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# Investigation and Optimization of Metastructure with Energy Loss

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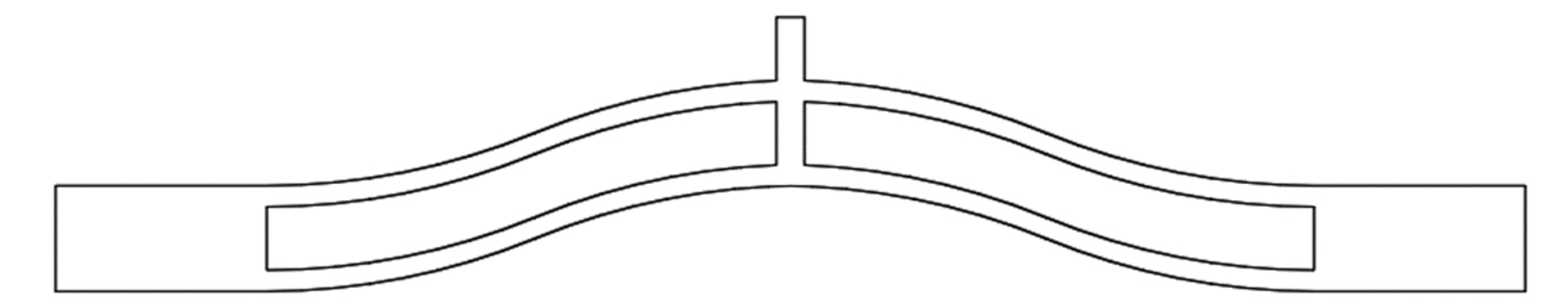
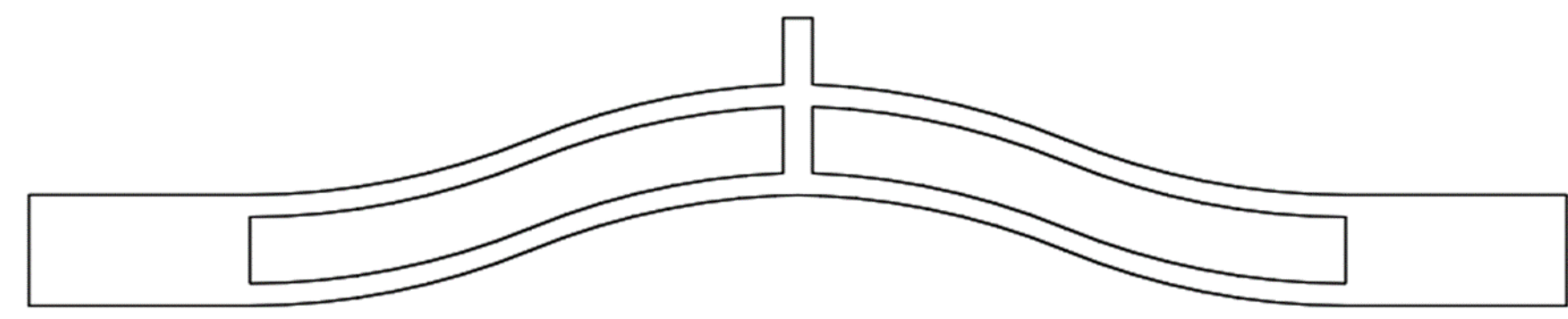
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# Investigation and Optimization of Metastructure with Energy loss

