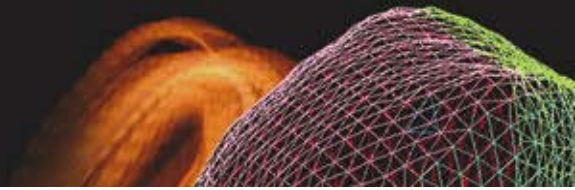


Finite Element Analysis to determine the impact of Infill density on Mechanical Properties of 3D Printed Materials

Zahra Andleeb

Abyss Solutions

3D Printing of Materials

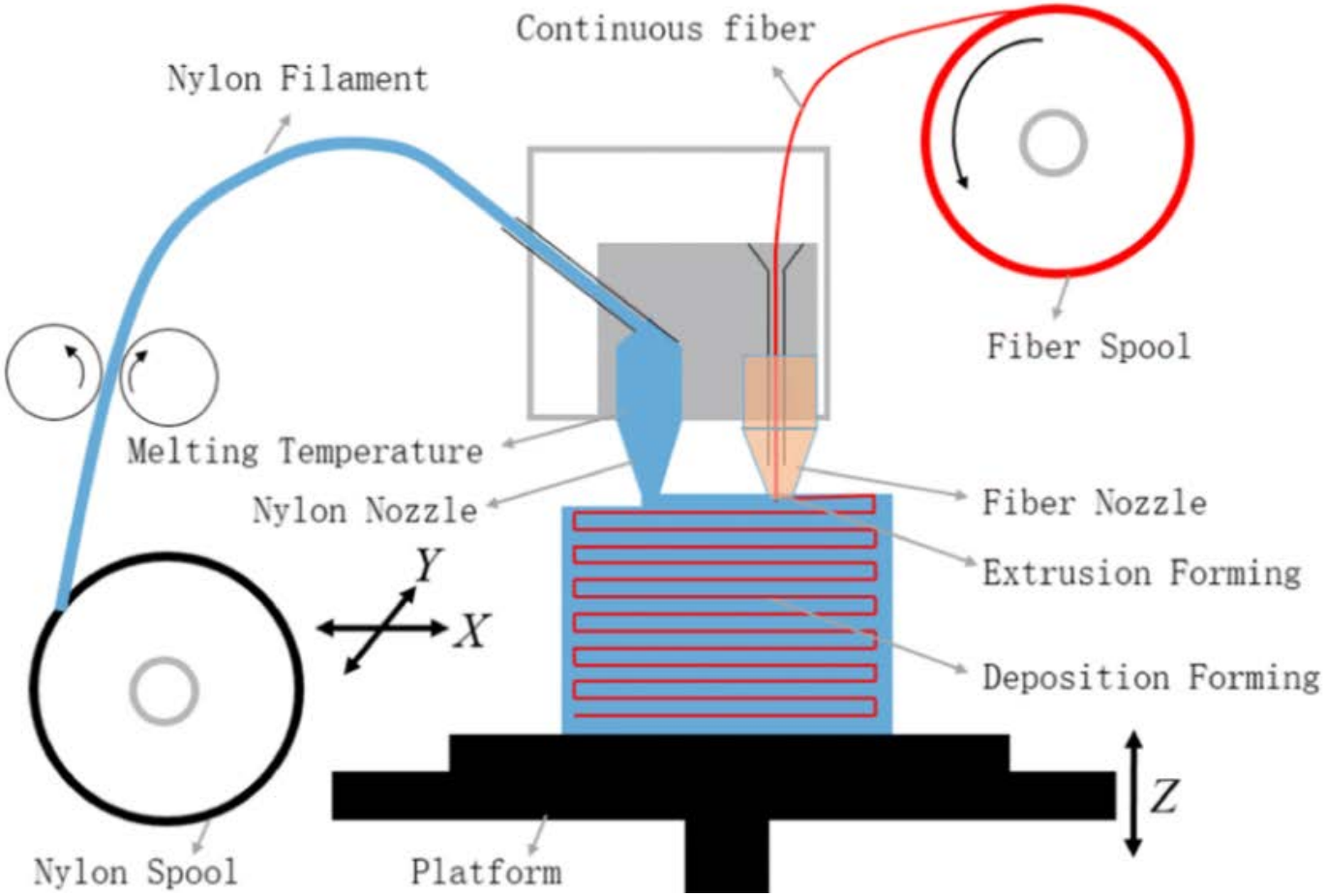


Figure 1: Schematic view of the 3D printing of Composite reinforced with continuous carbon fiber [3]

Infill patterns in 3D printing

Figure 2: Cross-section of 3D printed parts with different infills [17]

Infill density Calculation

$$Infill\ (\%) = \frac{V - V_{hollow}}{V_{solid} - V_{hollow}} \qquad (1)$$

Where V is the volume of cuboid (mm^3), V_{hollow} is the volume of hollow cuboid (mm^3) and V_{solid} is the volume of solid cuboid (mm^3).

Table 1: Volume of various Infills (%)

Configuration	Volume (mm^3)	$Infill\ (\%) = \frac{V - V_{hollow}}{V_{solid} - V_{hollow}}$
0	192.824 (hollow)	0 %
1	369.45	10 %
2	538.02	19 %
3	693.79	28 %
4	1348.4	64 %
5	2000 (solid)	100 %

FEA Analysis

- 10 mm x 10 mm x 20 mm cuboid
- Linear Isotropic Material with Young's Modulus of **70 GPA** and Poisson ratio is **0.3**
- Quarter symmetry was applied to reduce mesh size

