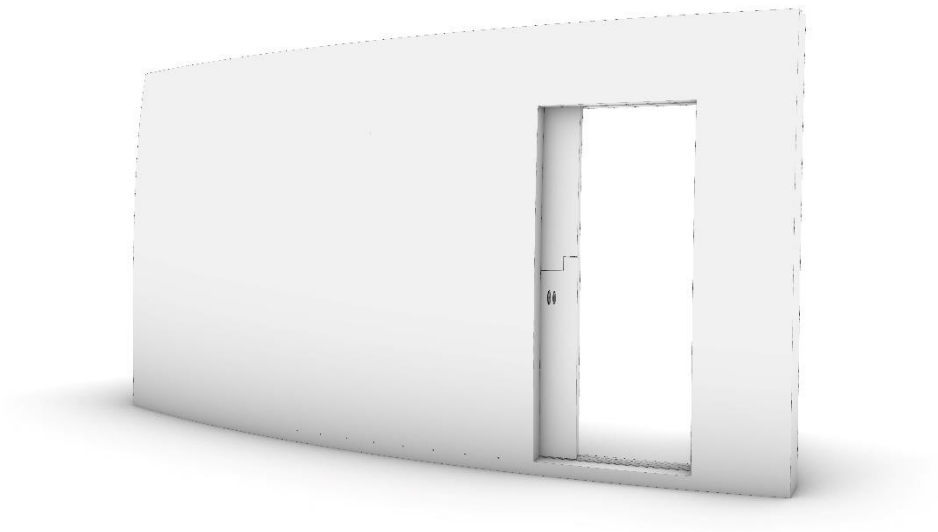
Opening the bottle:
Designing openable surfaces in a mono material construction of recycled PET



P5 presentation
Ma Thesis TU Delft

Noah van den Berg
4282620

Primary tutor:
Paul de Ruiter

Secondary tutor:
Fred Veer

Graduation track: ‘living in a bottle’

- Non sustainable material usage
- Mono material construction
- Waste stream material
- Tiny house

My assignment: opening the bottle

- Usabilty of the tiny house

Design challenges:

