2021「中技社科技獎學金」
2021 CTCI Foundation Science and Technology Scholarship
境外生生活助學金
Living Grant for International Graduate Students

Simulation for Additive Manufactured Ti-6Al-4V Cuboctahedron Cellular Structure for Compression Behavior

A. Dhinakar and J.K.Chen*
National Taipei University of Technology, Institute of Materials Science and Engineering, Taipei 10608

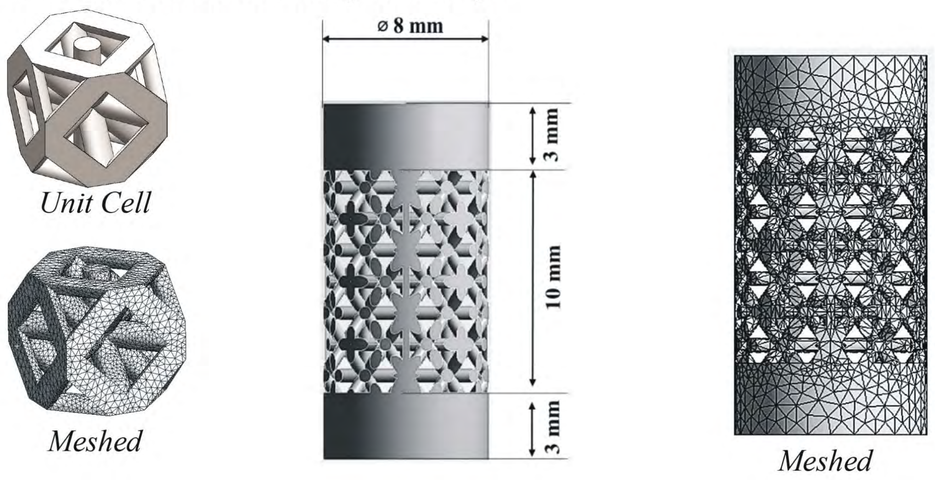
Introduction

Cuboctahedron unit cell of 3 porosity is printed using Electron Beam Melting (EBM).

Table 1: Strut diameter for the unitcell printed.

Porous %	56%	67%	86%
EBM	600 μm	500 μm	300 μm

Figure 1: Unit cell and nomenclature of EBM sample



Unit cell is modelled using Solidworks and ANSYS workbench is used for compression simulation. 10 node tetrahedral 3D solid element is used to mesh with global size of 0.1 mm.

Modelling

Sample is loaded from top and arrested at the bottom.

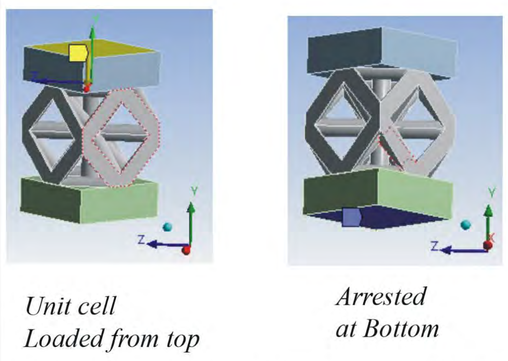


Figure 3: Loading condition shown with unit cell

Force reaction through axis of cylinder is used:

Stress distribution on Top surface of cylinder is used:

Deformation between top and bottom of the porous part is used:

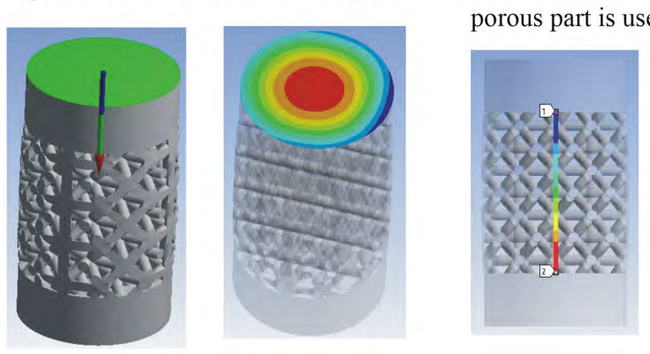


Figure 4: Detail on measurement considered in FEA(ANSYS)

Stress vs Strain curve

Stress vs strain curve for the measured experimental and computational stress such as von-Mises and normal stress is plotted for all 3 sample porosity.

