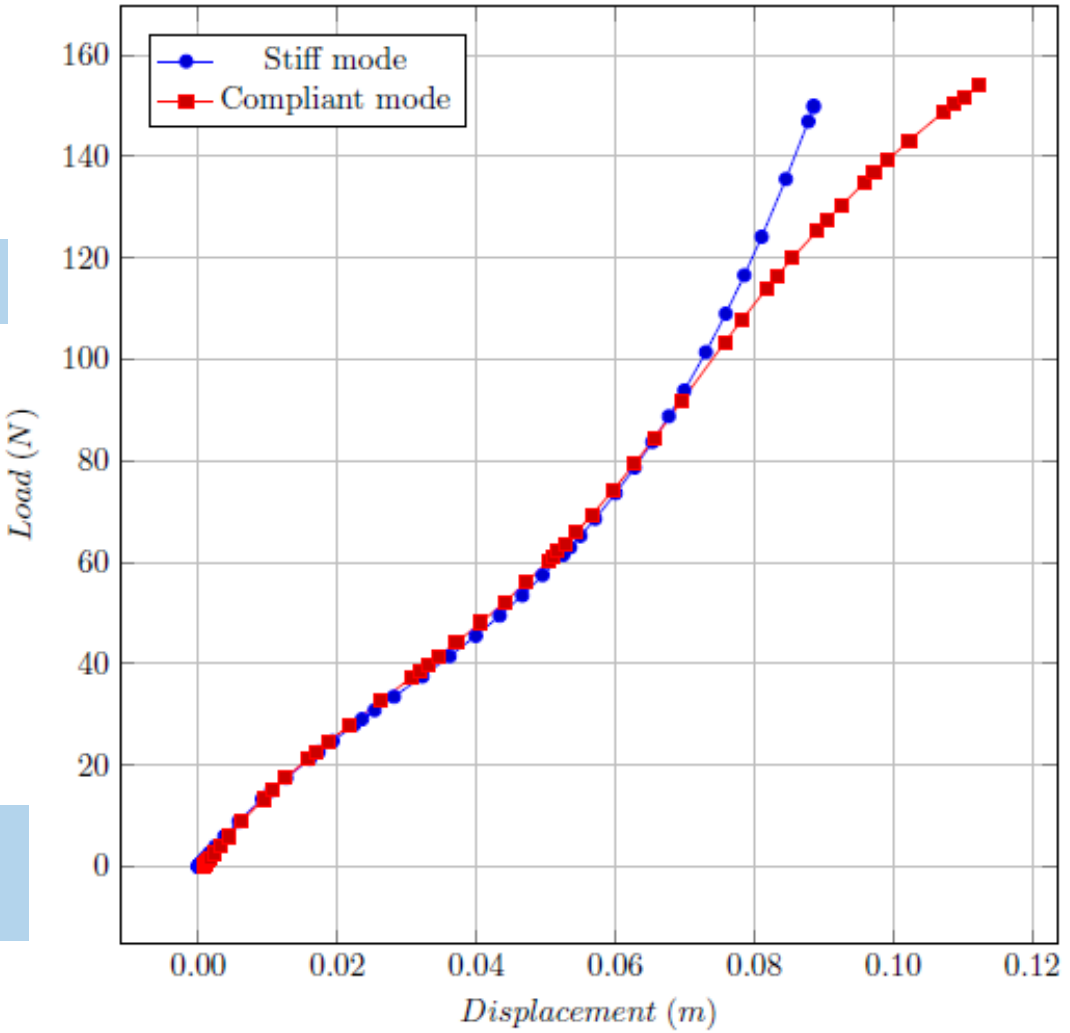
STIFFNESS TAILIORING : R30 8S 8U 4C



Stiff mode