Andrew Montalbano

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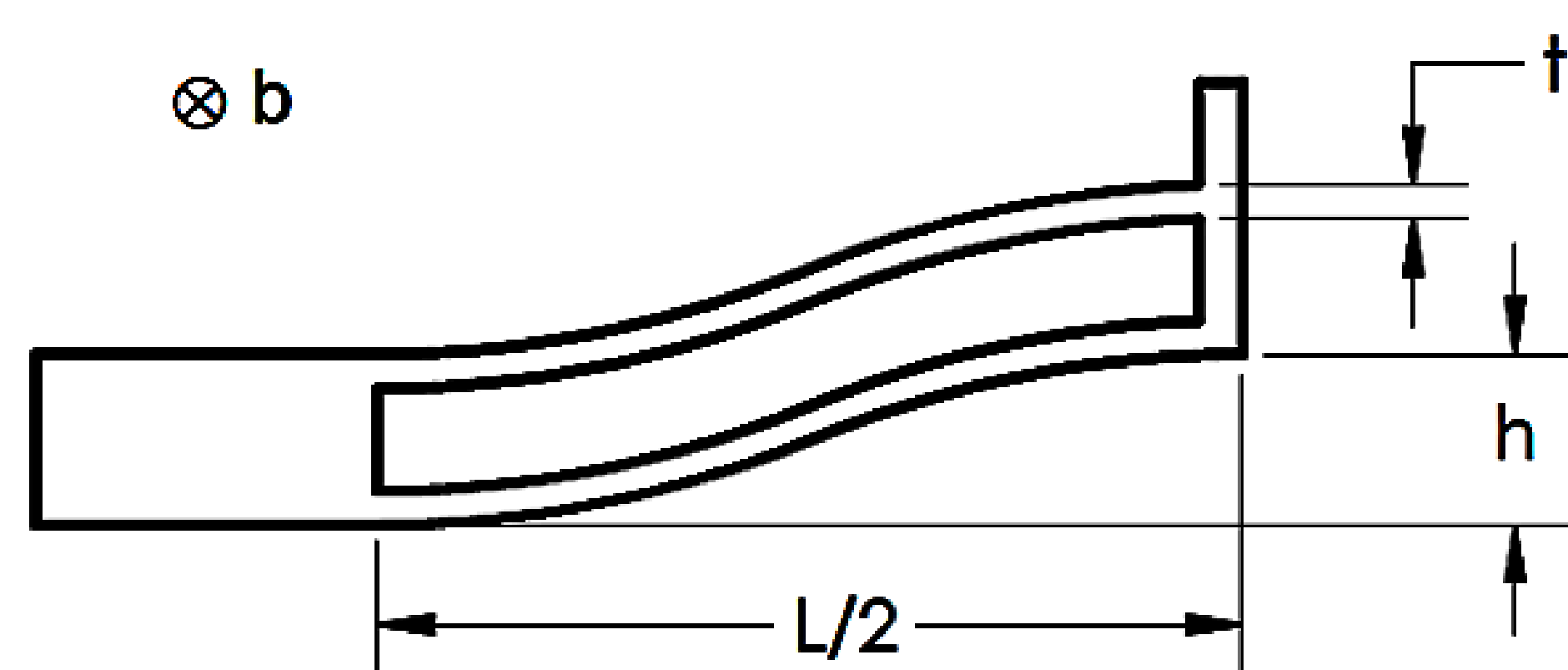
## ABSTRACT

