Rationally designed lattice structure for human cancellous bone vertebral implants

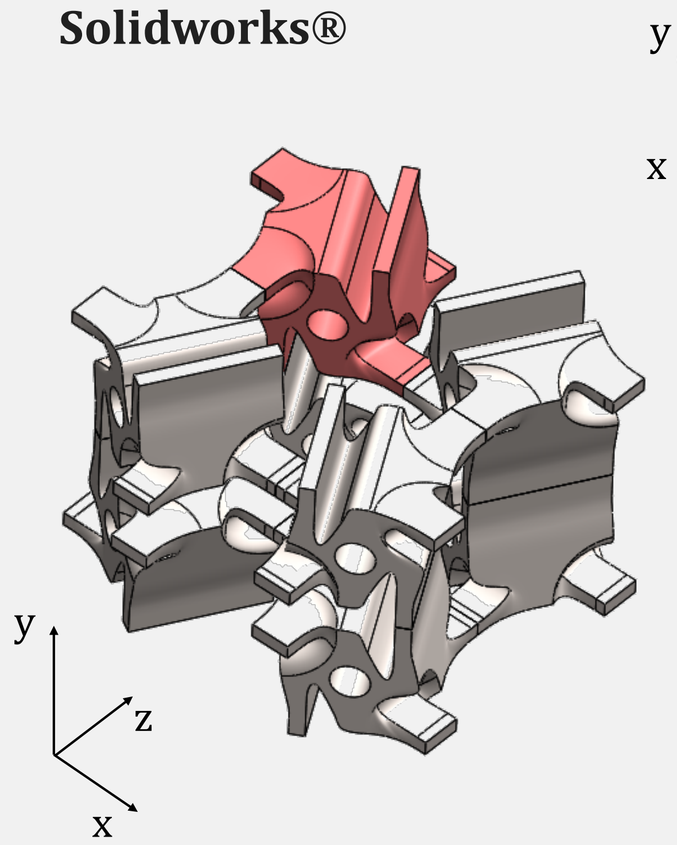
A. Sorrentino, D. Castagnetti

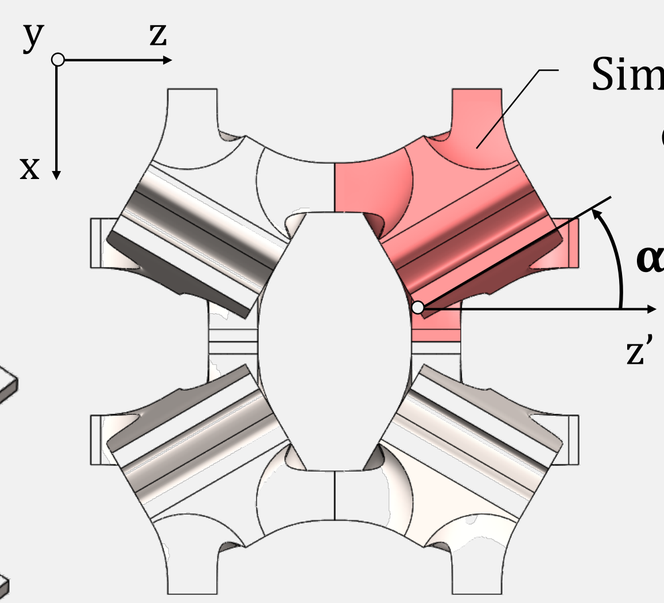
RESEARCH OBJECTIVE

The work investigates a novel titanium lattice structure for human cancellous bone vertebral implants by exploiting the unusual properties of auxetic metamaterials. Specifically, we rationally design and experimentally validate an innovative 3D-printed cellular structure that consists of a bio-inspired auxetic rotating geometry with the aim to develop a porous biomaterial with similar mechanical properties to that of human trabecular bones.

