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Investigation and Optimization of Metastructure with Energy Loss

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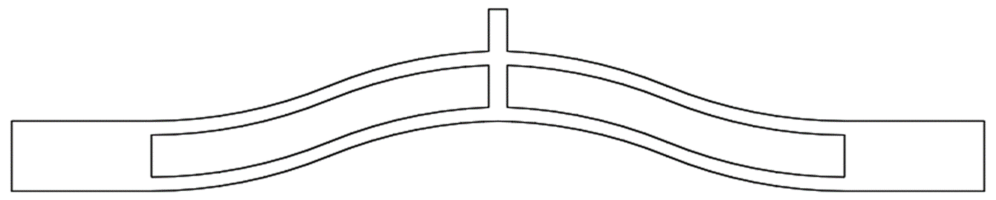
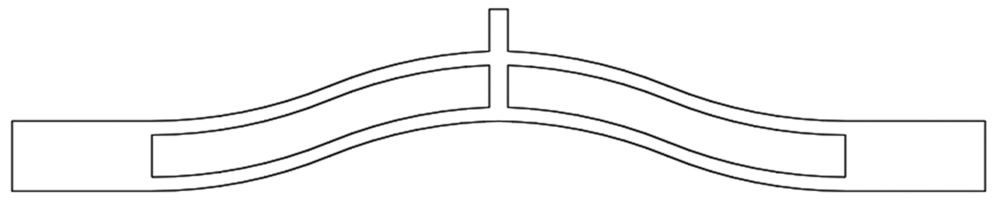




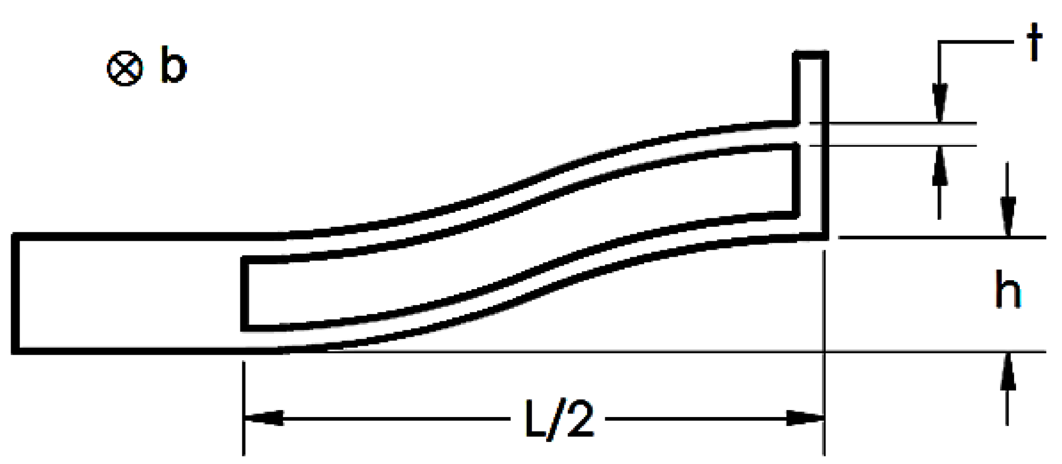
ABSTRACT

Hyperelastic materials such as rubber provide hysteretic energy loss when loaded. In contrast, elastic materials such as steel or titanium do not. Previous works show that designing a structure consisting of cells of curved-bistable beams produces a structure that provides energy loss. This research focuses on exploring the mechanisms behind energy loss as to maximize the energy loss