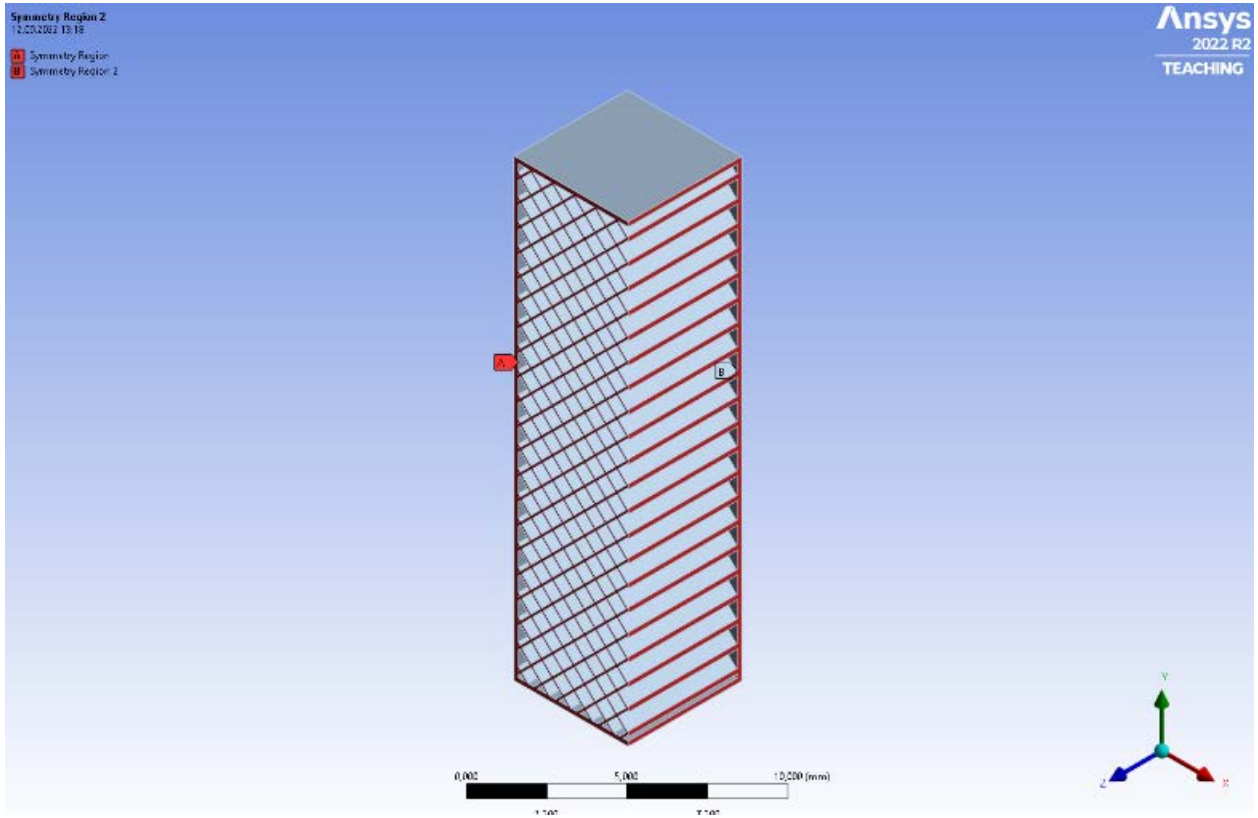


Figure 3: Quarter symmetry for mesh size reduction

FEA Analysis

Figure 4: Boundary condition of compressive load of 1 MPa on the top surface

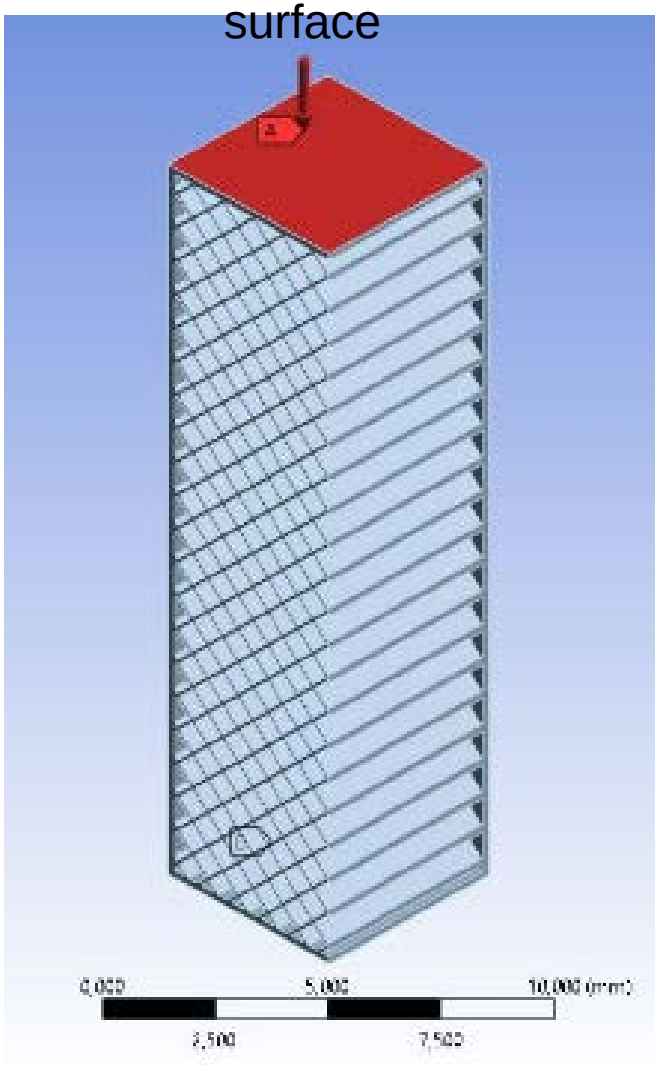
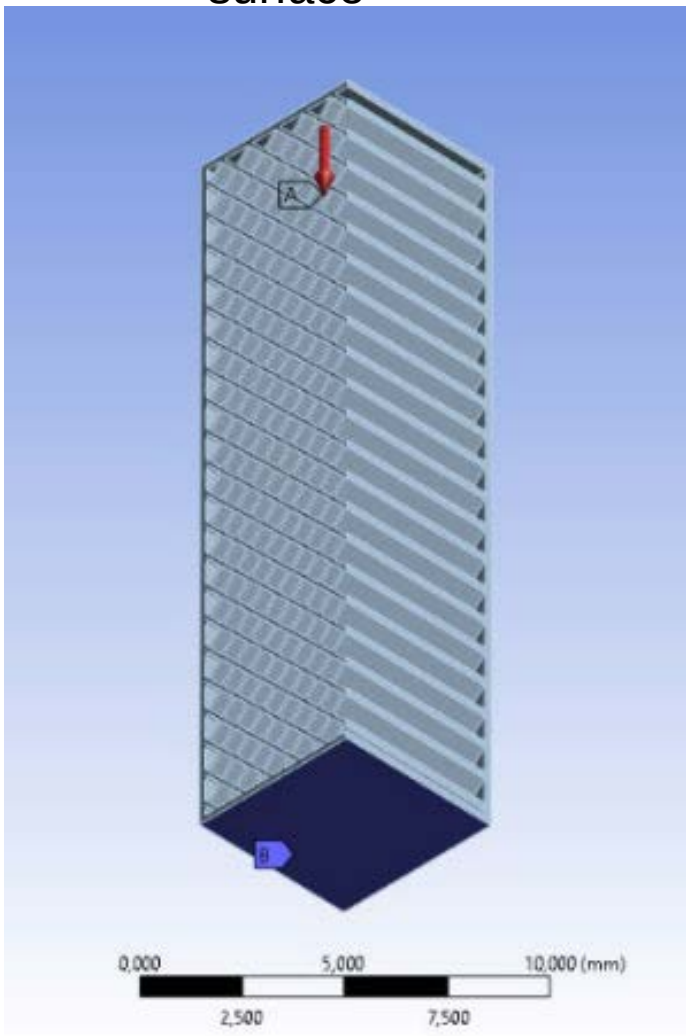
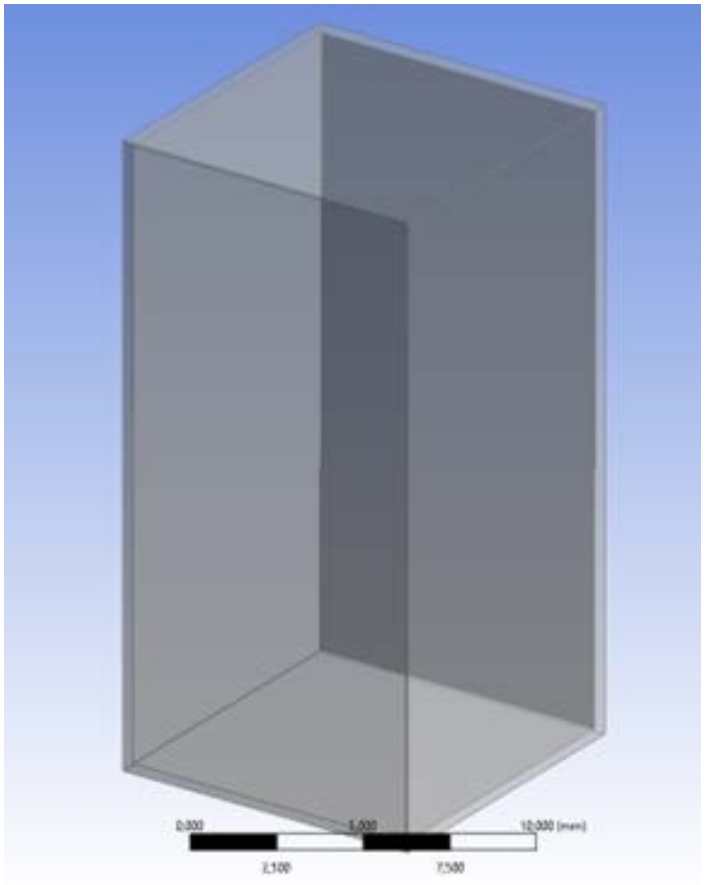


Figure 5: Fixed support in the bottom surface

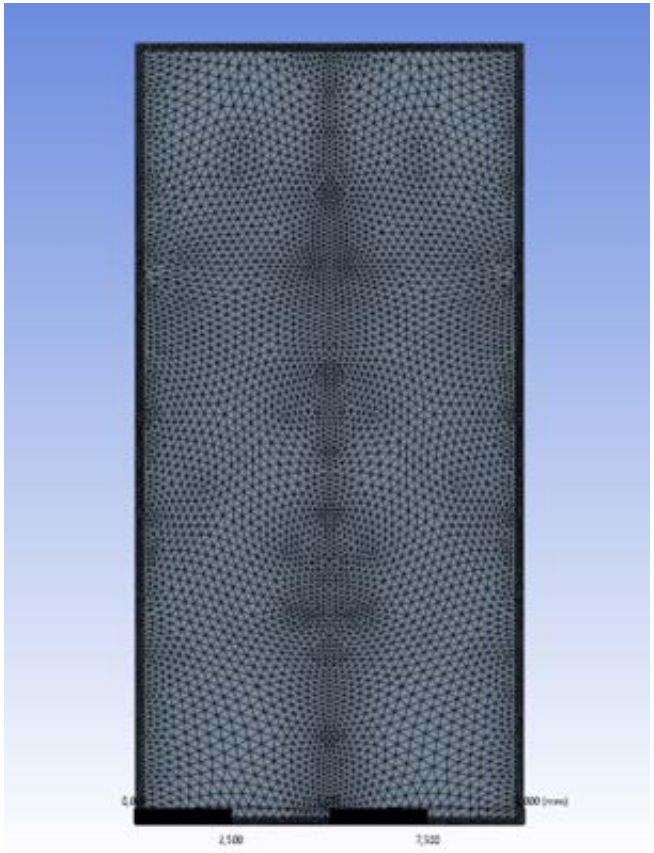


CAD Model and FEA Mesh of Configuration 0 (Volume: 192.824 mm^3), infill ratio of 0%)