- No function specific materials
- Form dictates function
- Multi curved wall

Table of Contents

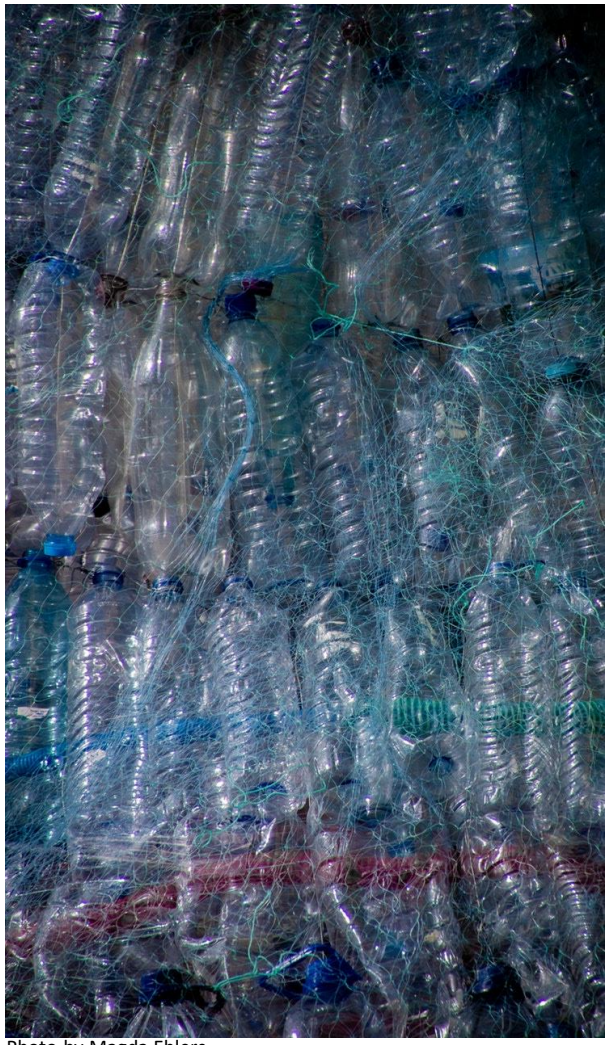


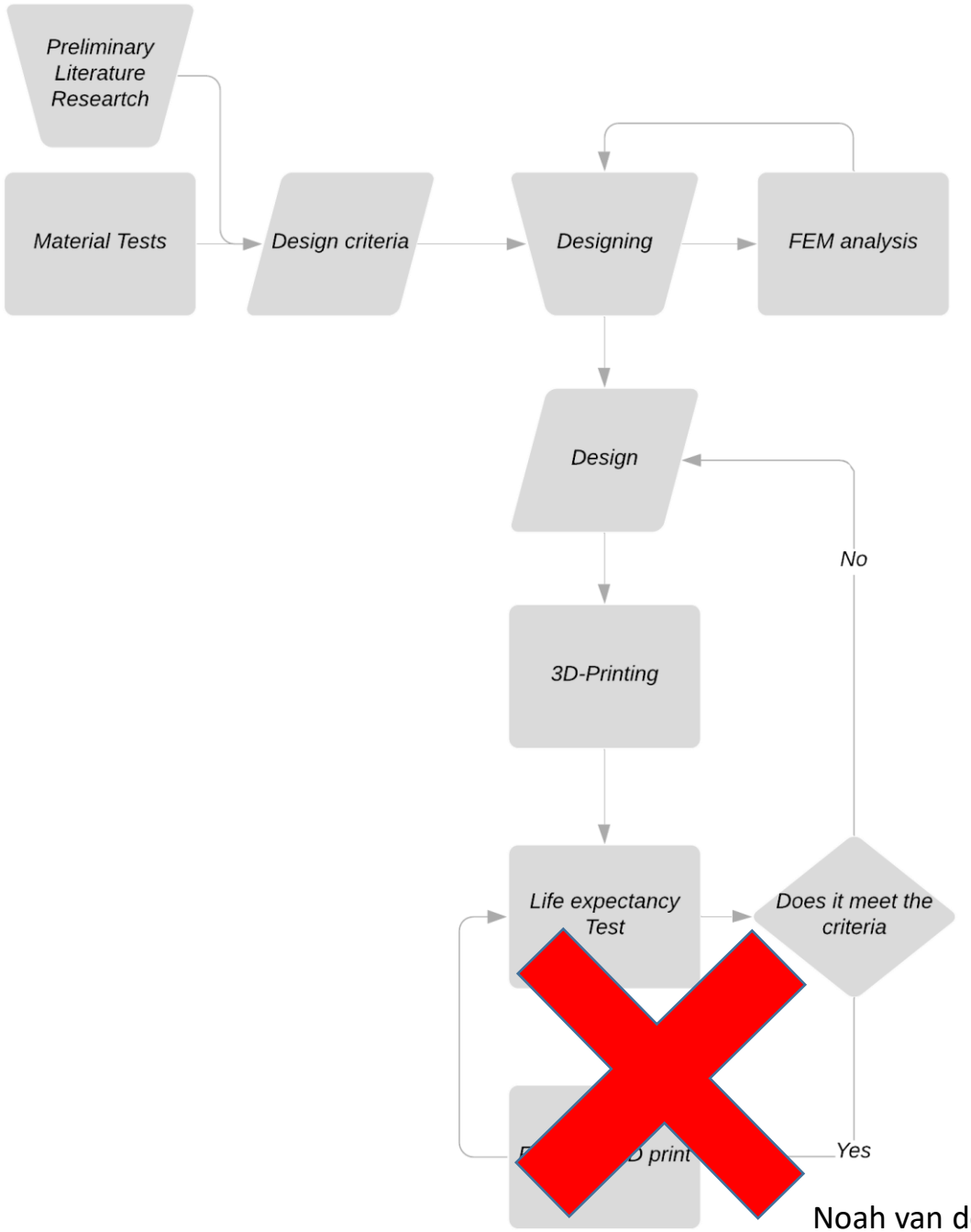
Photo by Magda Ehlers

Research question

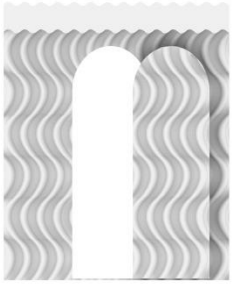
How can an openable surface be included in a mono material 3D printed tiny house, using FDM 3D printing?