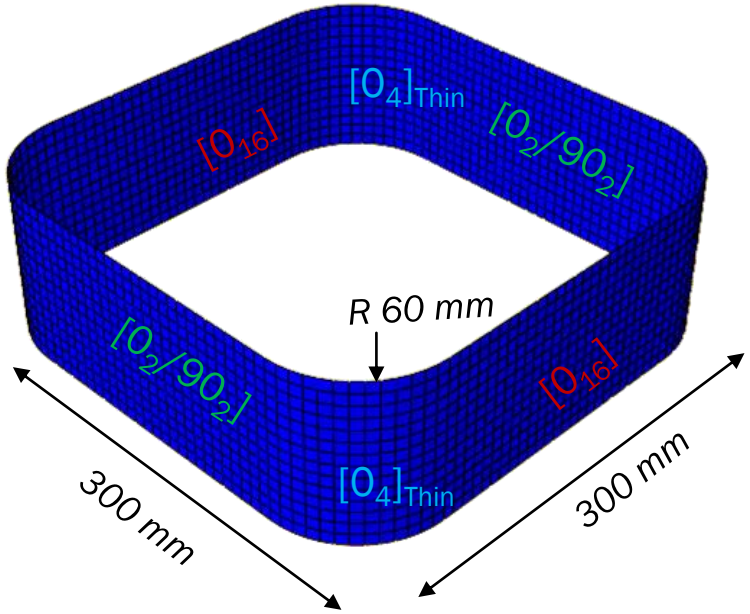


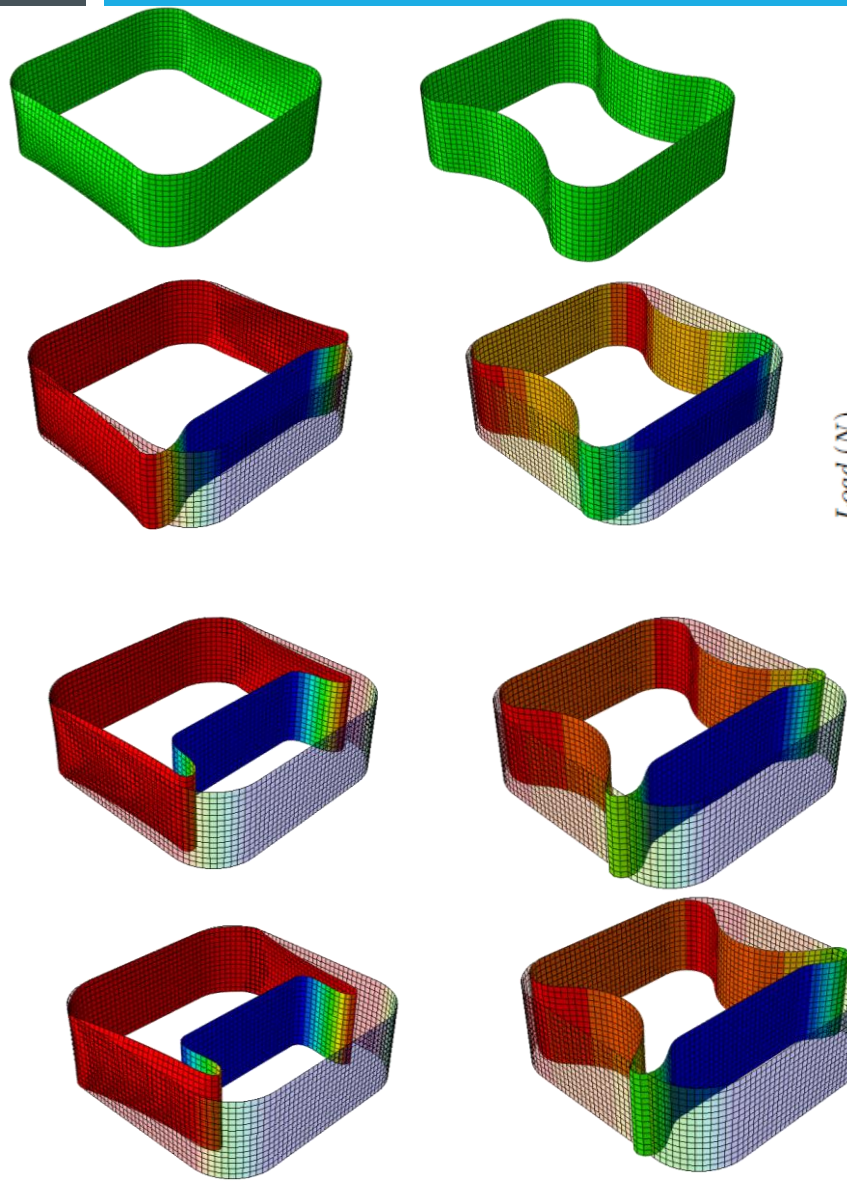
Compliant mode



**Contour indicates U_x*

