# USER MANUAL: Additively Manufactured Coupon for Characterizing Mechanical Performance of a Lattice in Tension

## Tool Reference

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# USER MANUAL: Additively Manufactured Coupon for Characterizing Mechanical Performance of a Lattice in Tension

## 1. General Information

Additive manufacturing (AM) is increasingly being used for medical device production with most AM implants having a lattice structure. This RST is a lattice coupon design, instructions for applying the user's lattice structure to the coupon, and example design files showing different lattice structures incorporated into the tensile coupon design. Additive manufacturing (AM) is increasingly being used for medical device production with a majority of AM implants having a lattice structure. This tensile coupon is a pin loaded design which makes it compatible with most mechanical load frame systems. The design can incorporate a range of lattice designs with simple Boolean operations by the end user. These tensile coupons are applicable to both metal and polymer materials.

## 2. Information for Users

**Content under this RST**

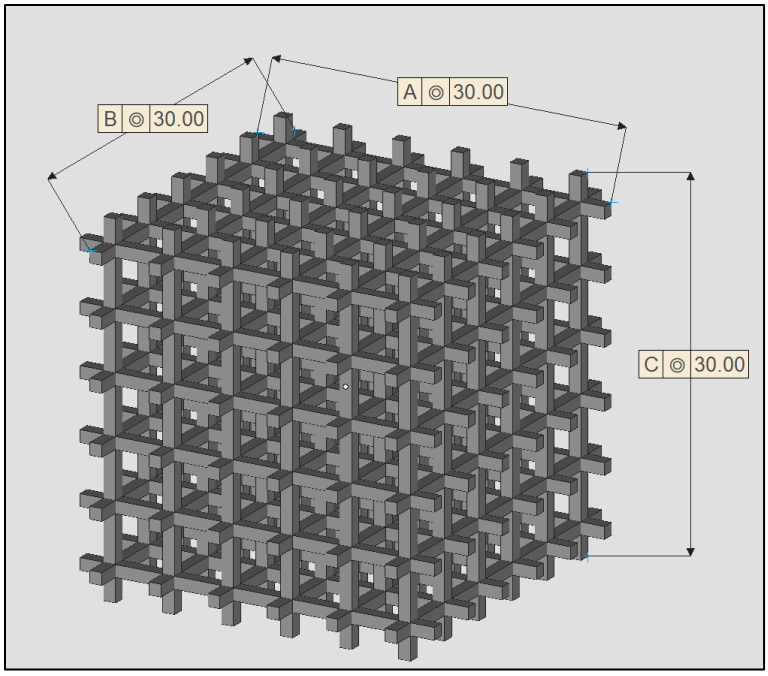
This RST includes the following content found at NIH's 3D Print Exchange. Entry number DPX-021370 https://3d.nih.gov/entries/3DPX-021370

- The coupon end grips (tenscomp ends simple.stl)
- 5 examples of lattices incorporated into the coupon end grips