- How can geometry allow for a surface to be moved?
- What are the criteria for an openable surface?
- What are the physical and structural properties of recycled PET?
- How can one optimize geometry for 3D printing?
- How does a 3D-printed openable surface hold up under use?
- How does the openable surface connect to the structure of the 3D printed tiny house?

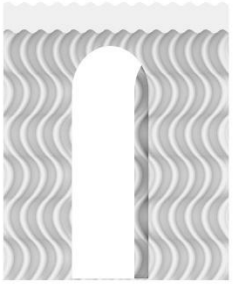
Methodology



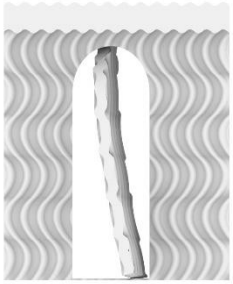
Ways of opening a surface



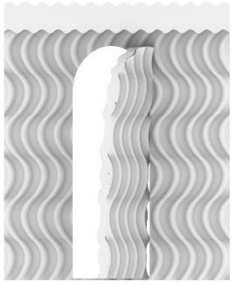
Pop-out



Sliding



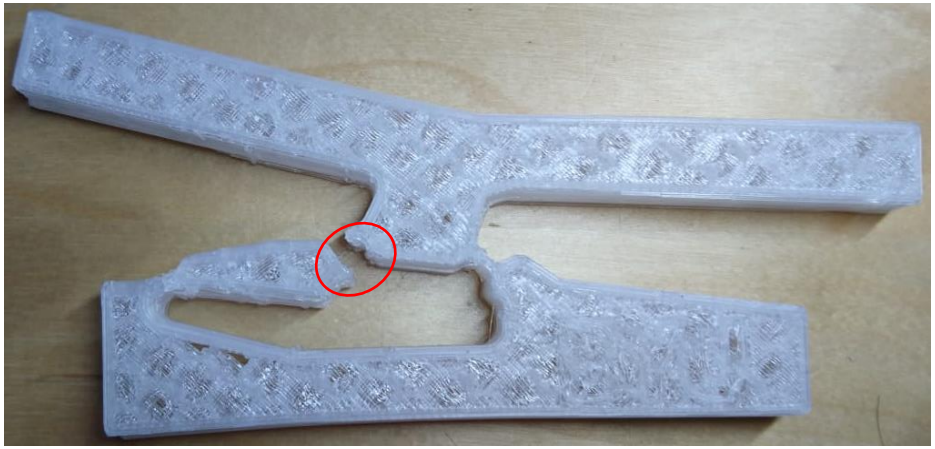
Rotating



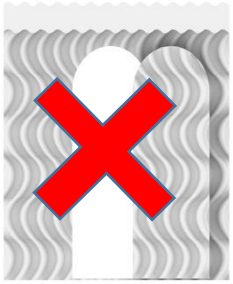