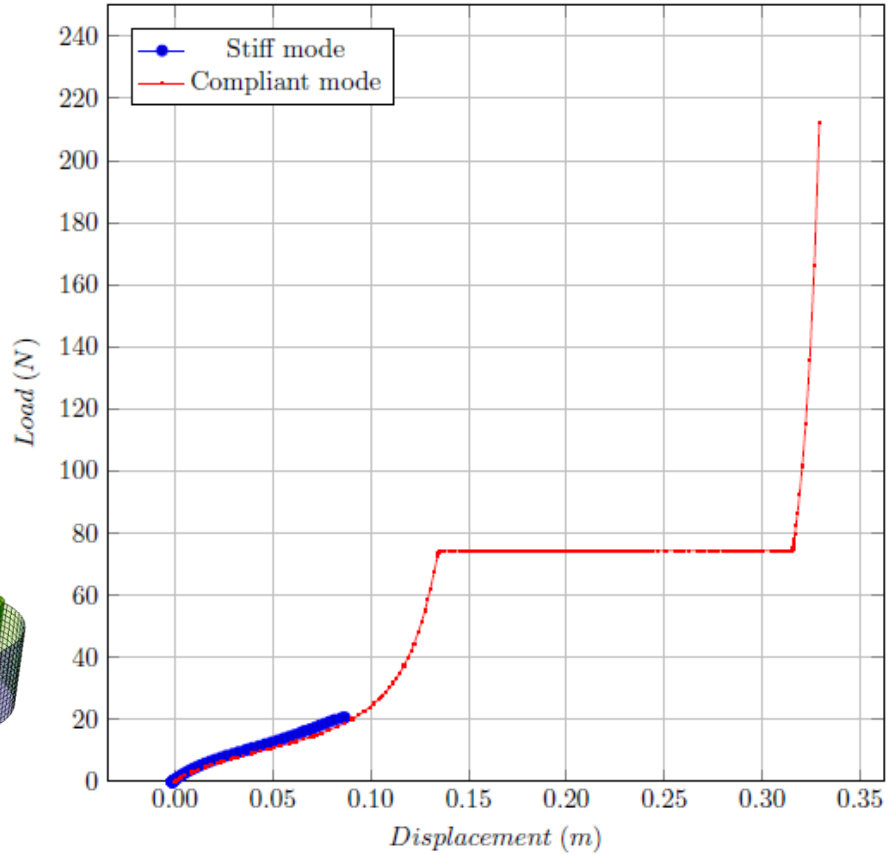
R60 8S 4U 4C



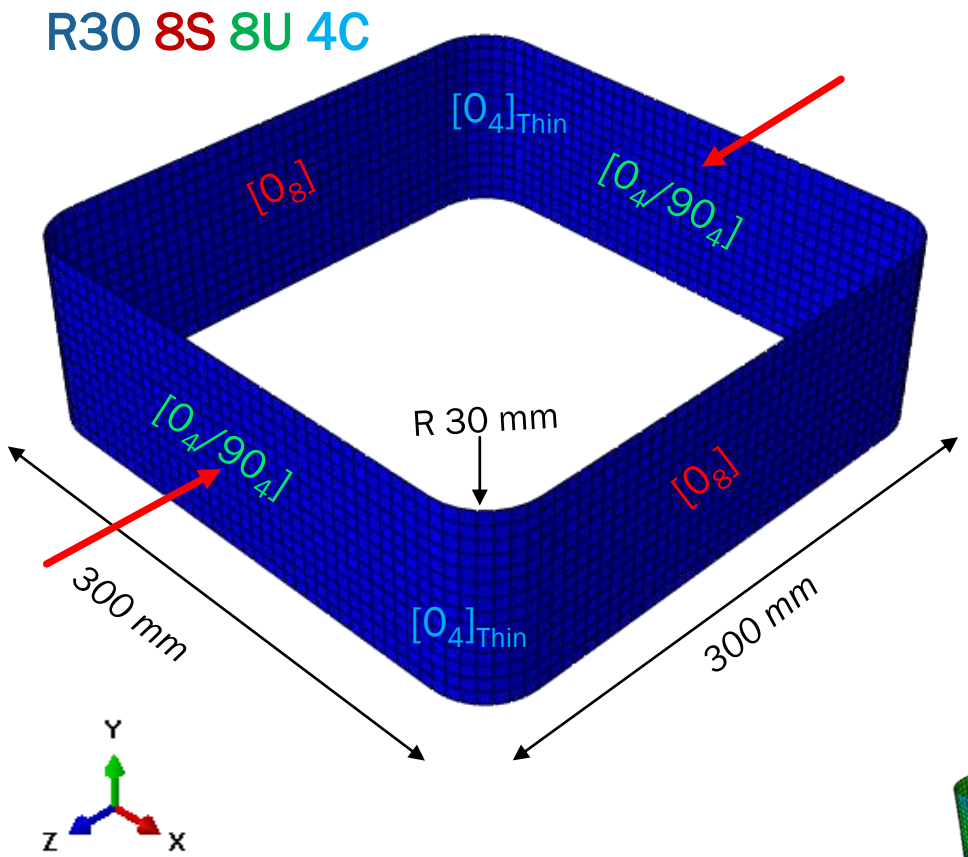