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

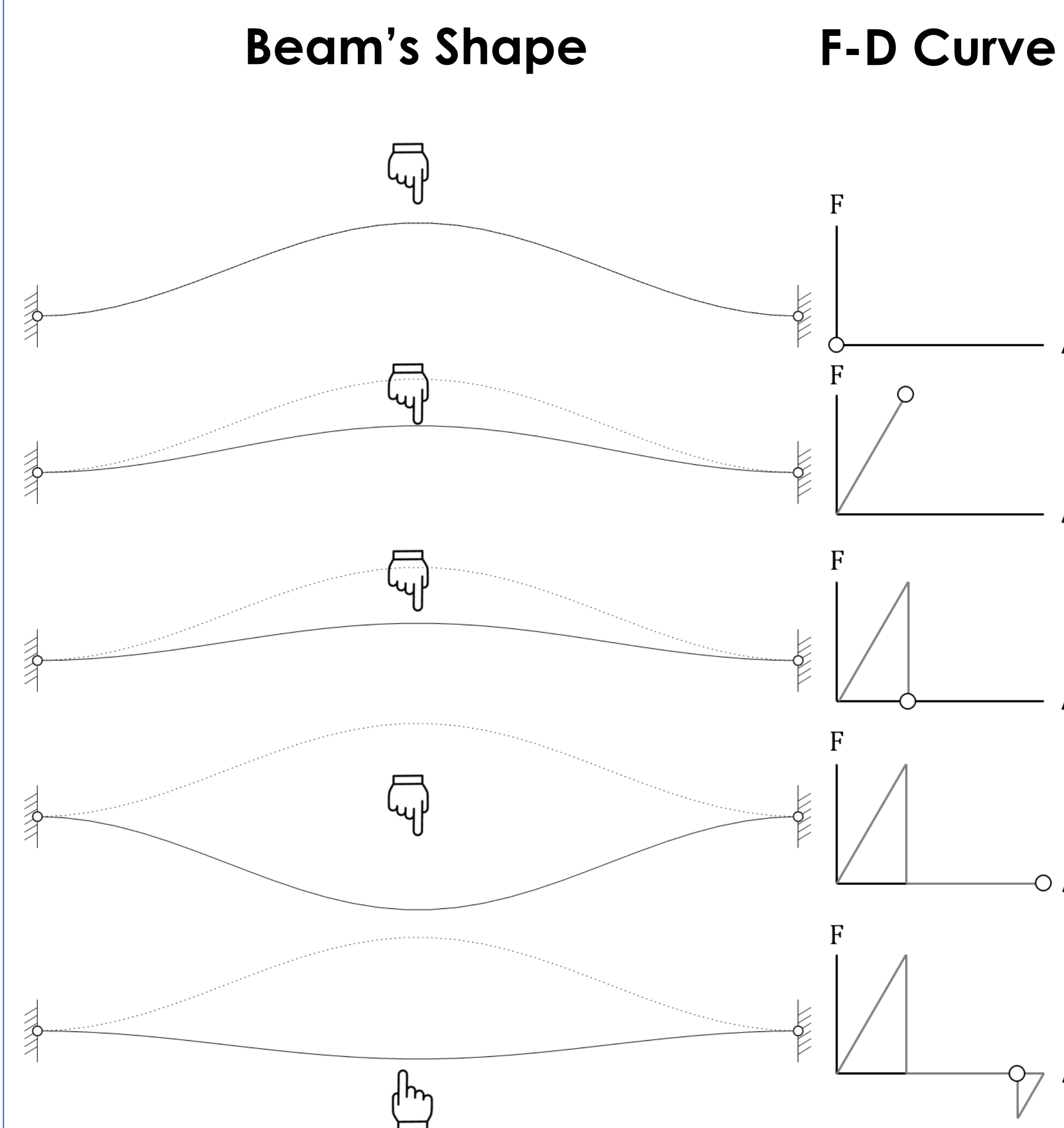
The beam's shape is given by:

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



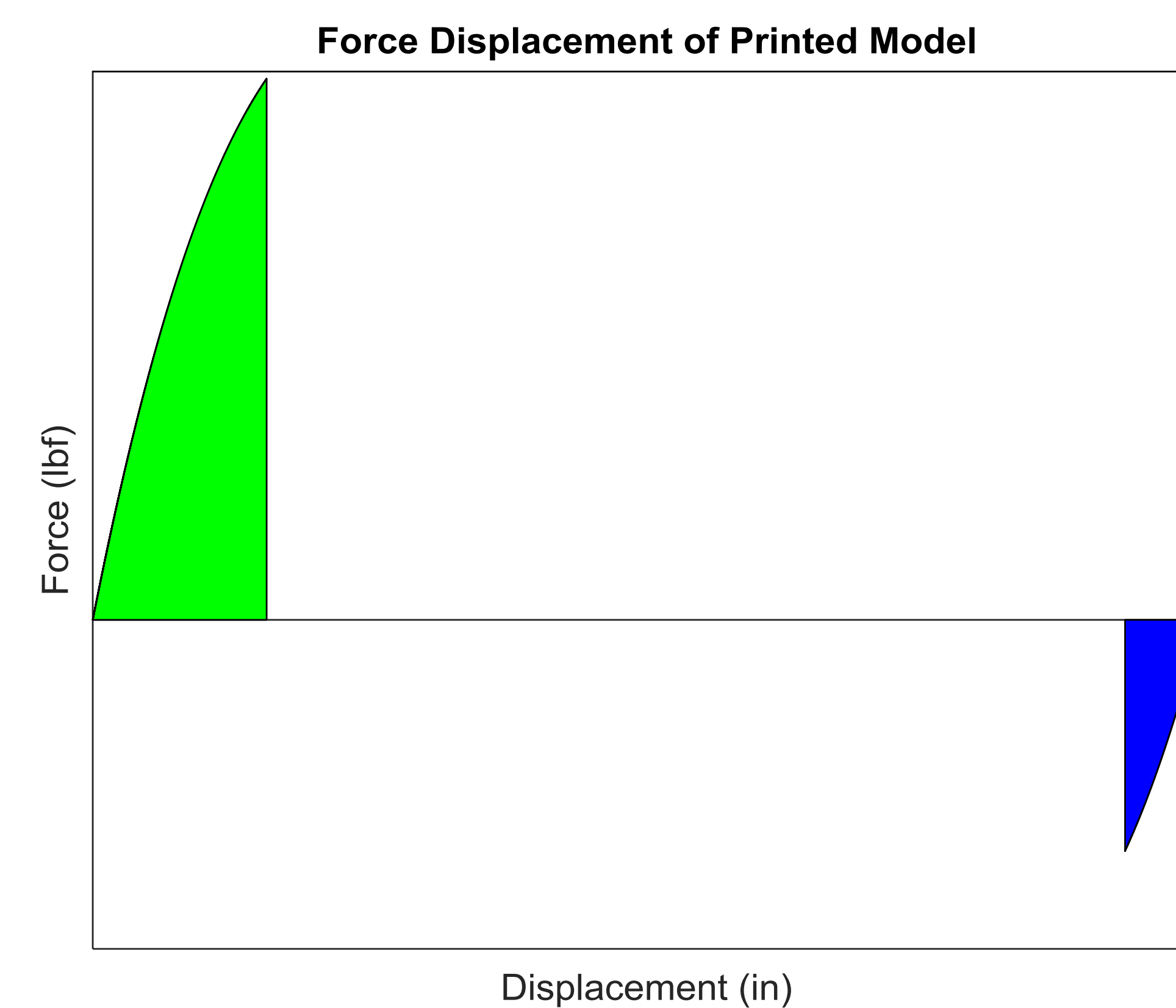
## MECHANICAL PROPERTIES

- 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