Hinged

Preliminary test & research results

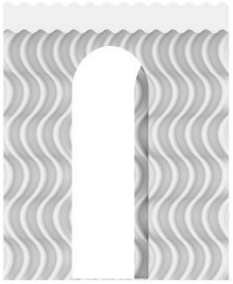
Compliant mechanism test in printed PET



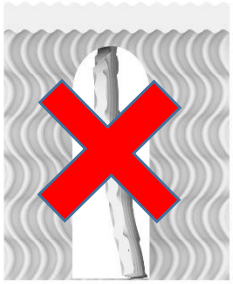
Ways of opening a surface



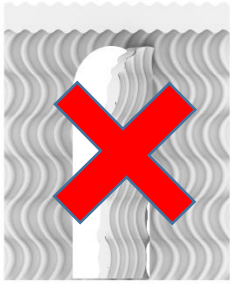
Pop-out



Sliding

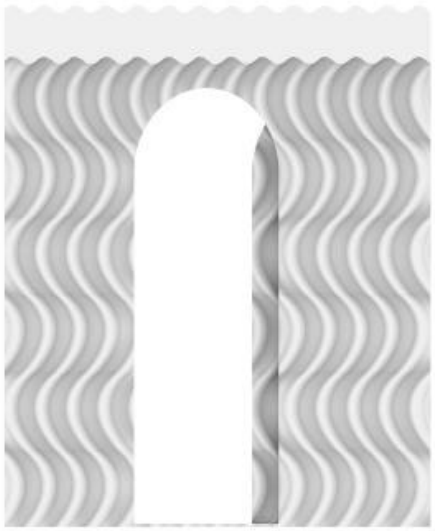


Rotating



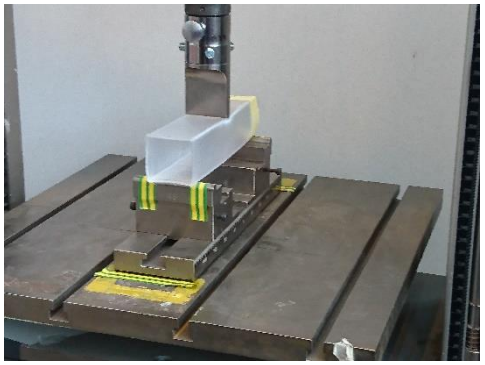
Hinged

Preliminary test / research results



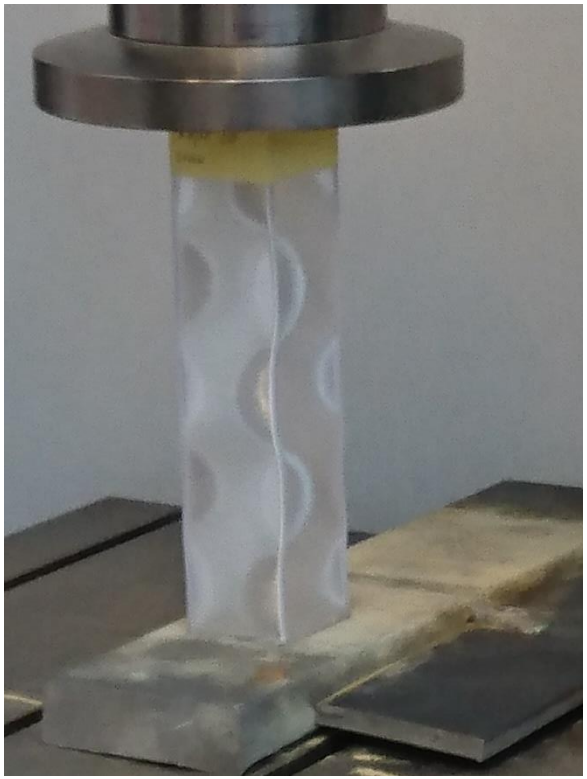
Sliding

Three point bend test



Source	Young's modulus
CES virgin PET (unfilled, semi-crystalline)	2760 – 3100 MPa
Recycled PET(Ultrafuse rPET)	1334 – 1640 MPa
Calculated based on 3 point bend test	600 MPa