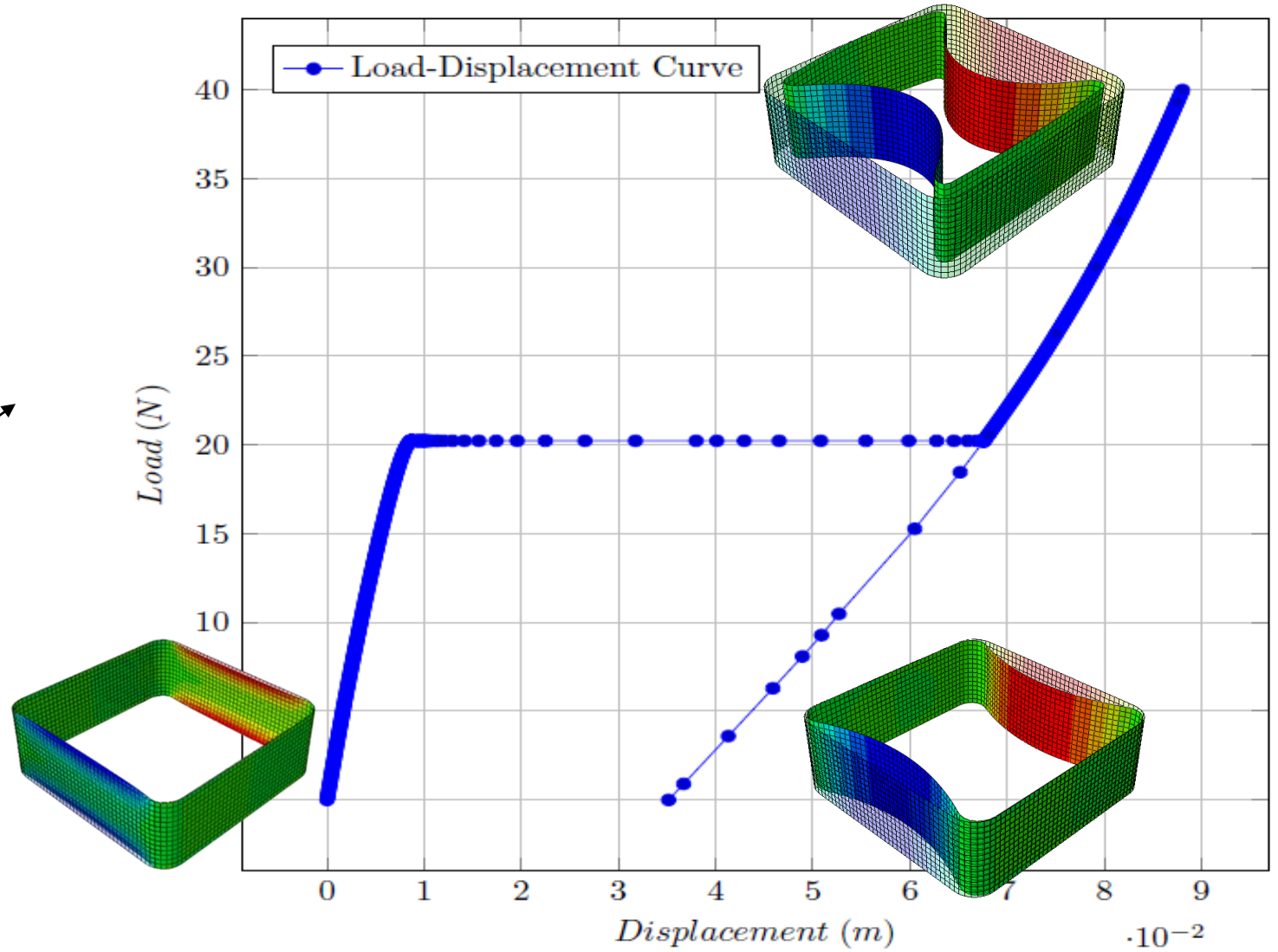
Stiff mode

Compliant mode



DESIGN OF UNIT CELL - EXPLORING BISTABILITY (R30)