## 3. Instructions to incorporate lattice geometry into the coupon

a. *Prepare your lattice:*

The lattice section between the coupon end grips is 20x20x20 mm. To use the coupon, the user first needs to generate a 20x20x20 mm cube of their lattice structure. While lattice edge effects can be an issue, users are encouraged to consult ISO/ASTM 52959 'Additive Manufacturing of metals - Test artefacts - Compression validation coupons for lattice designs' for information on the size of the lattice volume for minimizing edge effects. If the 20x20x20 mm lattice section has partial unit cells, the lattice should be centered on the grips such that the all the edges have the same amount of open lattice. This lattice should be exported as a *.stl* file.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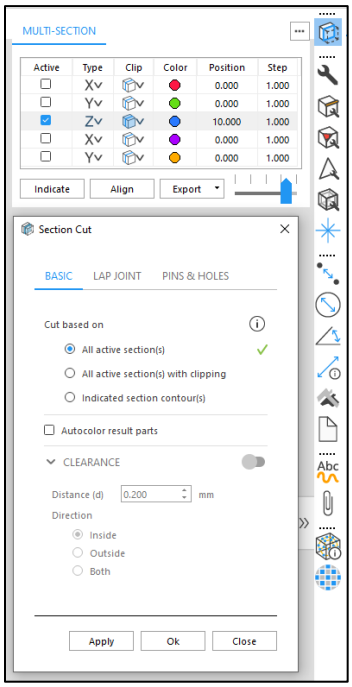
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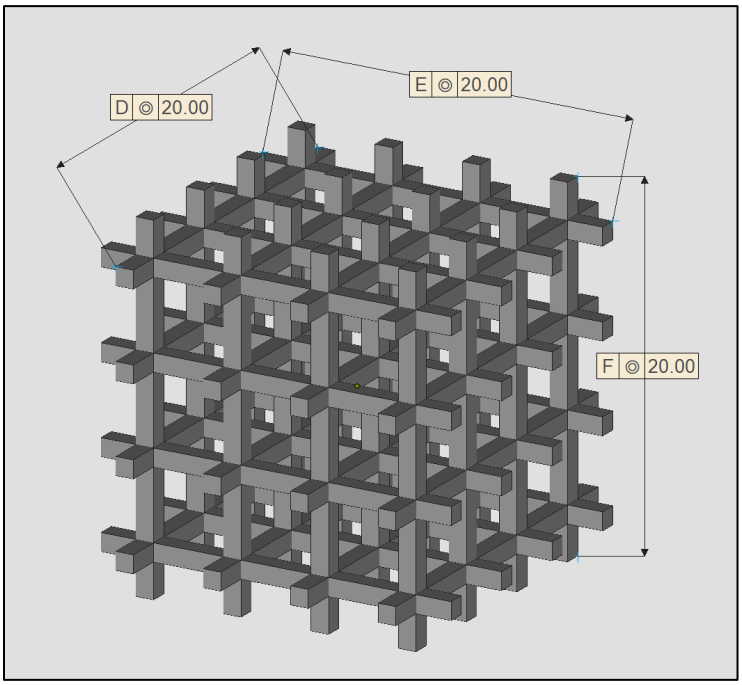
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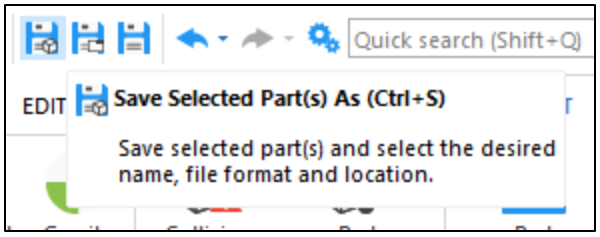
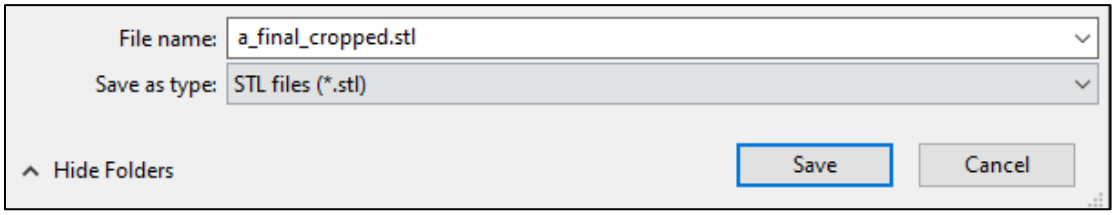
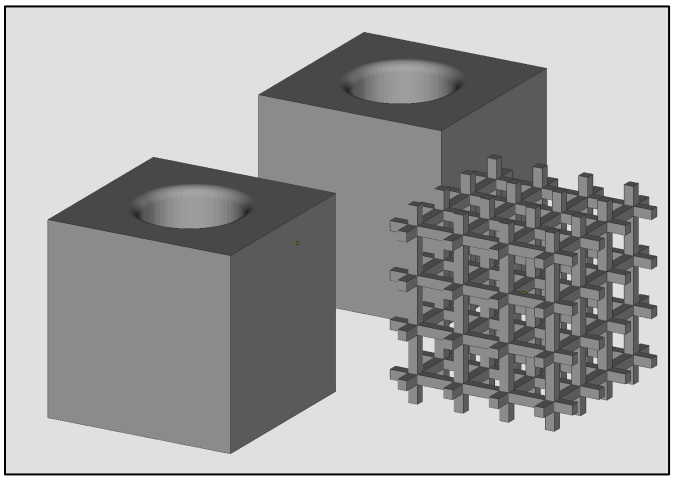
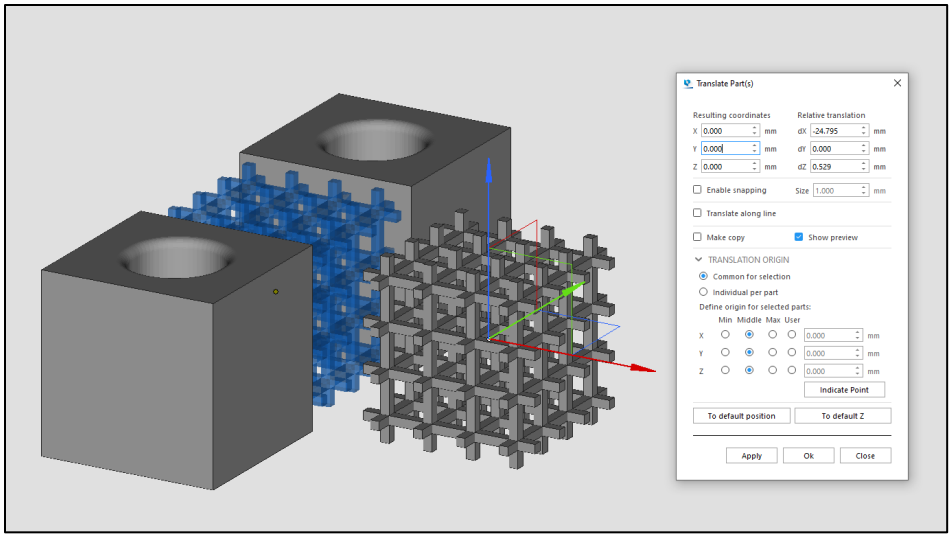