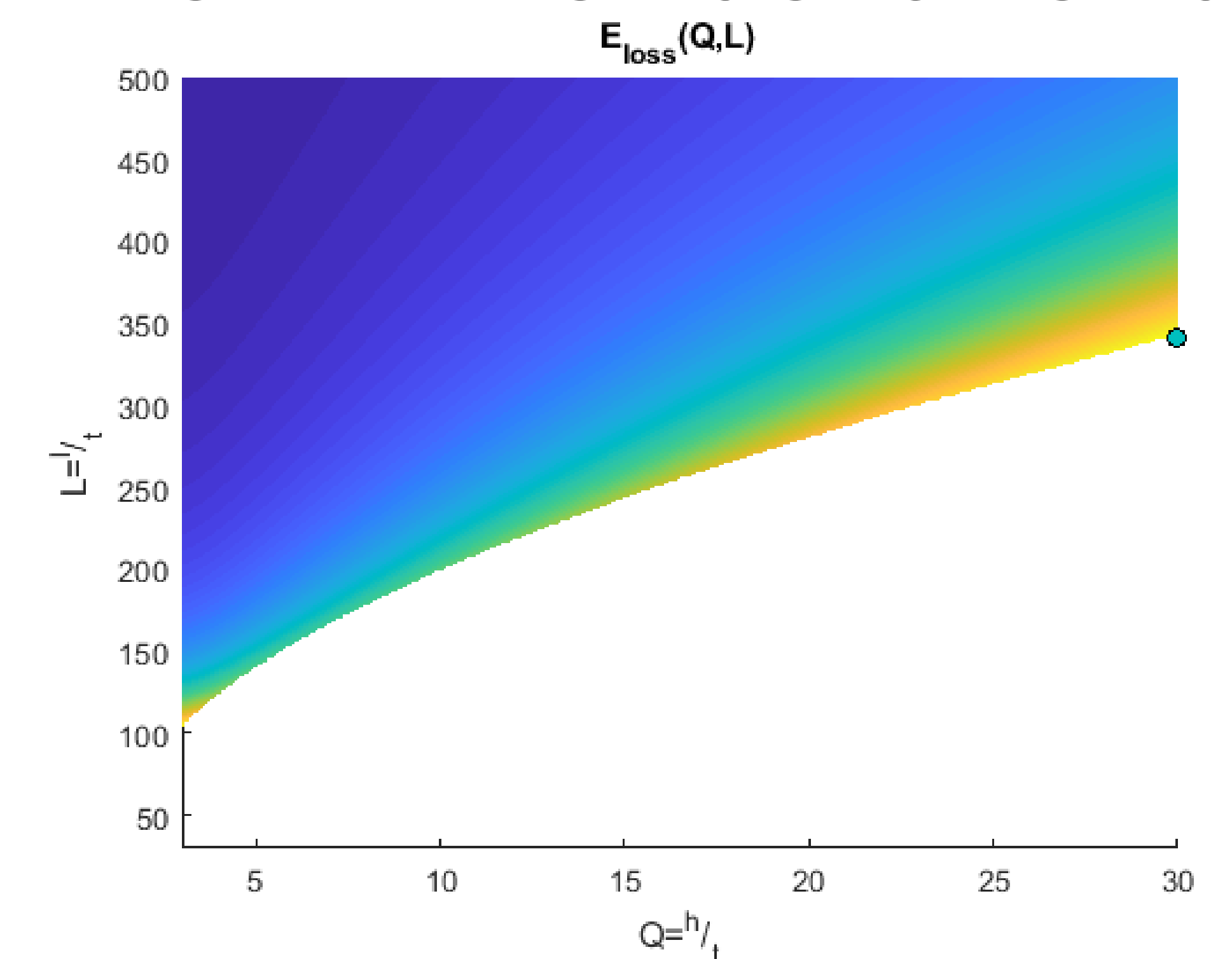
The energy necessary to make a beam deform is obtained by integrating its force-displacement curve