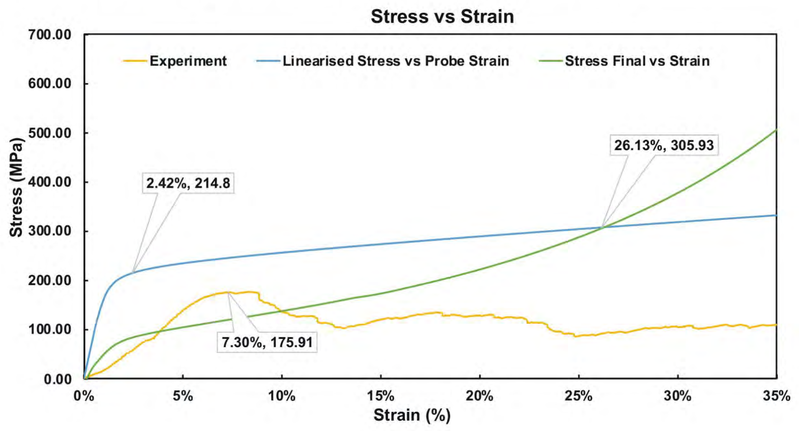


Figure 5: Stress vs strain for 56% sample measured with von Mises, Normal and Experimental

Analysis on von Mises Stress:

The von Mises stress is the single representative stress for the 3D stress that indiactes the yielding of the elements.

Proportional to deviatoric part of stress $\sigma_{VM} = \sqrt{\frac{3}{2}\sigma'_{ij} : \sigma'_{ij}}$

1. Weight ratio = number of local elements / total number of elements
2. Stress = $\sum_n$(weight ratio * stress range)

Yielding of 56% structure occurs around 284.11 MPa and fracture of the structure begins from 29.89 % strain.

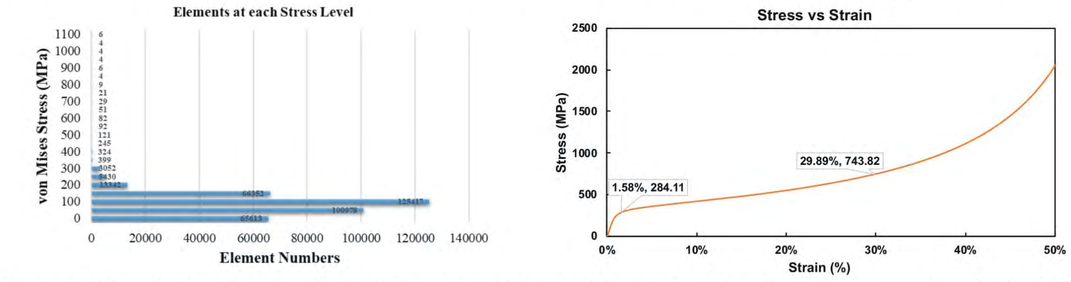
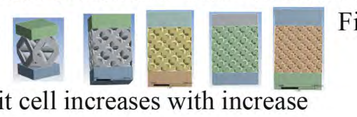


Figure 6: Graph showing number of elements with von Mises stress level and Stress vs Strain for 56% sample

Analysis on Unit Cell

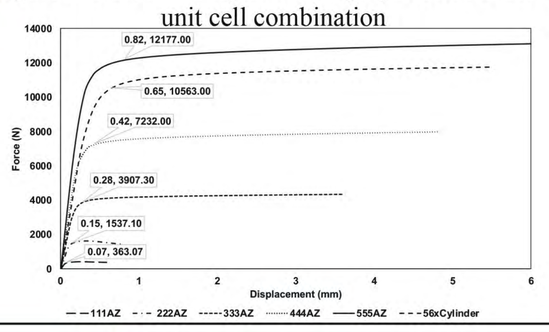


- Young's modulus of the unit cell increases with increase in number of unit cell.
- However the young's modulus as computed for cylinder is greater.