CAD Model of Configuration 1

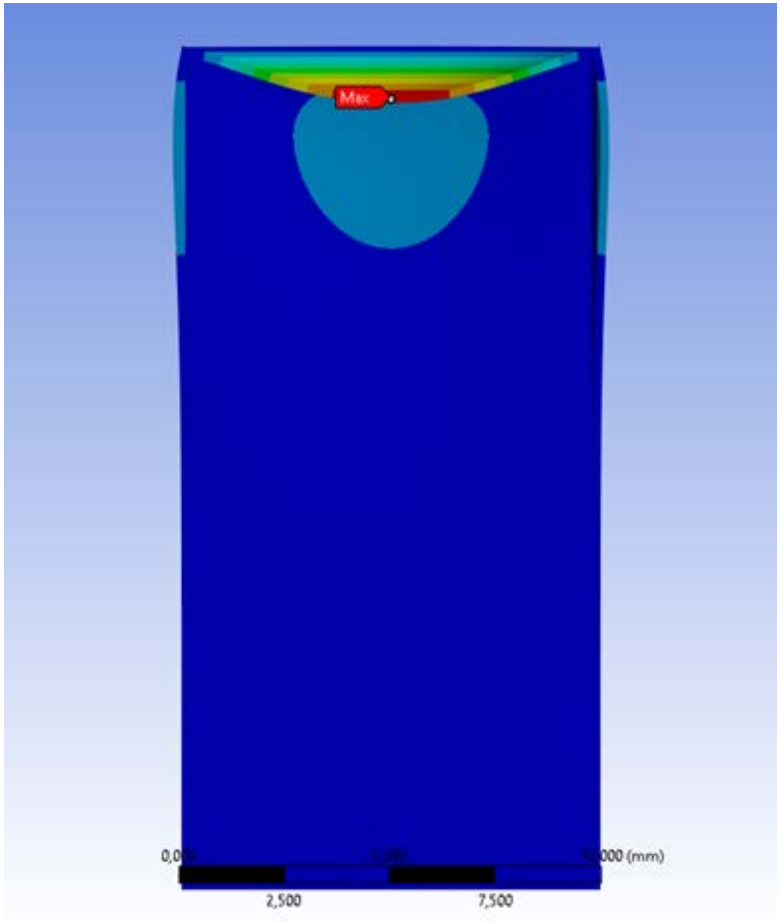


FEA Mesh of Configuration 1

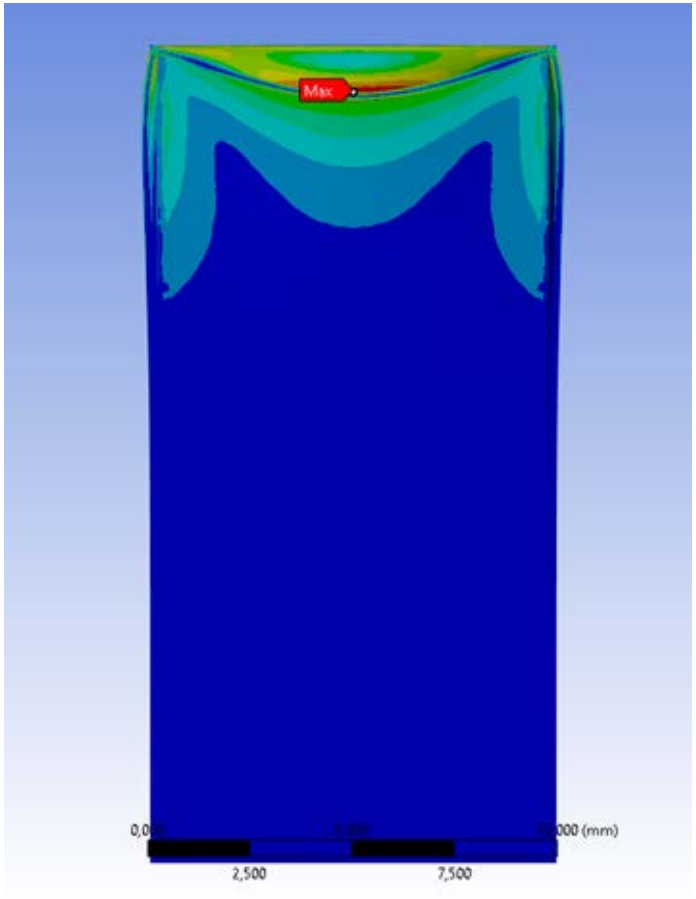


CAD Model and FEA Mesh of Configuration 0 (Volume: 192.824 mm^3), infill ratio of 0%)