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

## SURROGATE MODEL

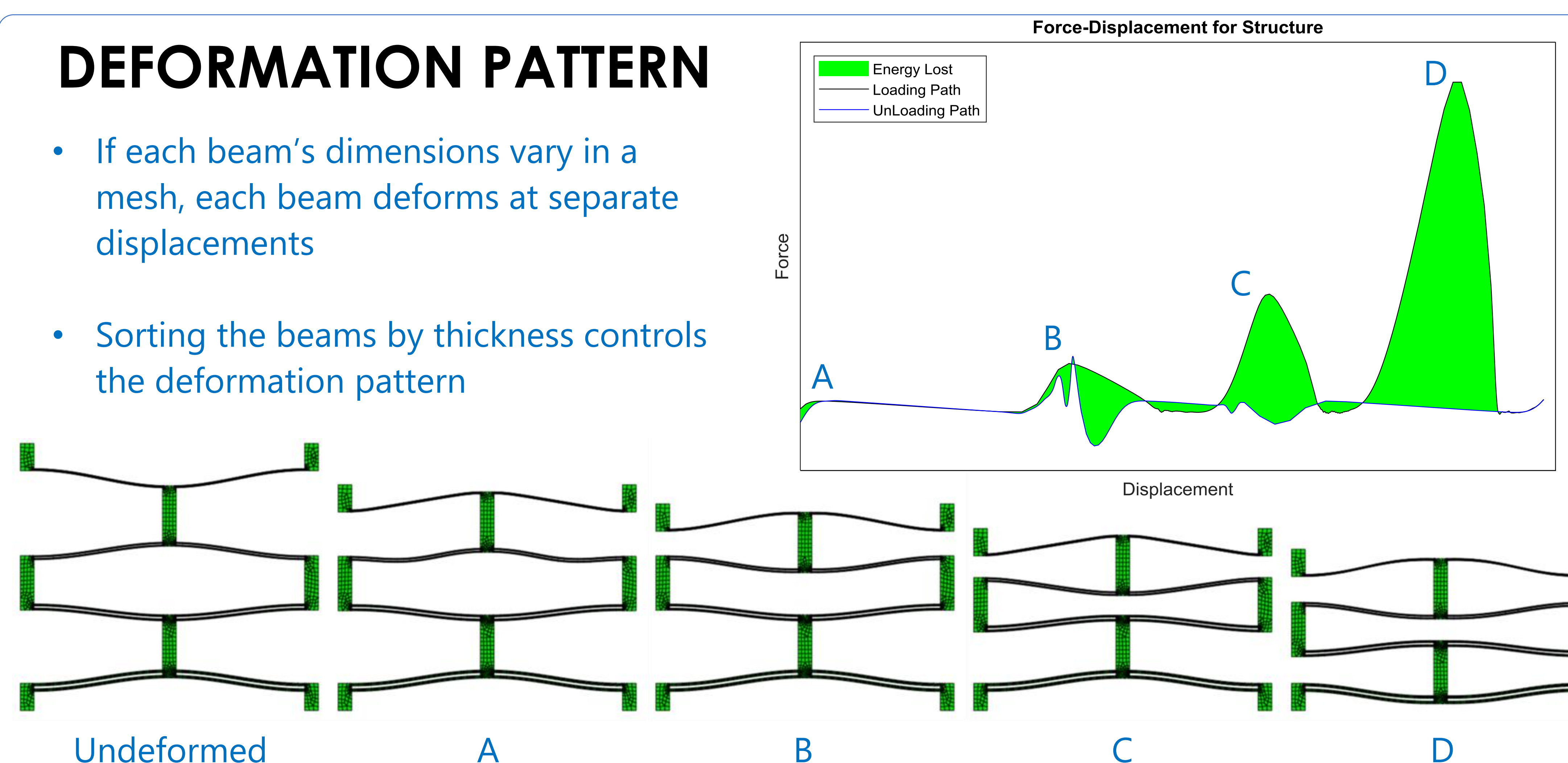
- A surrogate model was built to understand how the energy is effected by our variables