SELECTED GEOMETRY

The beam's shape is given by:

$$w(x) = \frac{h}{2}\left(1 - \cos\left(2\pi \frac{x}{l}\right)\right)$$



SURROGATE MODEL

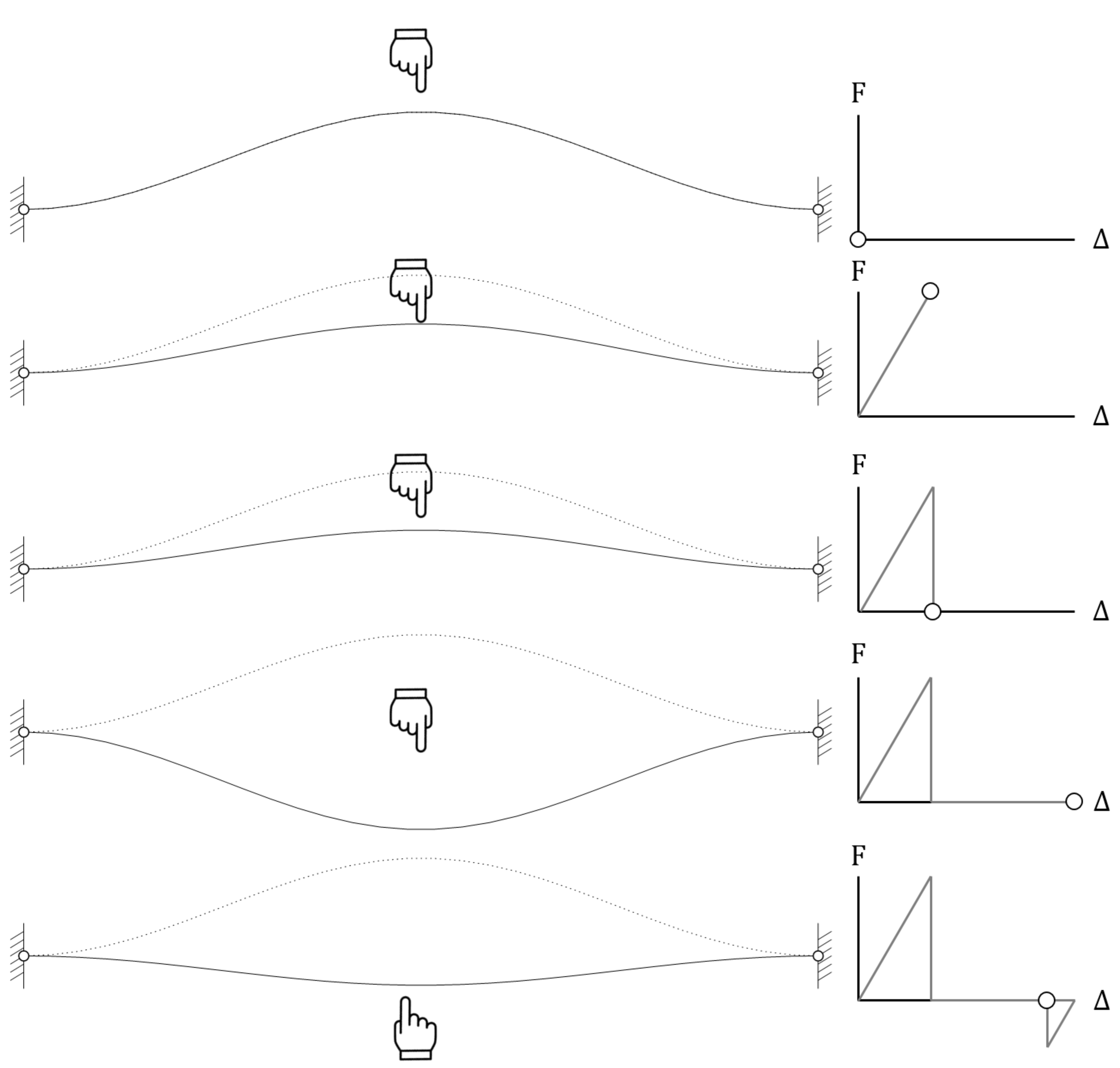
- A surrogate model was built to understand how the energy is effected by our variables

$$E_{loss} = Eb\, f(Q)\frac{h^2 t^3}{l^3}$$

- $f(Q)$ is obtained through curve fitting.
- Has a 0.05% Error
- Used to optimize the number of springs in a mesh to maximize the energy loss