Max Deformation = 0.36815 mm

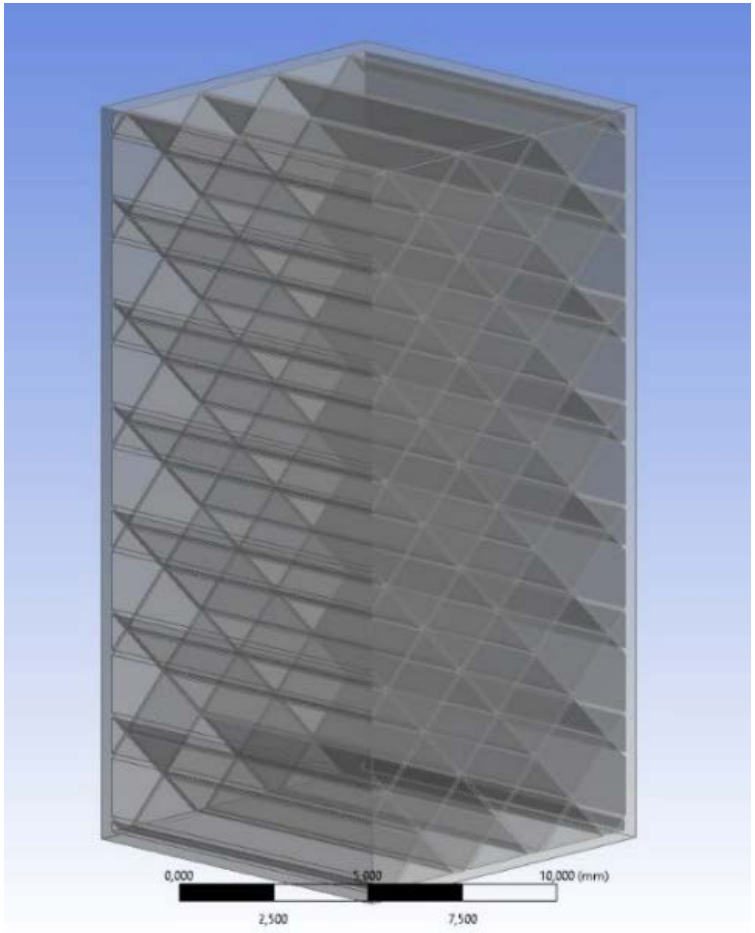


Von-Misses Stress = 432.95 MPa

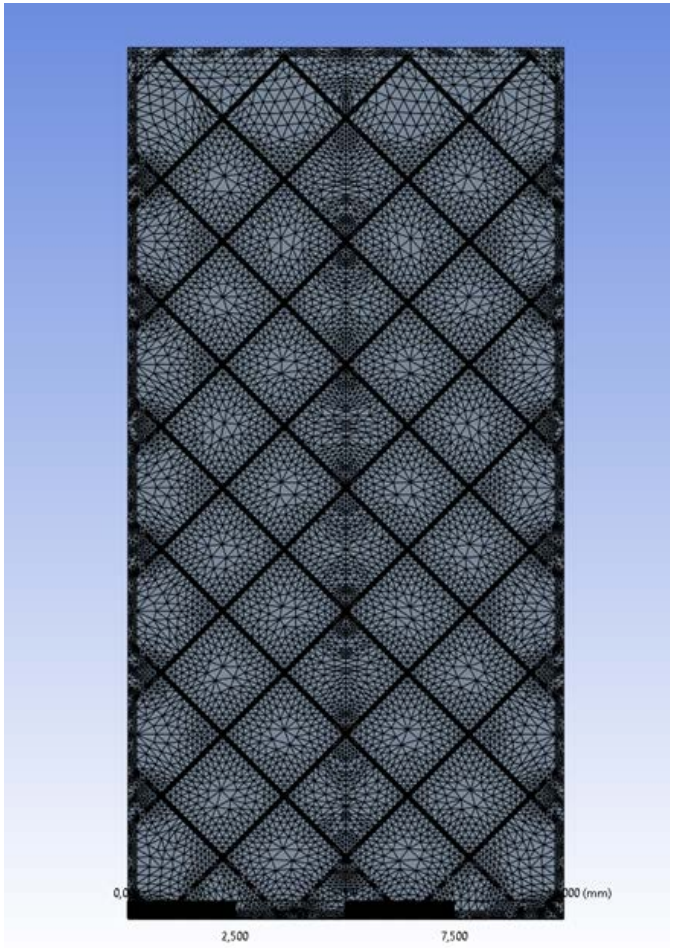


CAD Model and FEA Mesh of Configuration 1 (Volume: 369.45 mm^3), infill ratio of 10%)

CAD Model of Configuration 1

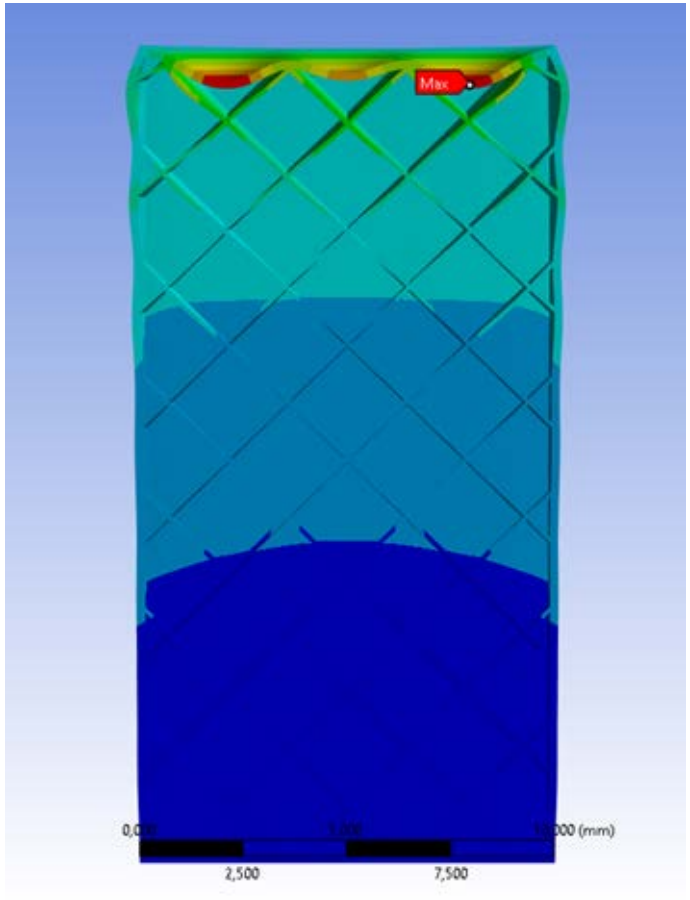


FEA Mesh of Configuration 1

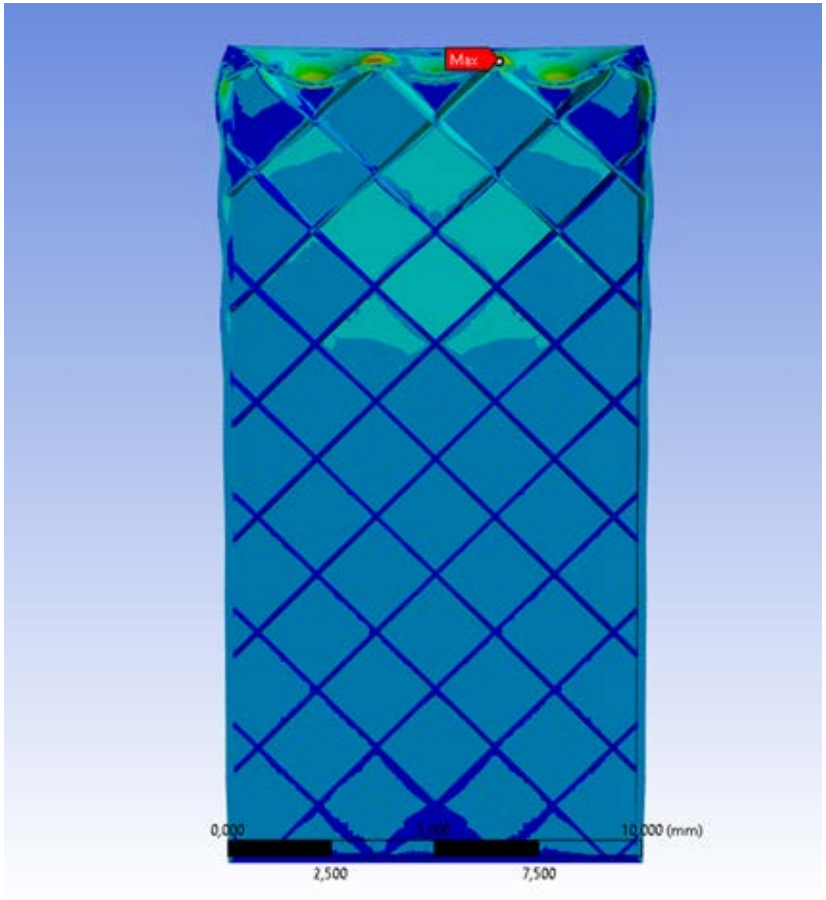


CAD Model and FEA Mesh of Configuration 1 (Volume: 369.45 mm^3), infill ratio of 10%)