Compression test

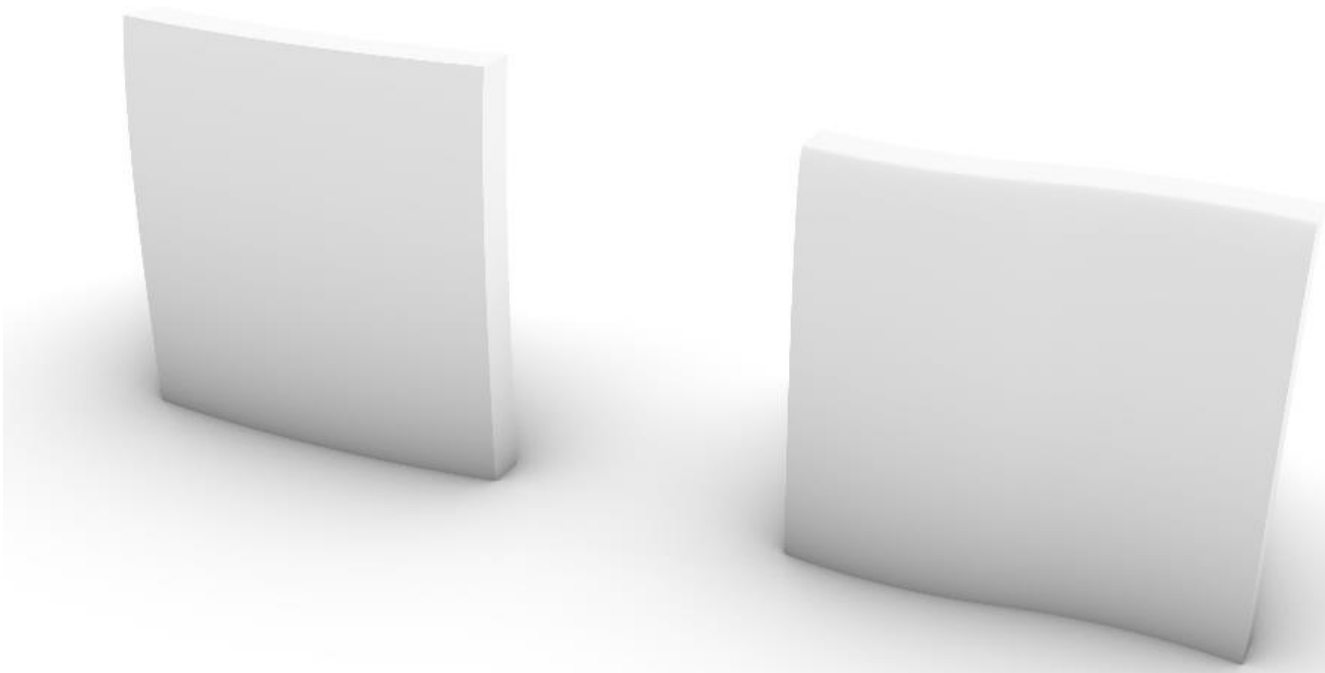


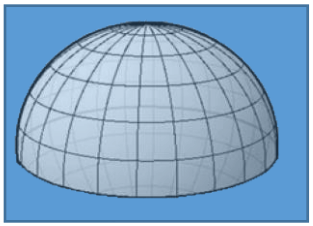
Design Criteria

- Shortened use period (25 years)
- PET only & as few components as possible
- Usability (clarity & ease of use)
- Structural capabilities
- Wind & watertight
- Maintenance

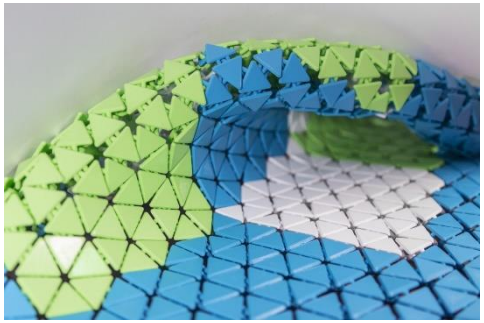
Production criteria for PET 3D printing
- As little material as possible (time & cost)
- No sharp corners