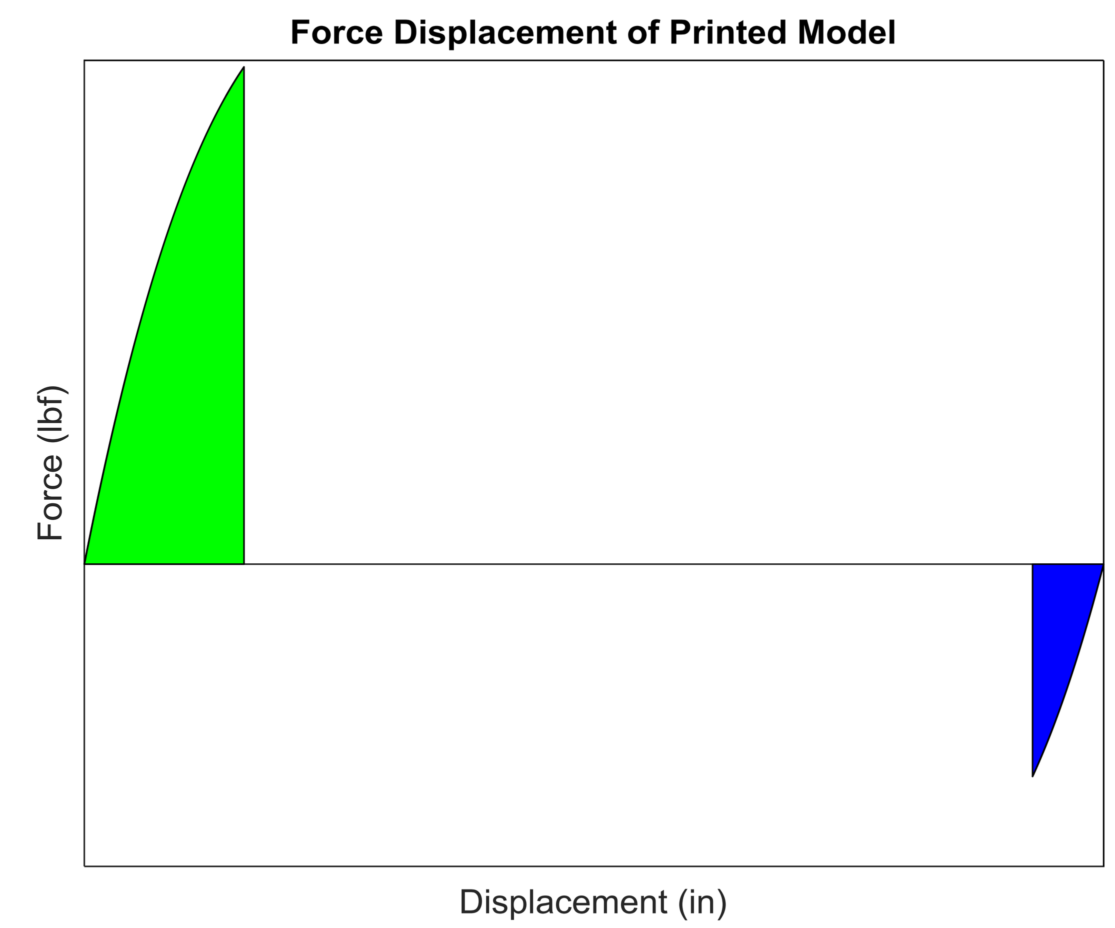
MECHANICAL PROPERTIES

- Energy loss occurs when the energy needed to move a system to one state is more than the energy needed to move back
- One way to achieve this is by having different loading and unloading profiles