Deformation = 0.010921 mm

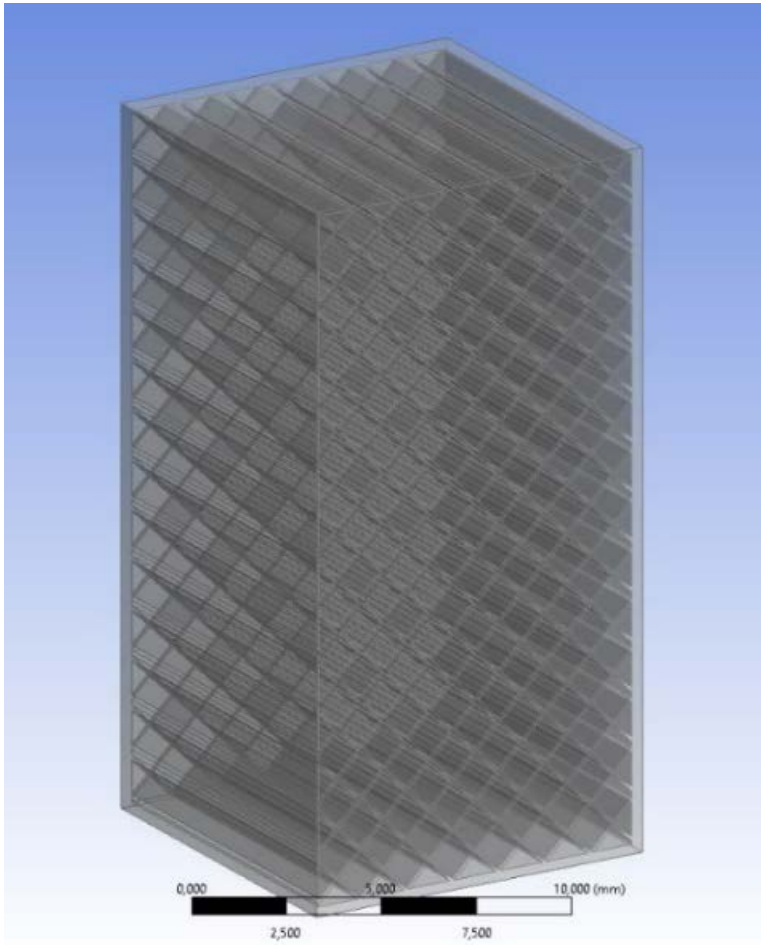


Von-Misses Stress = 79.051 MPa

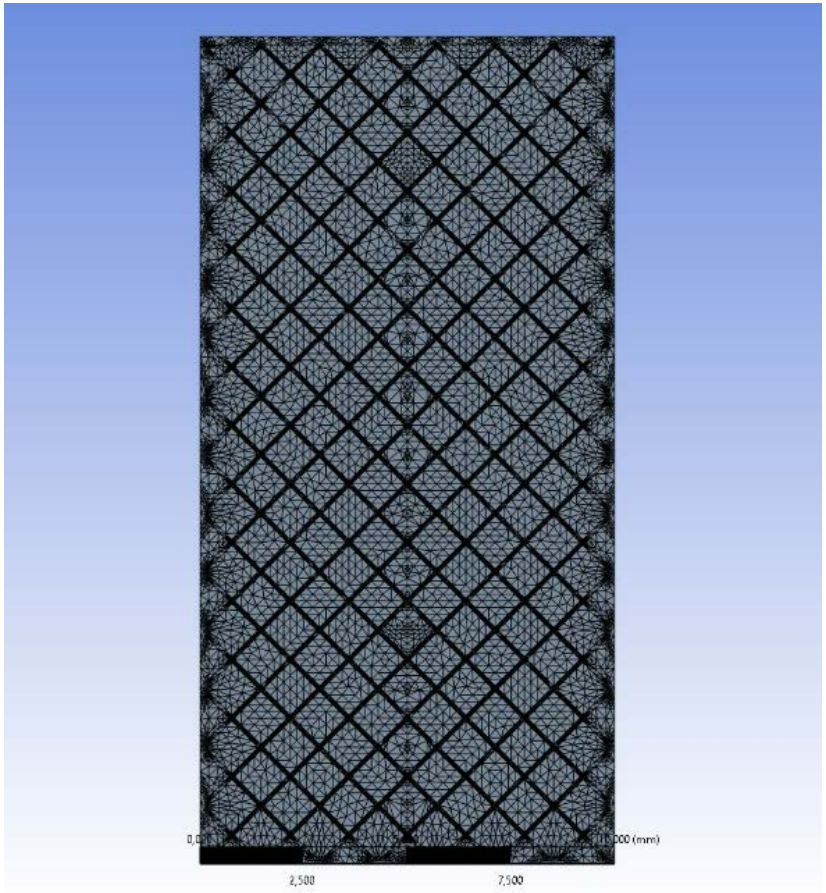


CAD Model and FEA Mesh of Configuration 2 (Volume: 538.02 mm^3), infill ratio of 19%)

CAD Model of Configuration 2

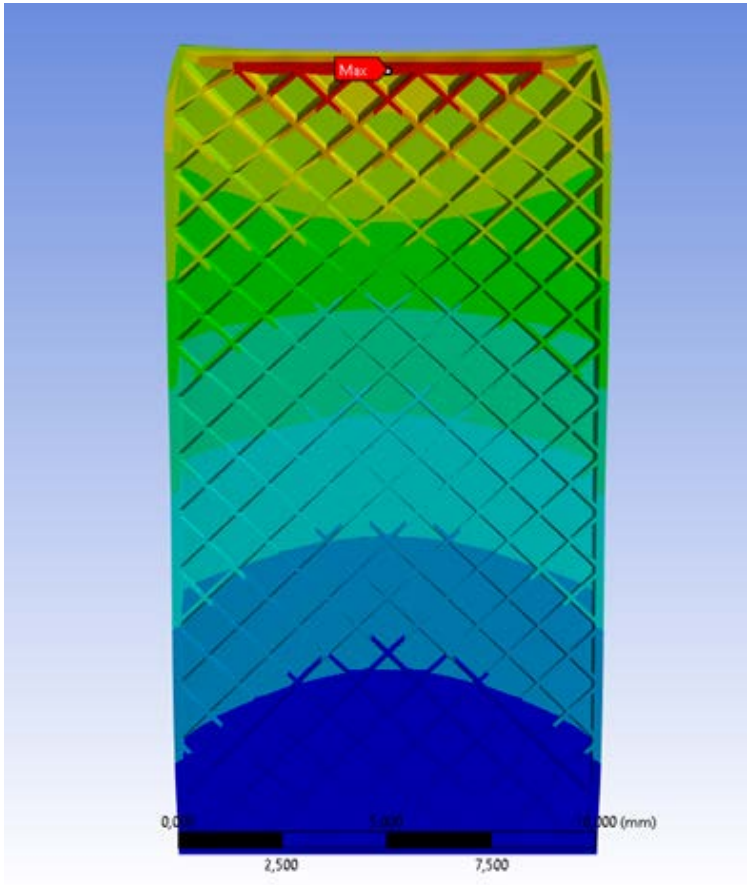


FEA Mesh of Configuration 2

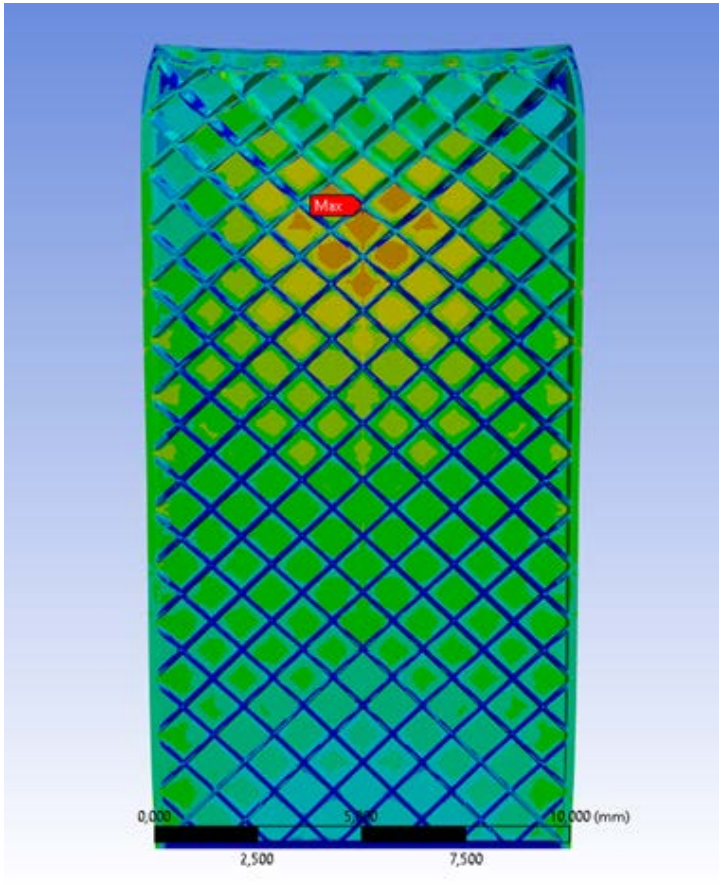


CAD Model and FEA Mesh of Configuration 2 (Volume: 538.02 mm^3), infill ratio of 19%)