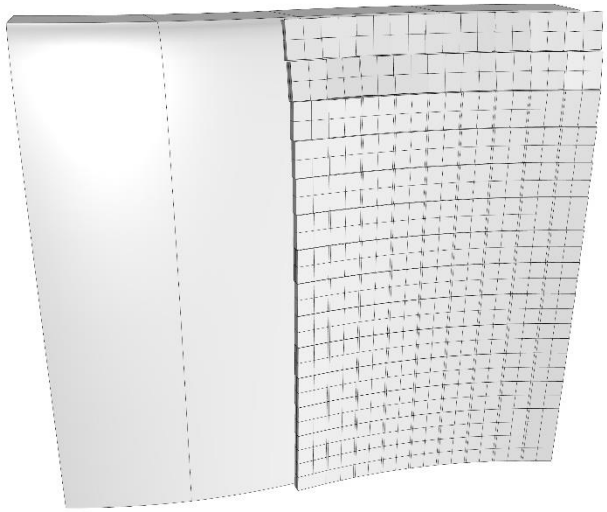
Multi curved wall



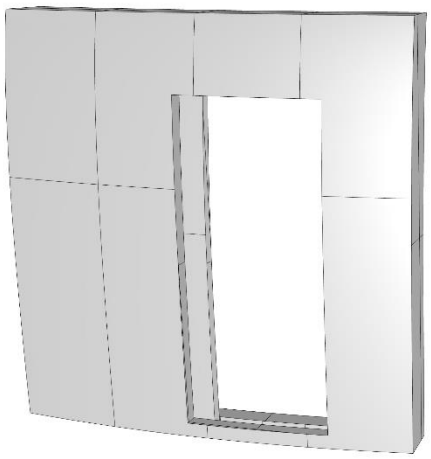


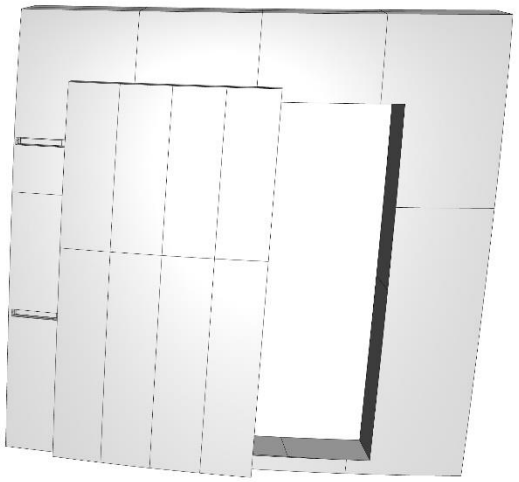
Complex curved wall



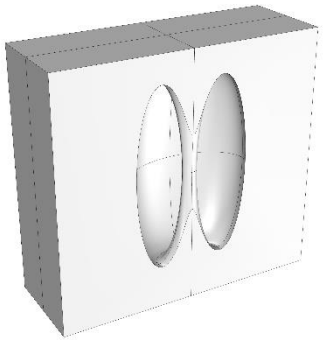


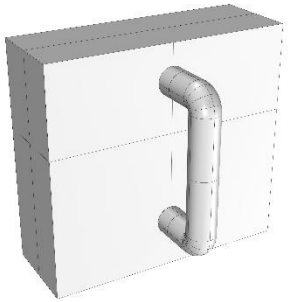
Sliding system

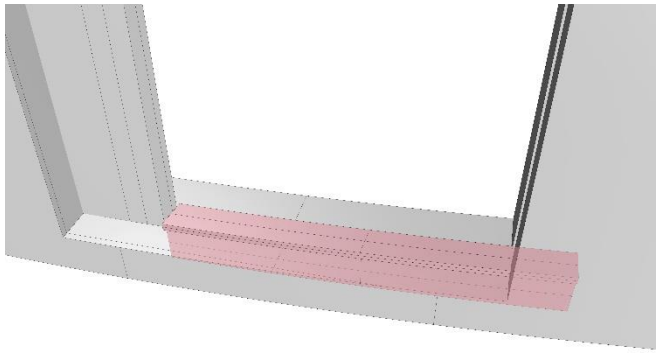