REPRESENTATIVE UNIT CELL

Solidworks®



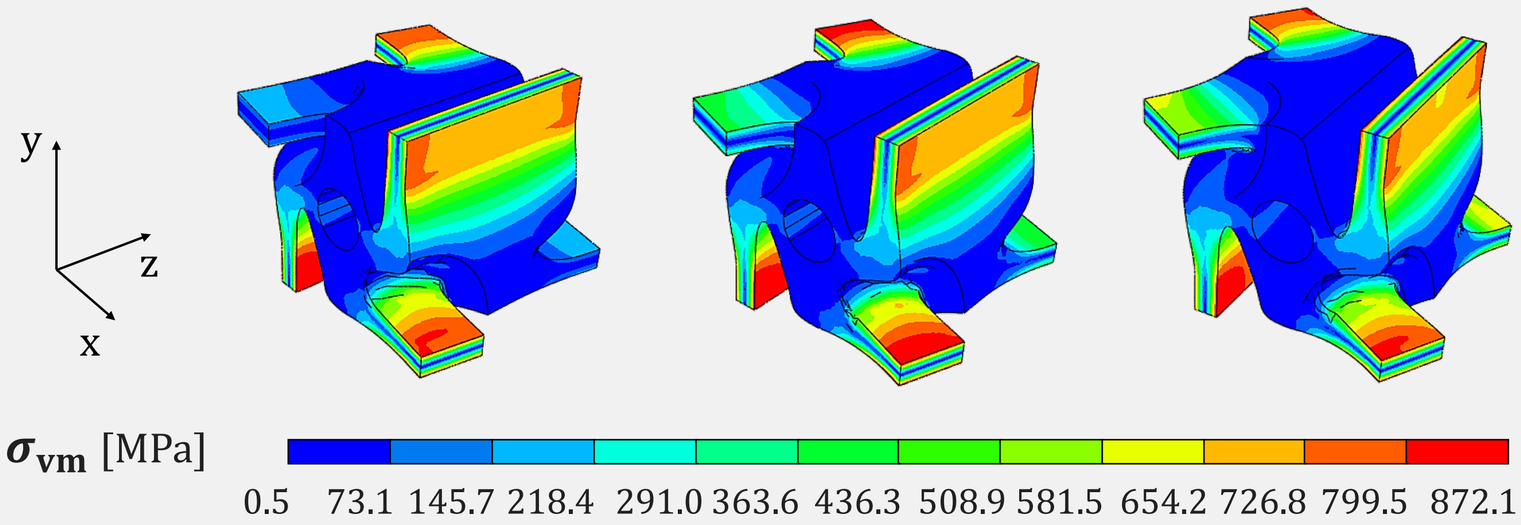


$10° \leq \boldsymbol{\alpha} \leq 30°$

$3.65\ \text{mm} \leq \mathbf{L_{s,i}} \leq 5.14\ \text{mm}$

NONLINEAR FINITE ELEMENT ANALYSIS

Abaqus® α = **10°** α = **20°** α = **30°**



$\boldsymbol{\sigma_{vm}}$ [MPa]