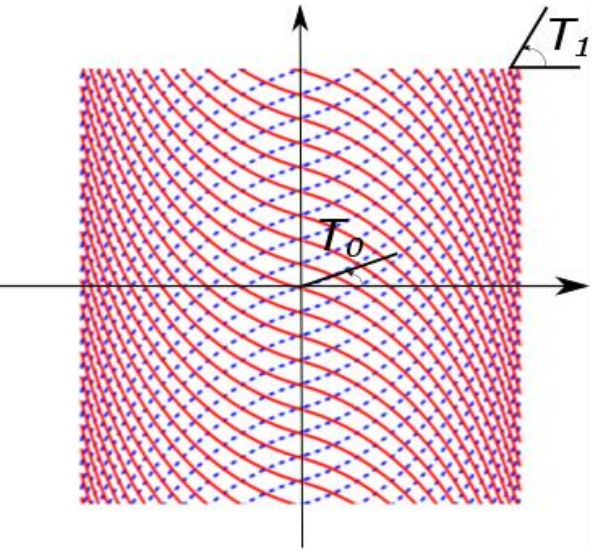




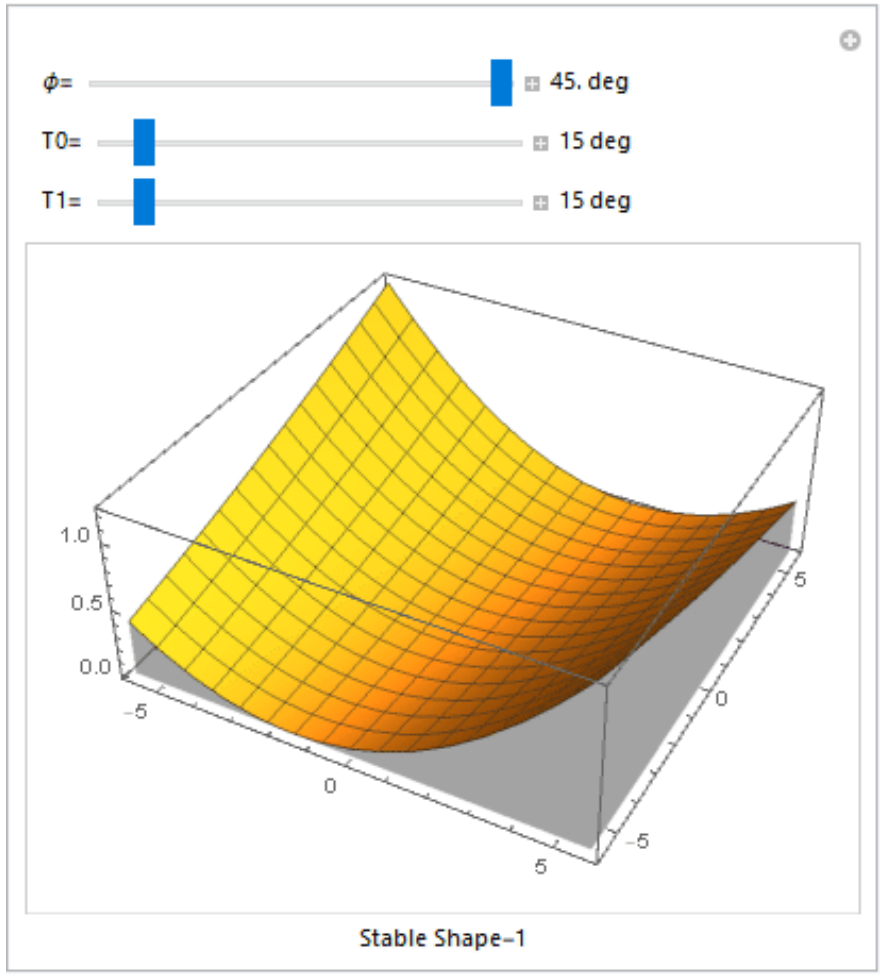
*Contour indicates U_z

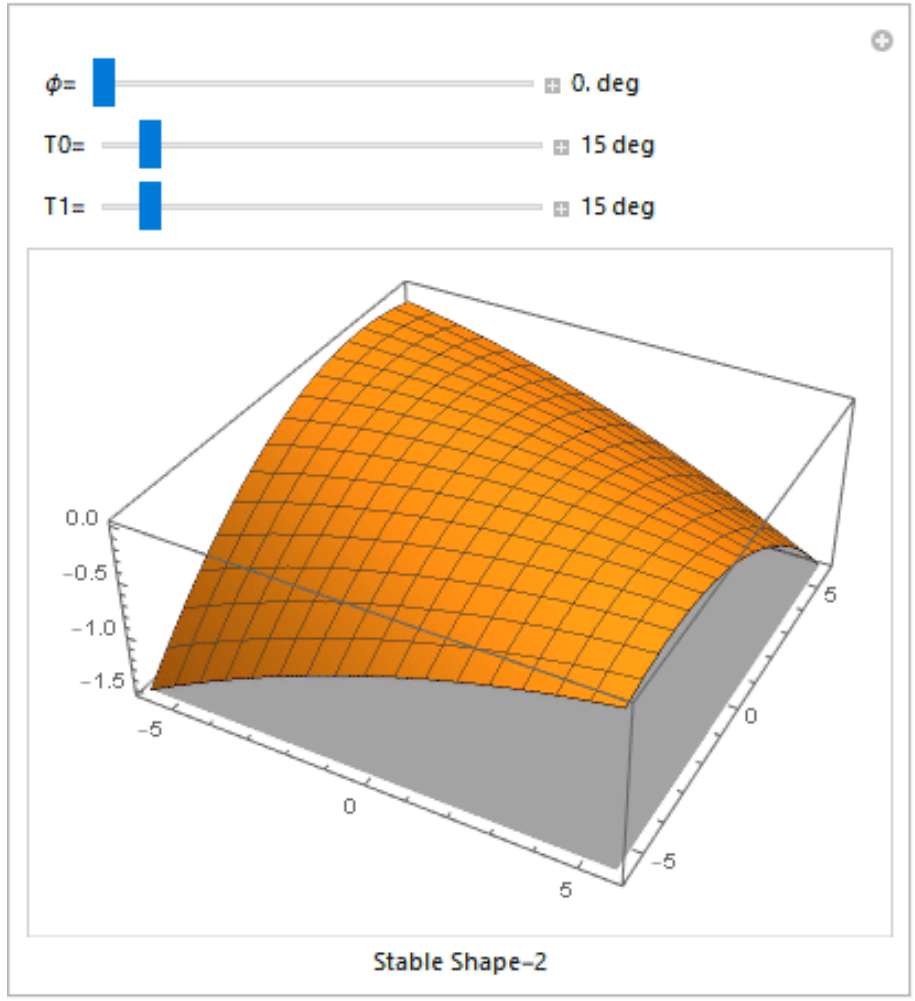