Deformation = 0.0047711 mm

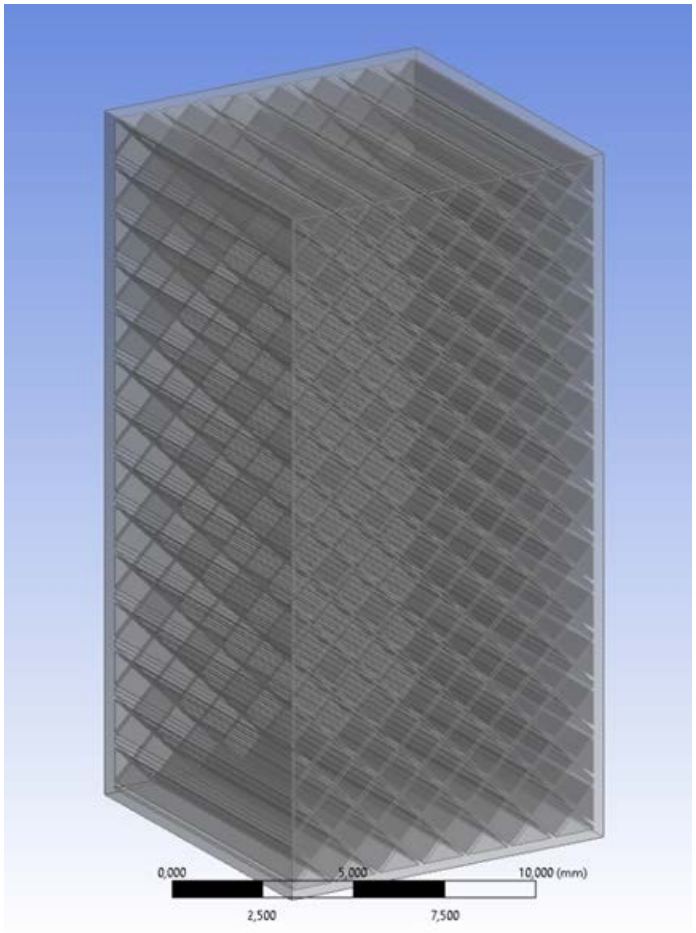


Von-Misses Stress = 24.534 MPa

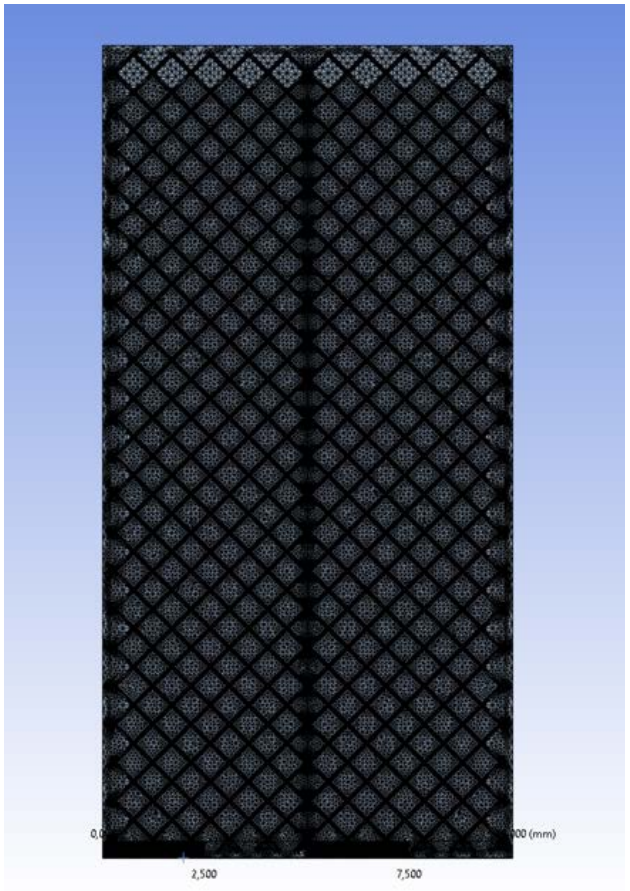


CAD Model and FEA Mesh of Configuration 3 (Volume: 693.79 mm^3), infill ratio of 28%)

CAD Model of Configuration 3

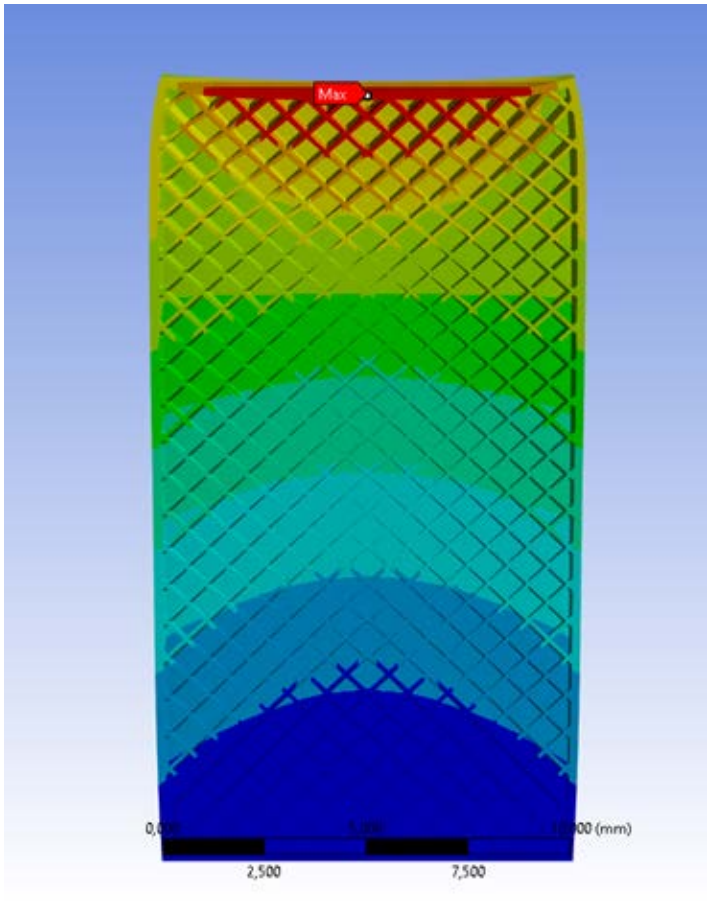


FEA Mesh of Configuration 3

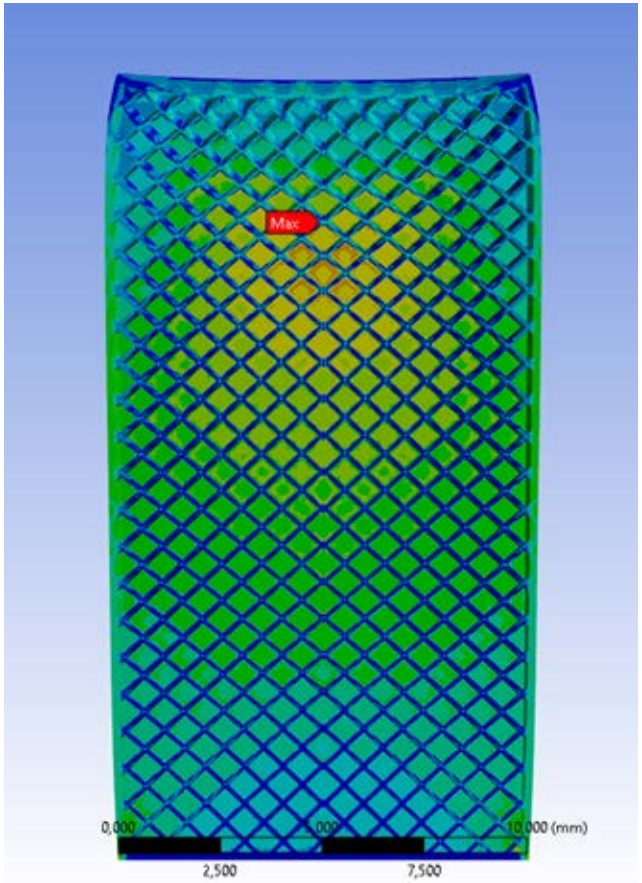


CAD Model and FEA Mesh of Configuration 3 (Volume: 693.79 mm^3), infill ratio of 28%)