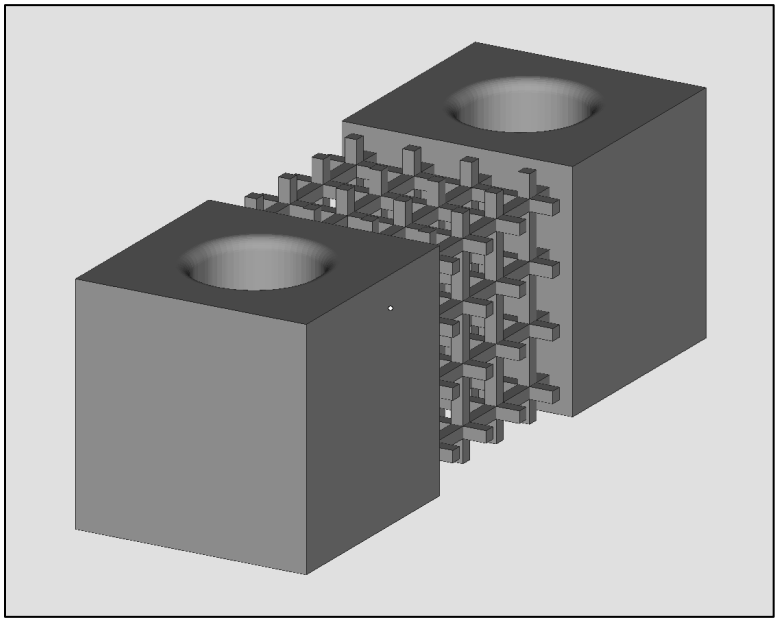




b. *Import Files*
Open your preferred CAD program and import the tensile end grips and the lattice cube.