DIVERSE STABLE SHAPES FROM VS LAMINATES

Obtained shapes after thermal cool-down for different parameters of VS laminates



Variable Stiffness Laminates



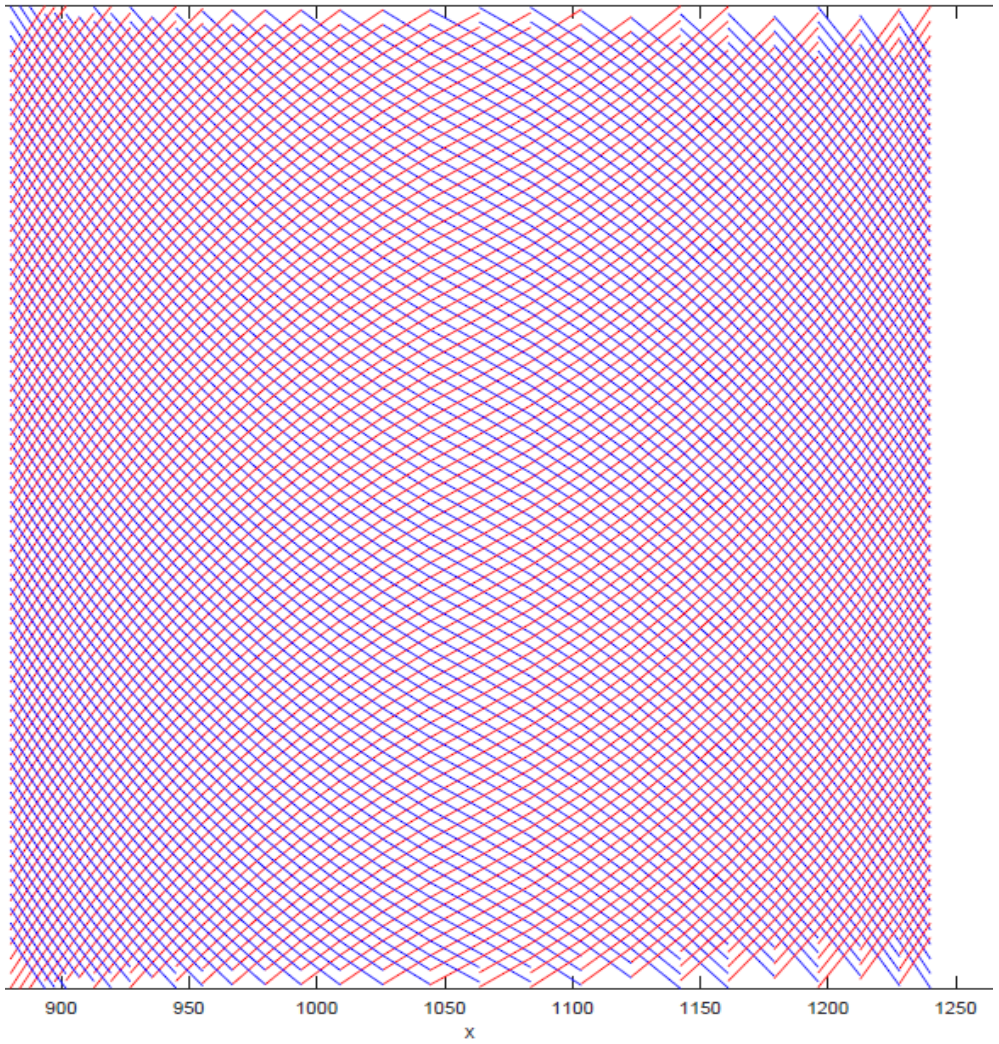


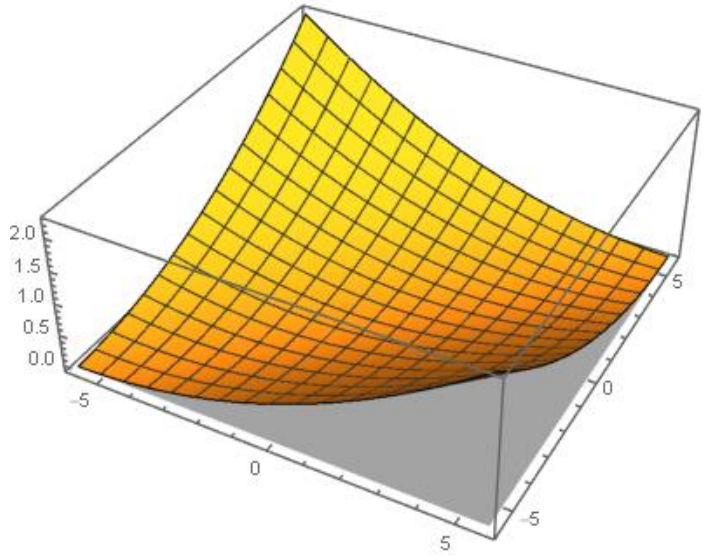
Haldar et al. 2018, Composite Structures