Deformation = 0.0038717 mm

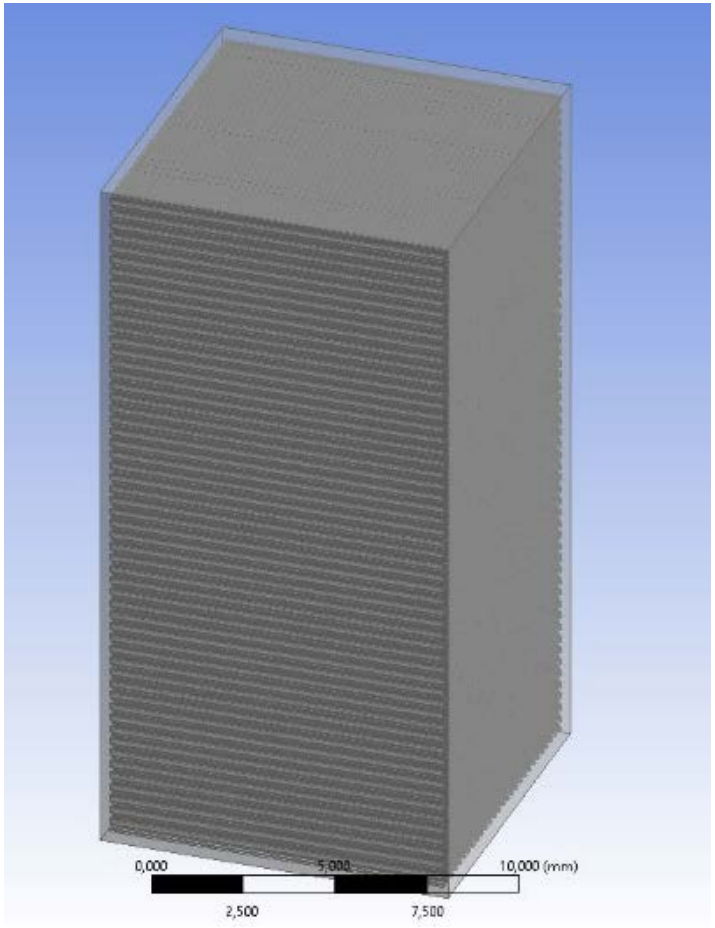


Von-Misses Stress = 24.227 MPa

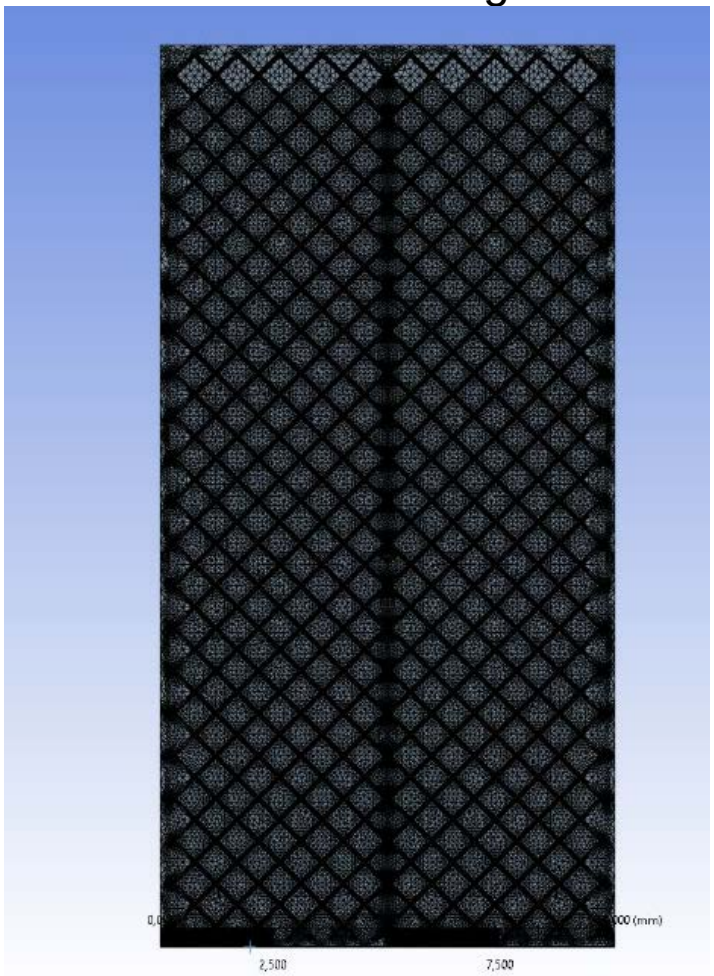


CAD Model and FEA Mesh of Configuration 4 (Volume: 1348.4 mm^3), infill ratio of 68%)

CAD Model of Configuration 4

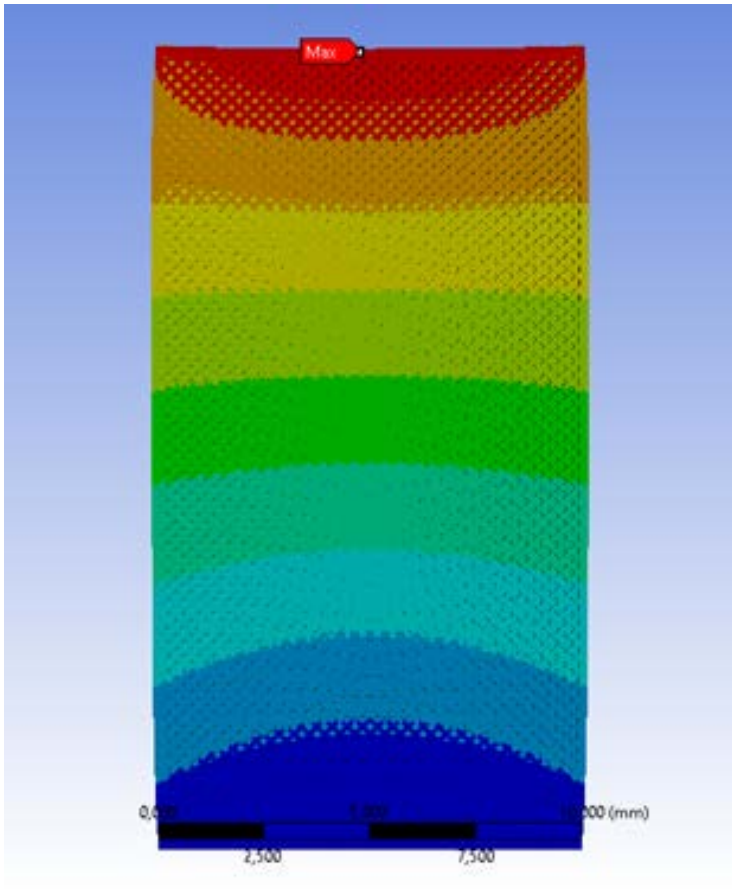


FEA Mesh of Configuration 4

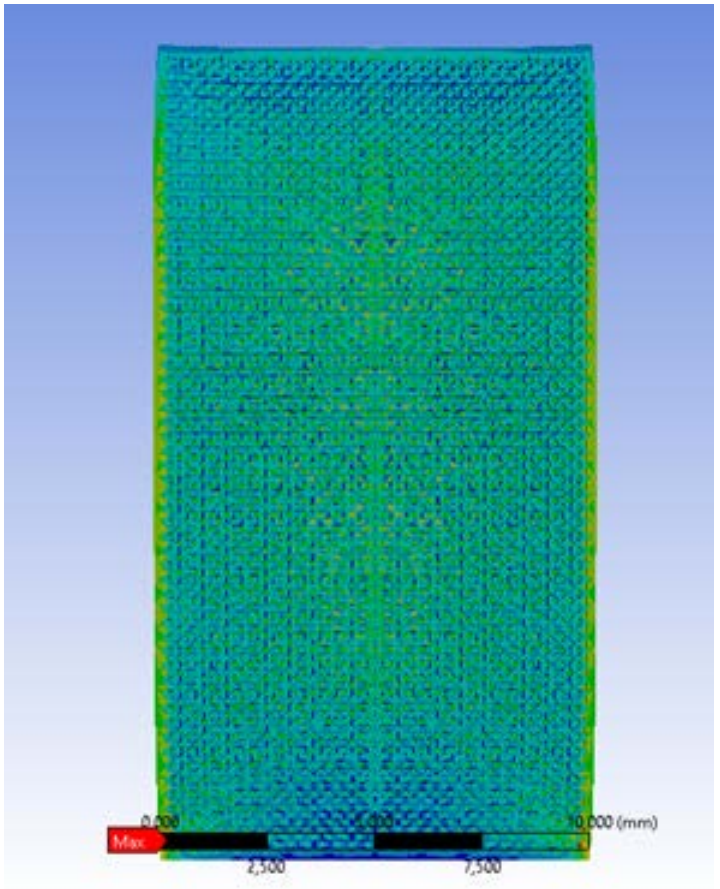


CAD Model and FEA Mesh of Configuration 4 (Volume: 1348.4 mm^3), infill ratio of 68%)