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

- $f(Q)$  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

## DEFORMATION PATTERN

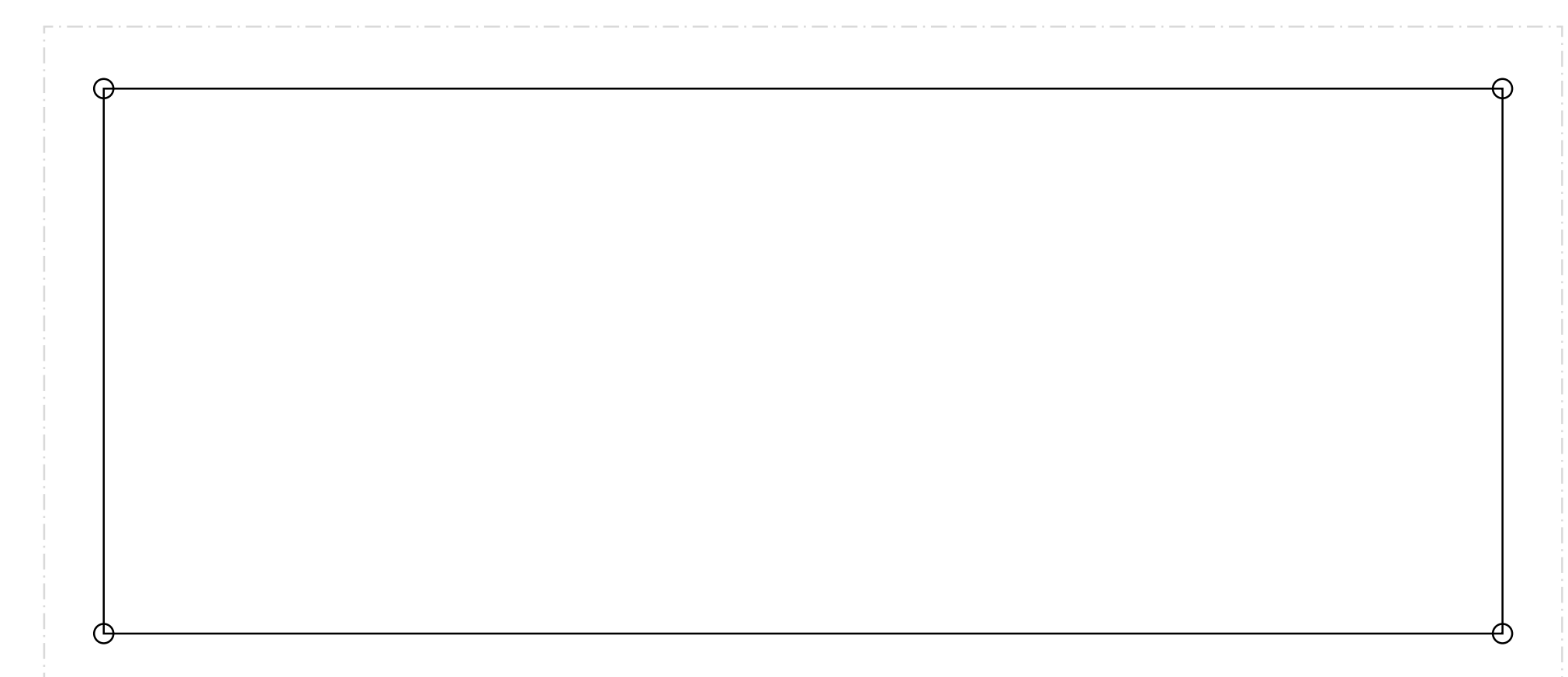
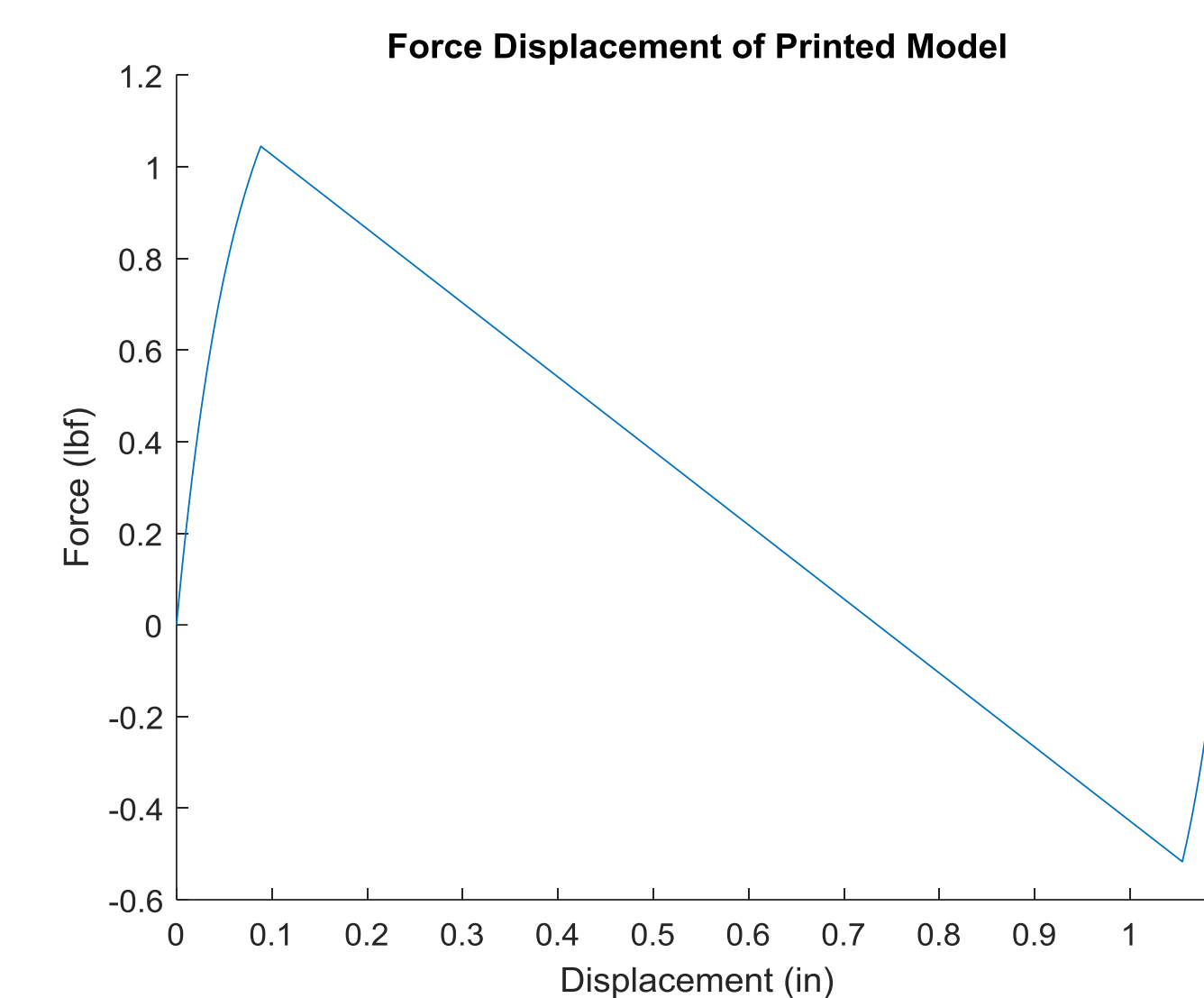
- If each beam's dimensions vary in a mesh, each beam deforms at separate displacements
- Sorting the beams by thickness controls the deformation pattern



## EXAMPLE

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

Gives an energy loss of:  
 $3.2091\text{mJ}$



## CONTACT

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