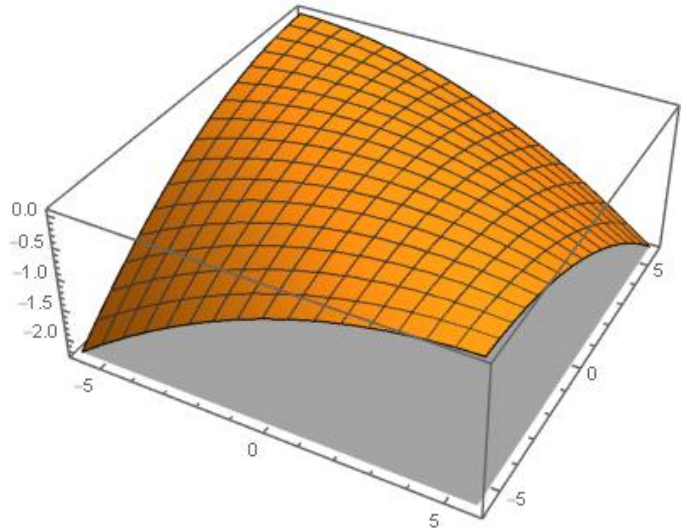
BISTABLE LAMINATE WITH ATL

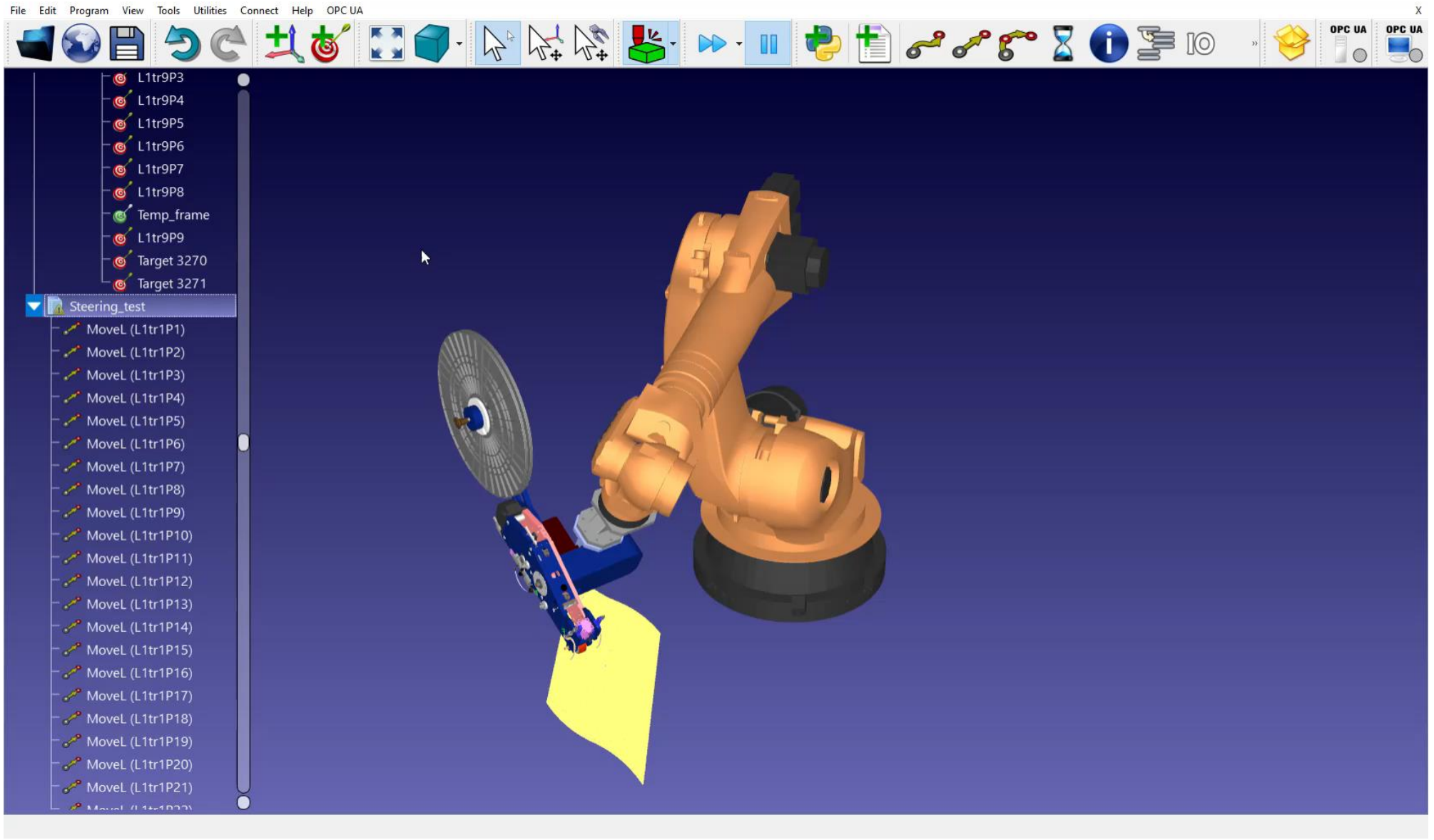
$$\phi\langle T_0|T_1\rangle$$

0<30|60>/0<-30|-60>








File
Edit
Program
View
Tools
Utilities
Connect
Help
OPC UA
X
OPC UA
OPC UA
L1tr9P3
L1tr9P4
L1tr9P5
L1tr9P6
L1tr9P7
L1tr9P8
Temp_frame
L1tr9P9
Target 3270
Target 3271
Steering_test
MoveL (L1tr1P1)
MoveL (L1tr1P2)
MoveL (L1tr1P3)
MoveL (L1tr1P4)
MoveL (L1tr1P5)
MoveL (L1tr1P6)
MoveL (L1tr1P7)
MoveL (L1tr1P8)
MoveL (L1tr1P9)
MoveL (L1tr1P10)
MoveL (L1tr1P11)
MoveL (L1tr1P12)
MoveL (L1tr1P13)
MoveL (L1tr1P14)
MoveL (L1tr1P15)
MoveL (L1tr1P16)
MoveL (L1tr1P17)
MoveL (L1tr1P18)
MoveL (L1tr1P19)
MoveL (L1tr1P20)
MoveL (L1tr1P21)