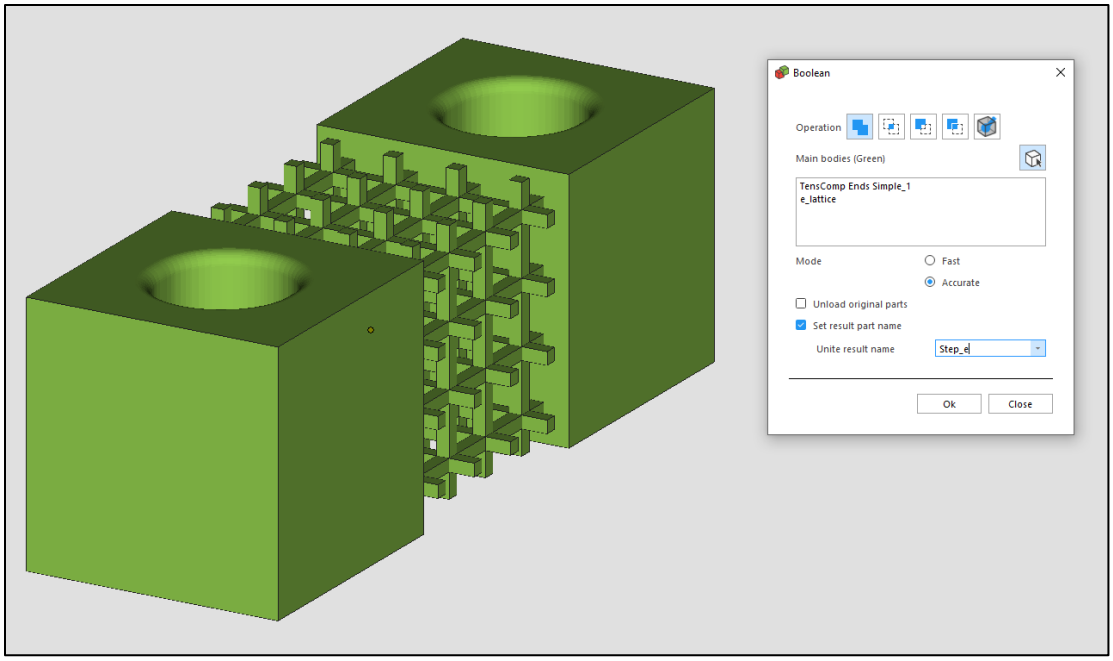
c. *Position the Components*
Move and rotate the end grips to align correctly with the lattice. The provided *.stl* file is already spaced at 20mm, this will need to be adjusted if using a modified lattice cube size. Ensure the lattice connects to the end grips to prevent print defects at the interface.



d. *Convert .stls to solid bodies (if needed)*
Some CAD software packages may require *.stl* files to be converted to solid bodies before performing Boolean operations. This is often performed using an option like "convert mesh to solid," "create solid from mesh," or a similar function name.

e. *Create a single unified model*
Select the lattice and both end grips. Find the Boolean operation tool, often called "combine," "merge," or "union" to merge the lattice and end grips.

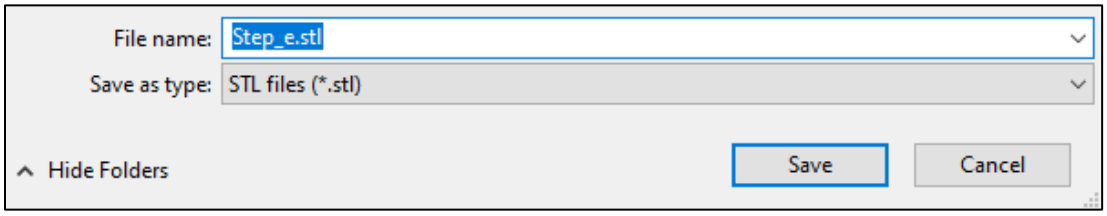



*f. Verify the result*

Confirm the lattice and end grips are merged into a single, unified 3D model. Confirm the pin holes on the end grips are preserved and in the correct positions and orientations.