Deformation = 0.00091986 mm

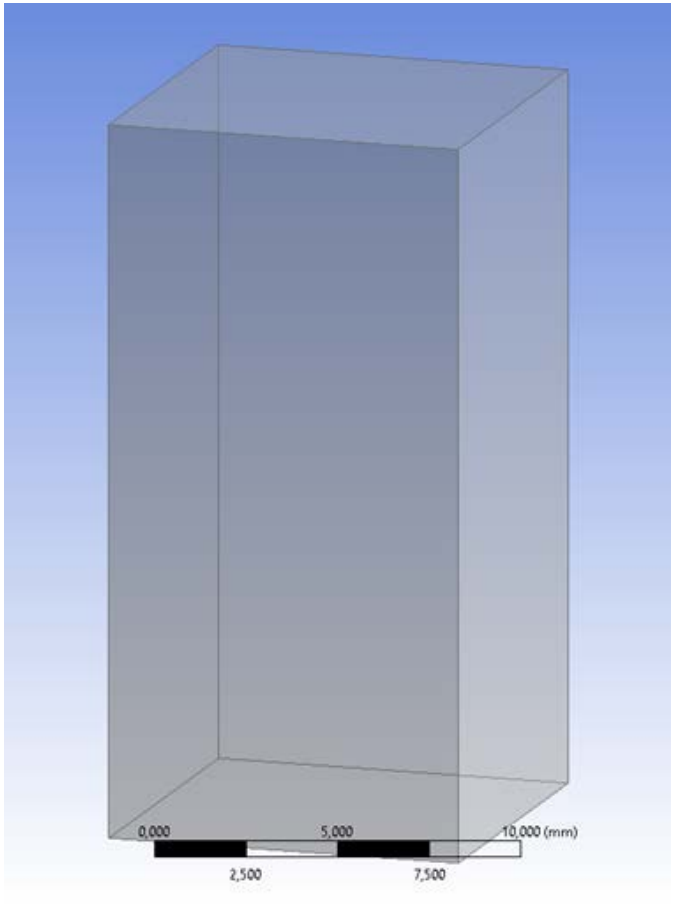


Von-Misses Stress = 5.1365 MPa

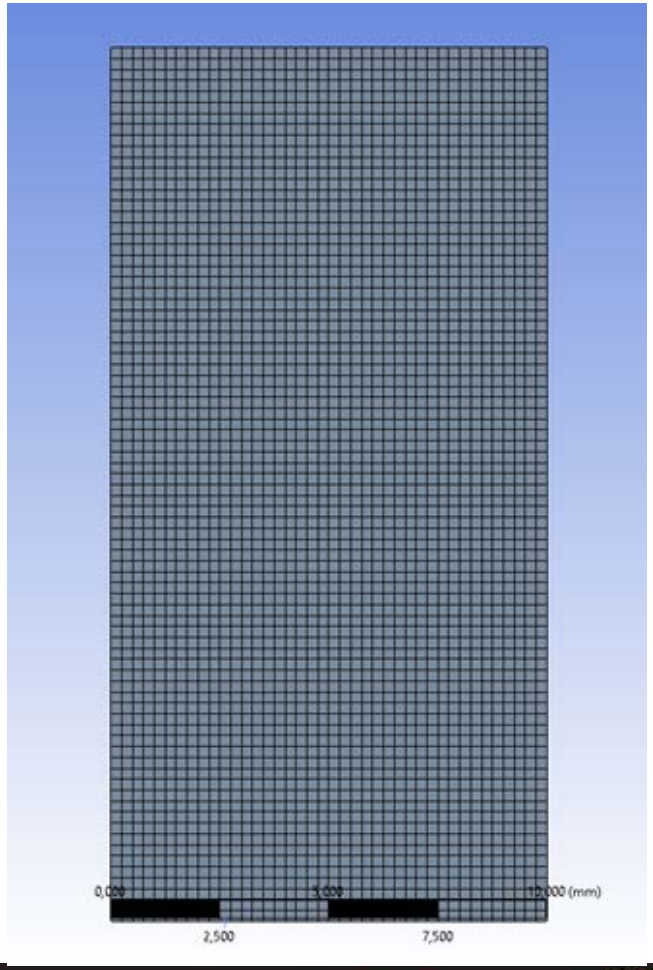


CAD Model and FEA Mesh of Configuration 5 (Volume: 2000 mm^3), infill ratio of 100%)

CAD Model of Configuration 3

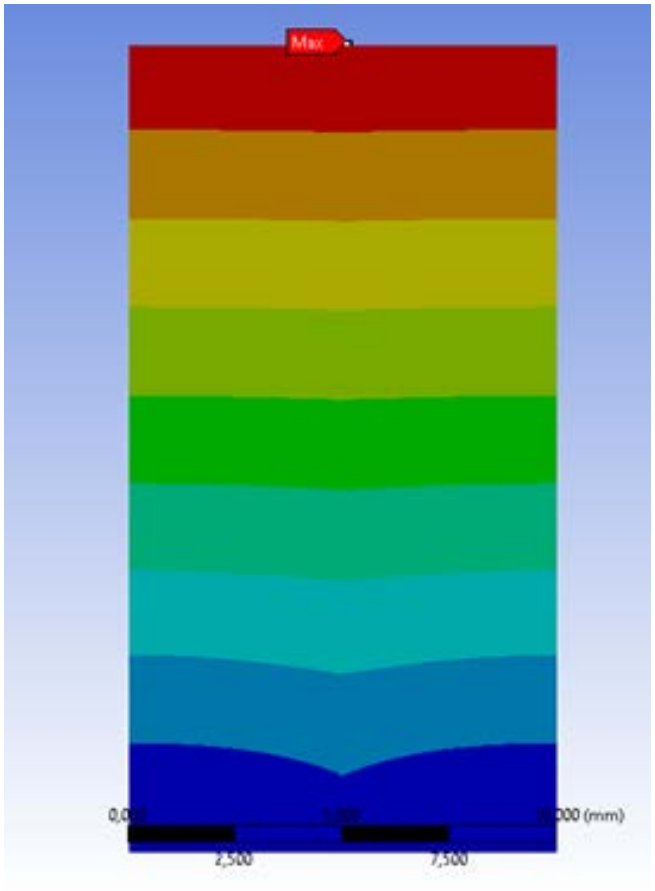


FEA Mesh of Configuration 3

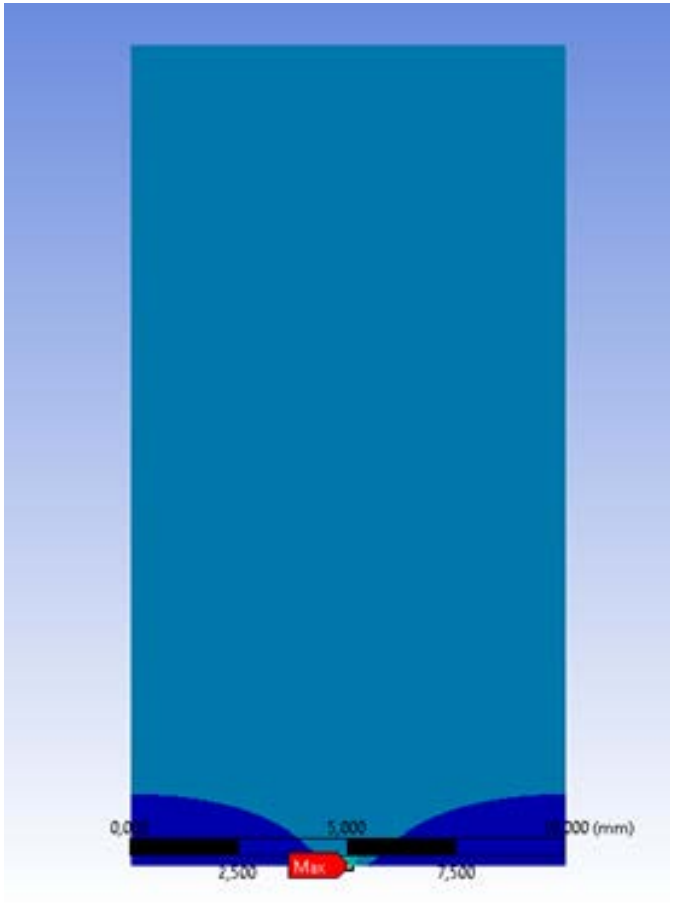


CAD Model and FEA Mesh of Configuration 5 (Volume: 2000 mm^3), infill ratio of 100%)

Deformation = 0.0002831 mm

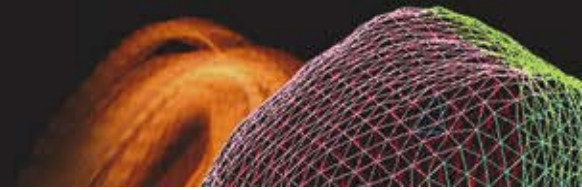


Von-Misses Stress = 3.1881 MPa



Results

Config. #	sides	Volume	Infill ratio	Infill ratio function with sides	Max. Deformation (mm)	Max. VM Stress (MPa)
0	0	192.824	0 %	0 %	0.36815	432.95
1	2	369.45	10 %	9 %	0.010921	79.051
2	4	538.02	19 %	19 %	0.0047711	24.534
3	6	693.79	28 %	27 %	0.0038717	24.227
4	16	1348.4	64 %	64 %	0.00091986	5.1365
5	18	2000	100 %	99 %	0.0002831	3.1881



Thank you