Table 2: Young's Modulus for each set of unit cell

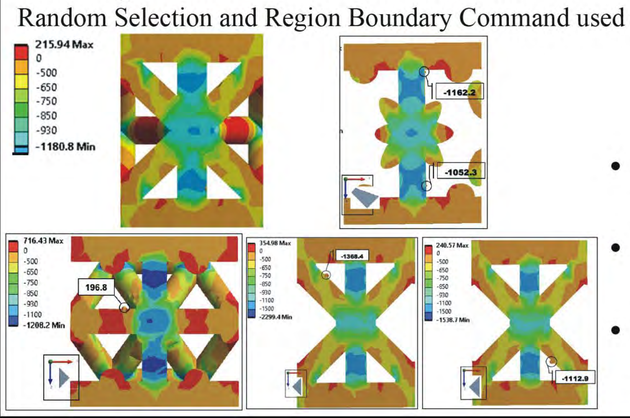
Mpa	Cylinder	111AZ	222AZ	333AZ	444AZ	555AZ
E.modulus	5211.48	5999.75	6035.15	5570	5167.59	3617.9
N(cell)	336 (approx.)	1	8	27	64	125

Figure 7: Force vs Displacement graph for each set of unit cell combination



Modelling CAD for Defects

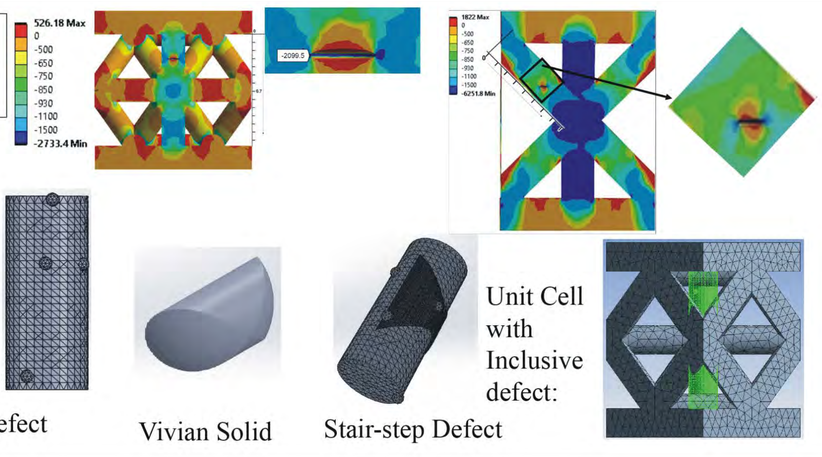
Random Selection and Region Boundary Command used to create Spherical and Ellipsoidal pore or inclusive defect in respective location.



Geometry created for Pore Defect: **a. Spherical Pore** **b. Ellipsoidal Pore**

- After including Defect in the designed CAD with help of Boolean Union.
- In ANSYS workbench, in meshing module: surface near the defects are meshed with face sizing of 0.01 mm.
- Interesting Result are avail and need to made analysis that give concise conclusion on effect of AM defects.

Unit Cell with Pore defect:



Conclusion:

In analysing the stress through ANSYS simulation following conclusion are arrived:

1. Bilinear simulation is effective in ansswering the plastic part of the stress. The yield point of the 56% experiment is 8.73% which is stiffer in the simulation result by yielding at 2.4 %.
2. The von Mises stress curve is effective in displaying the fracture strain. It predicts around 29.89% for 56% structure and the experimental structure fracture occurs around 31%.

Reference:
1. J.K.Chen, M.W.Wu, T.L.Chneg, P.H.Chiang, 'Continous compression behaviors of selective laser melting Ti-6Al-4V alloy with cuboctahedron cellular structures', Material Science & Engineering C, 2019, 100, 781-788.