0.5 73.1 145.7 218.4 291.0 363.6 436.3 508.9 581.5 654.2 726.8 799.5 872.1

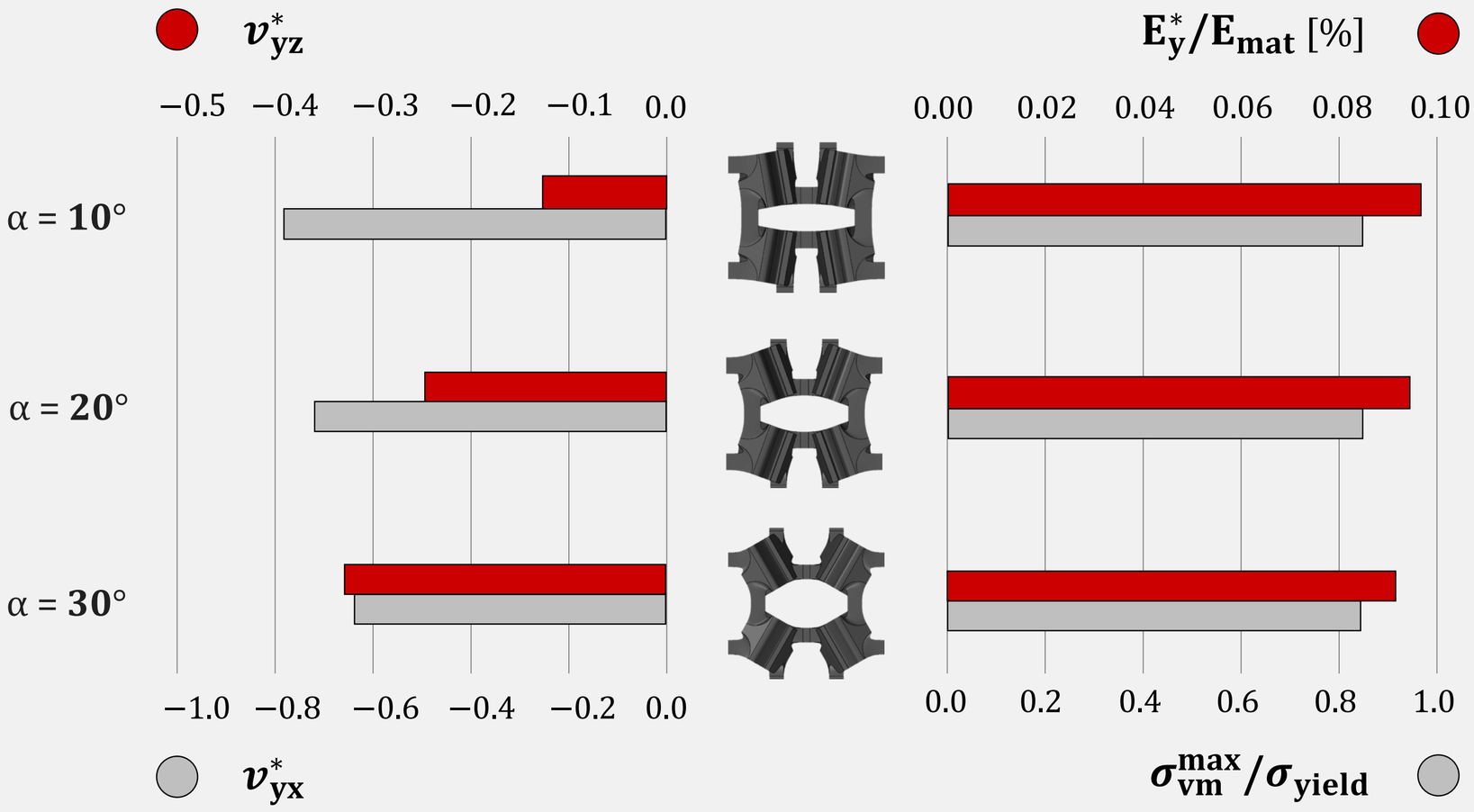
Periodic boundary conditions (**PBC**)

Ti6Al4V ($\sigma_{yield} = 1013$ MPa)

Global strain ($\boldsymbol{\varepsilon_y}$) = 3%

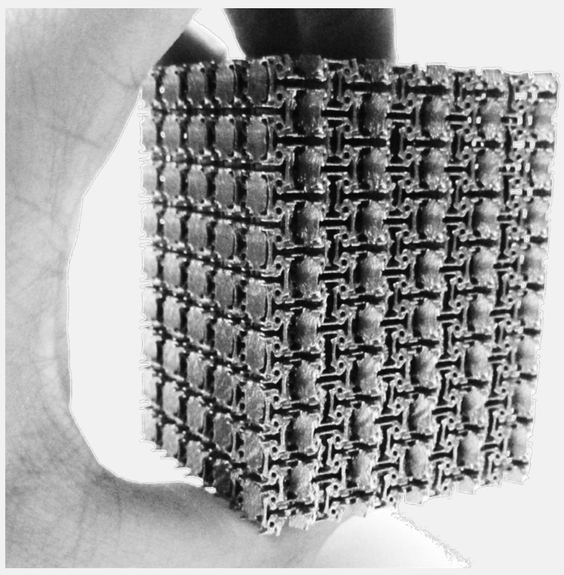
NUMERICAL RESULTS

Auxetic behavior



EXPERIMENTAL VALIDATION

α = **30°**



M2 Concept Laser machine® (SLM)

	E^*_y [MPa]	ε_y [%]	**Porosity** [%]
Target	> 75	> 2	> 70
FEA	102	3.5	76
Exper.	128	3.4	74

Department of Engineering Sciences and Methods (UNIMORE)
Via G. Amendola 2, 42122, Reggio Emilia, Italy