ENERGY LOSS

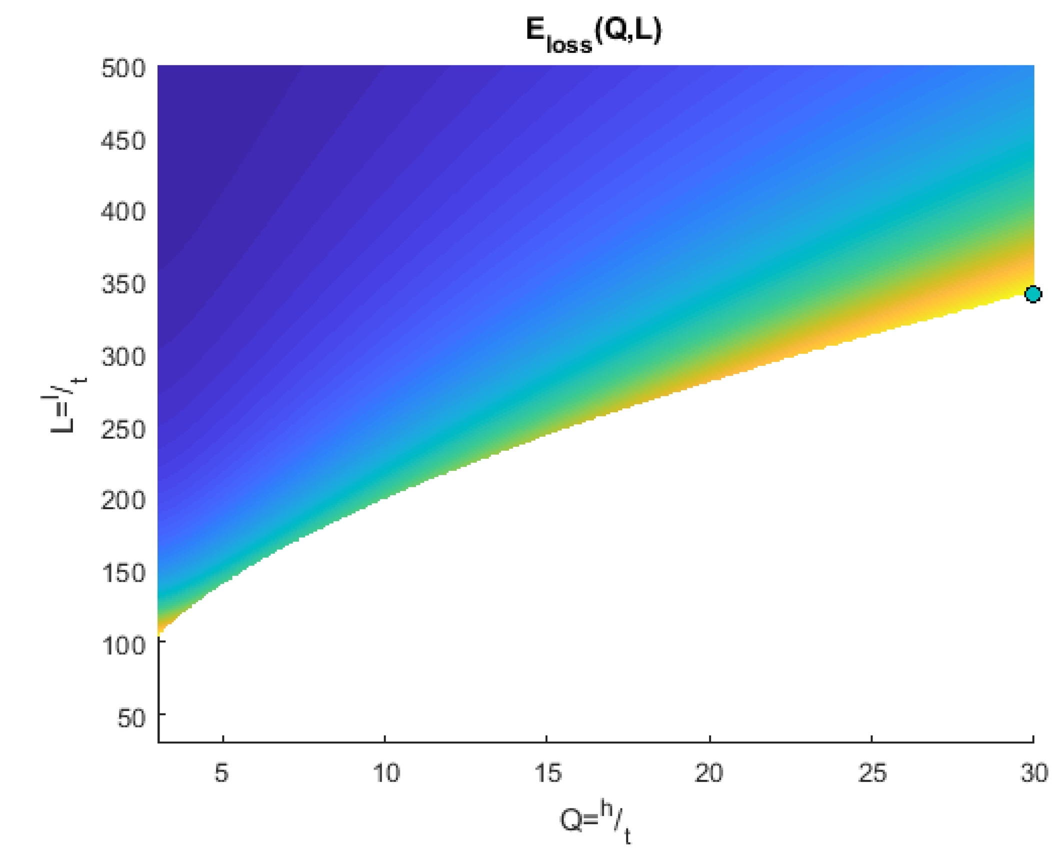
The energy necessary to make a beam deform is obtained by integrating its force-displacement curve



Subtracting these areas yields the energy lost by the system:

$$E_{loss} = E_{in} - E_{out}$$

DOMAIN OF SOLUTIONS

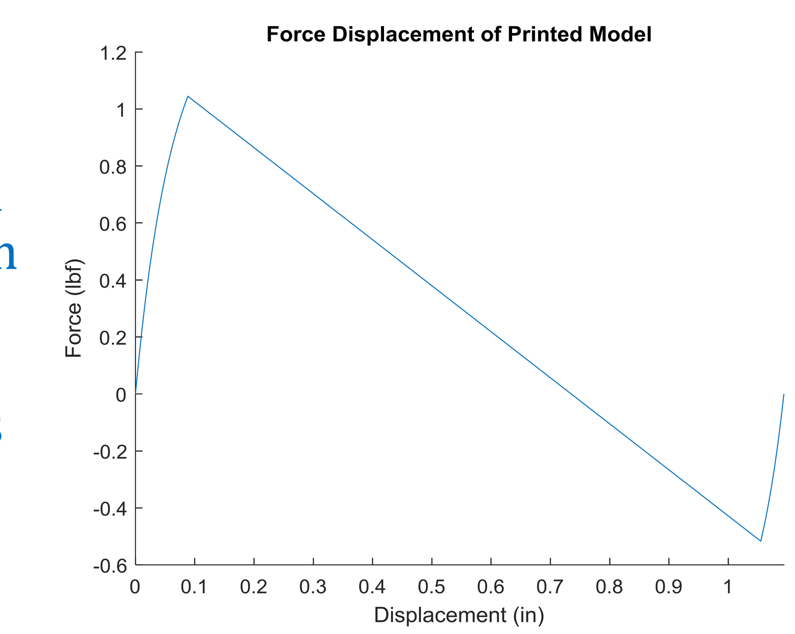


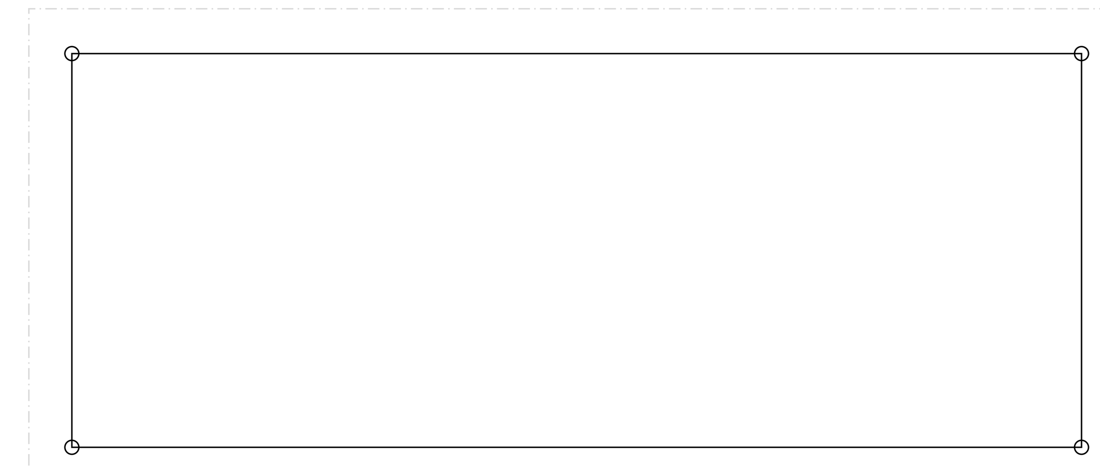
- The dot is the optimum solution for TiAl6V4
- The white zone shows where the material would fail