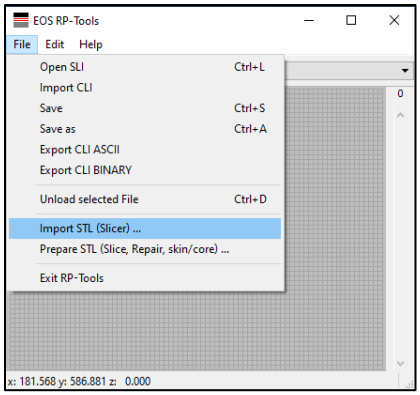
*g. Export the unified model as a .stl file*

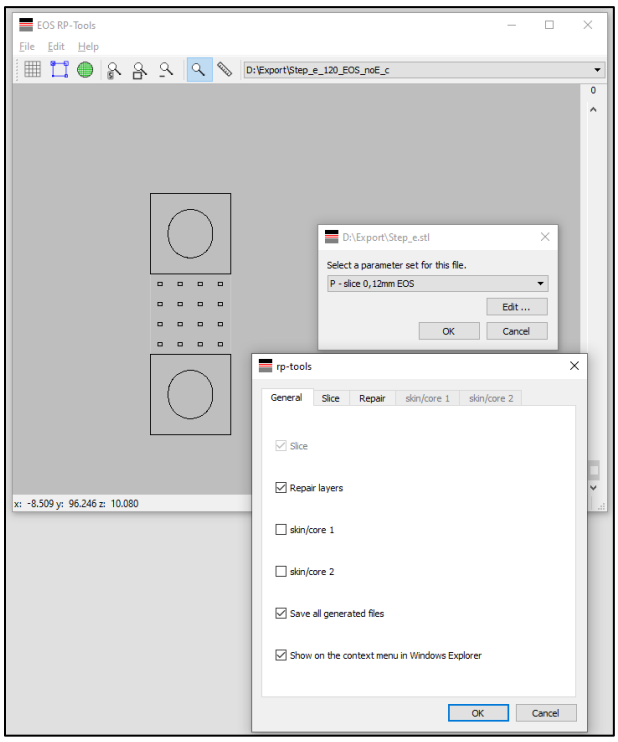
Export the unified 3D model as a new *.stl* file, confirm the export settings are appropriate for the user's workflow.




*h. Validate the exported .stl file*

Open the new *.stl* file in a 3D viewer or slicer software to ensure it is exported correctly and is ready to be additively manufactured.




*i. Build the coupon*

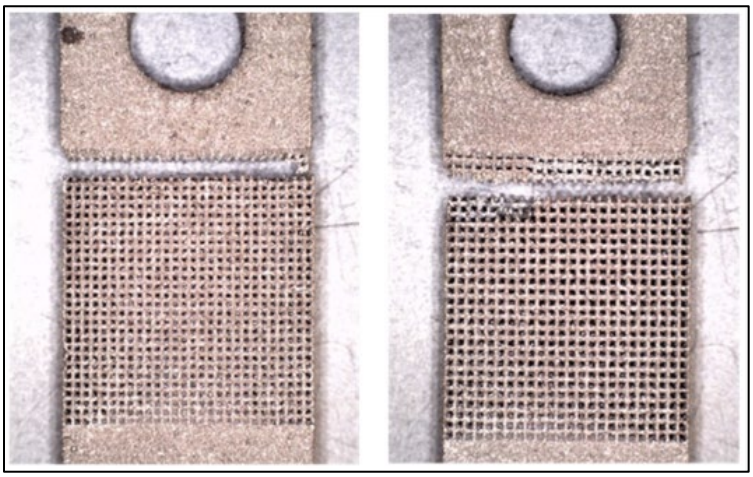
The user should use their regular AM workflow with the same build settings they would use to make lattice in their final product.

*j. Tensile testing*

Test conditions are left up to the user and should be based on existing standards for the lattice material.

## 4. Trouble shooting

The most common issue with using the RST is tensile failure at the interface between the lattice and the end grip, which would lead to a faulty tensile result.



Faulty tensile result (left) and acceptable tensile test (right. Figure 13a and 13b from Papazoglou, Dimitri P., et al. "Compression and Tensile Testing of L-PBF Ti-6Al-4V Lattice Structures with Biomimetic Porosities and Strut Geometries for Orthopedic Implants." Metals 14.2 (2024): 232.

Providing the AM build parameters have been optimized for the user's lattice structure, a common cause of this is an issue with merging the lattice (e.g., *.stl* file) with the end grips. This can be mitigated by generating a slightly taller lattice than the prescribed size such that when the Boolean operation is performed there is lattice embedded in the end grips which should ensure there are no defects at the lattice/end grip interface. Care should be made that the lattice does not intervene with the pin holes.