EXAMPLE

With:
$h = 16\text{mm}$
$t = 1.5\text{mm}$
$l = 260\text{mm}$

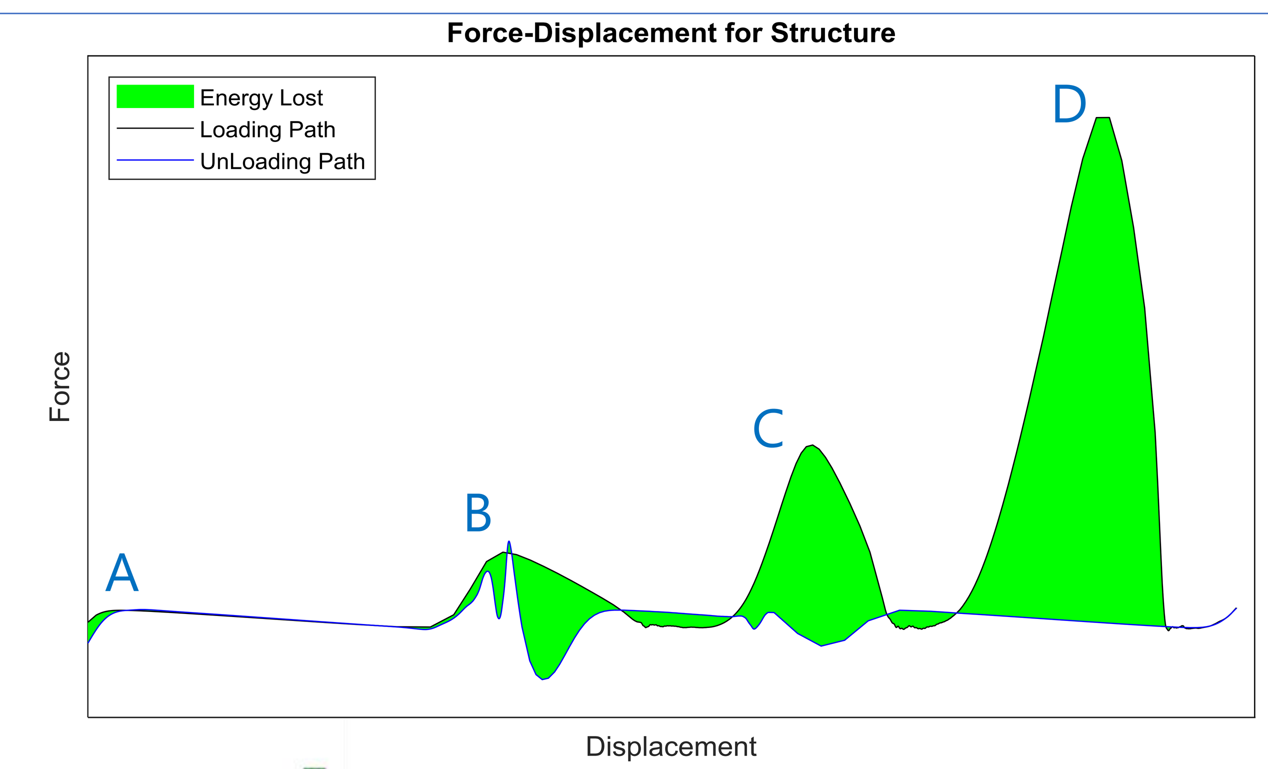
Gives an energy loss of:
3.2091mJ

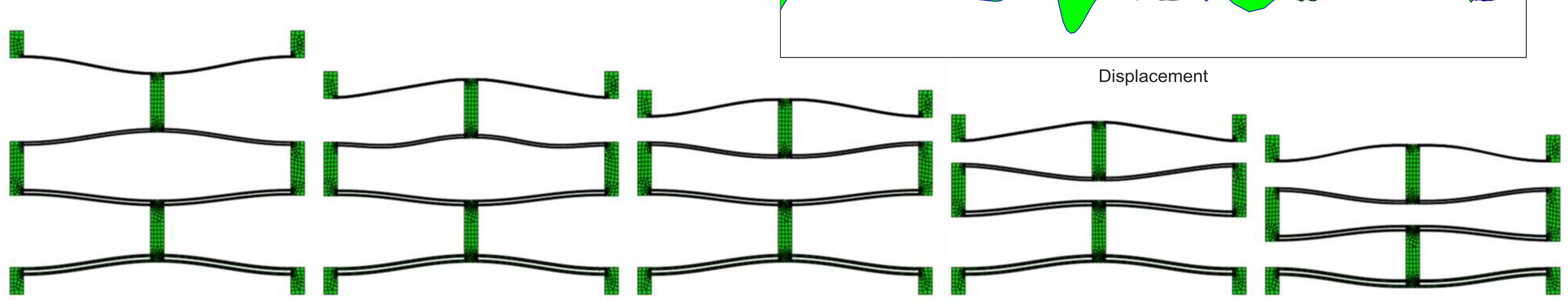




DEFORMATION PATTERN

- If each beam's dimensions vary in a mesh, each beam deforms at separate displacements
- Sorting the beams by thickness controls the deformation pattern





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