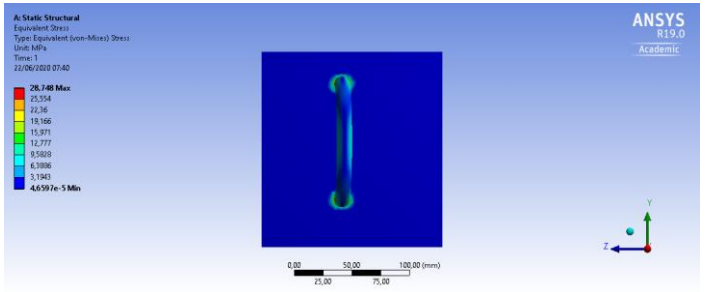
Design steps

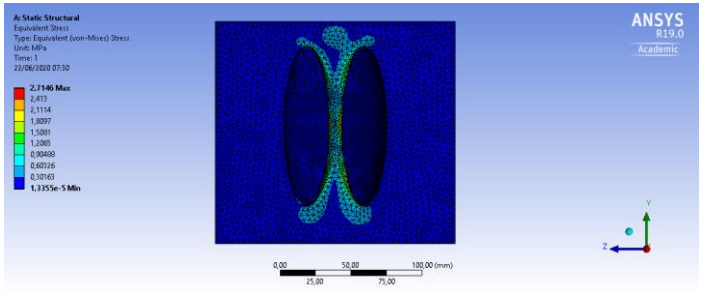




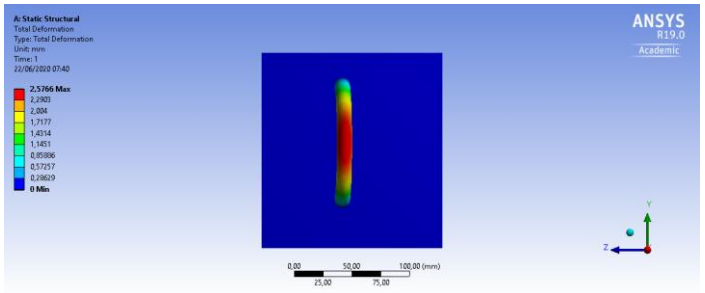


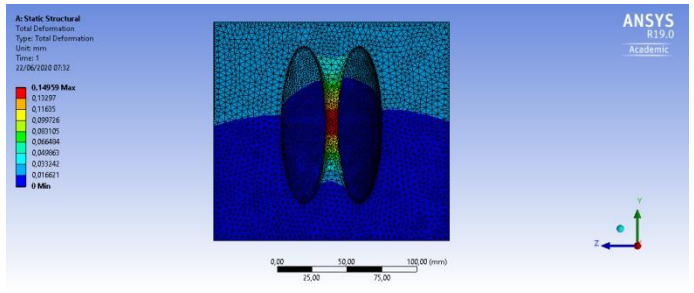
Door handle





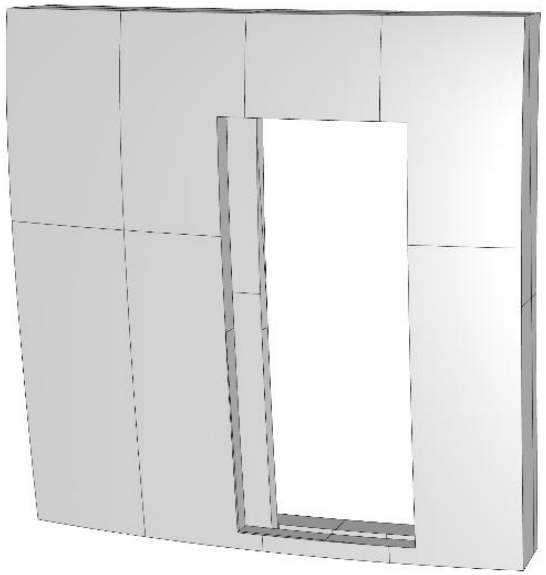
Stress



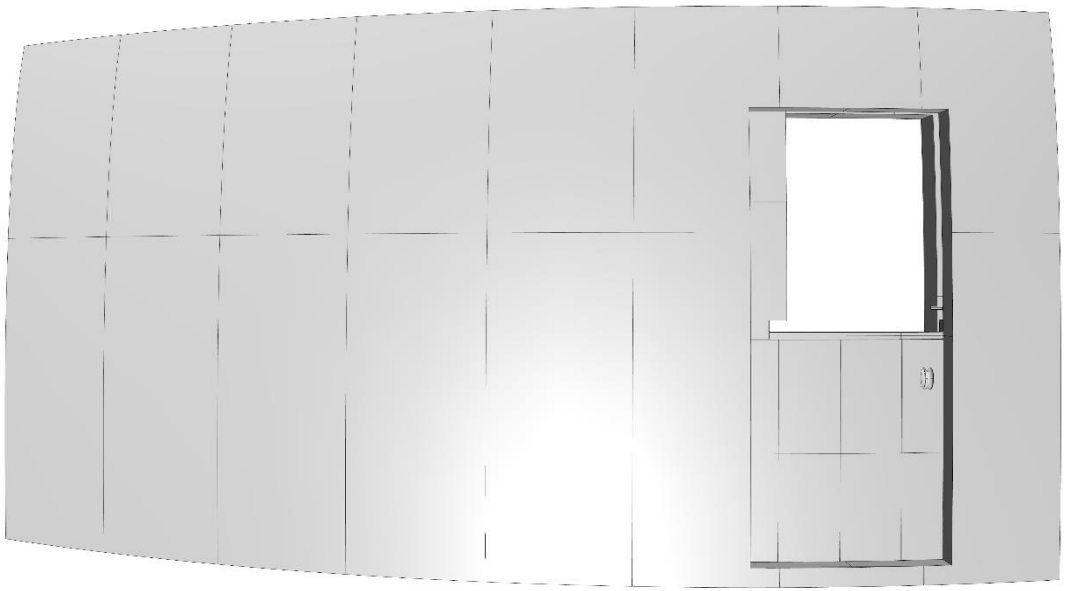


Deformation

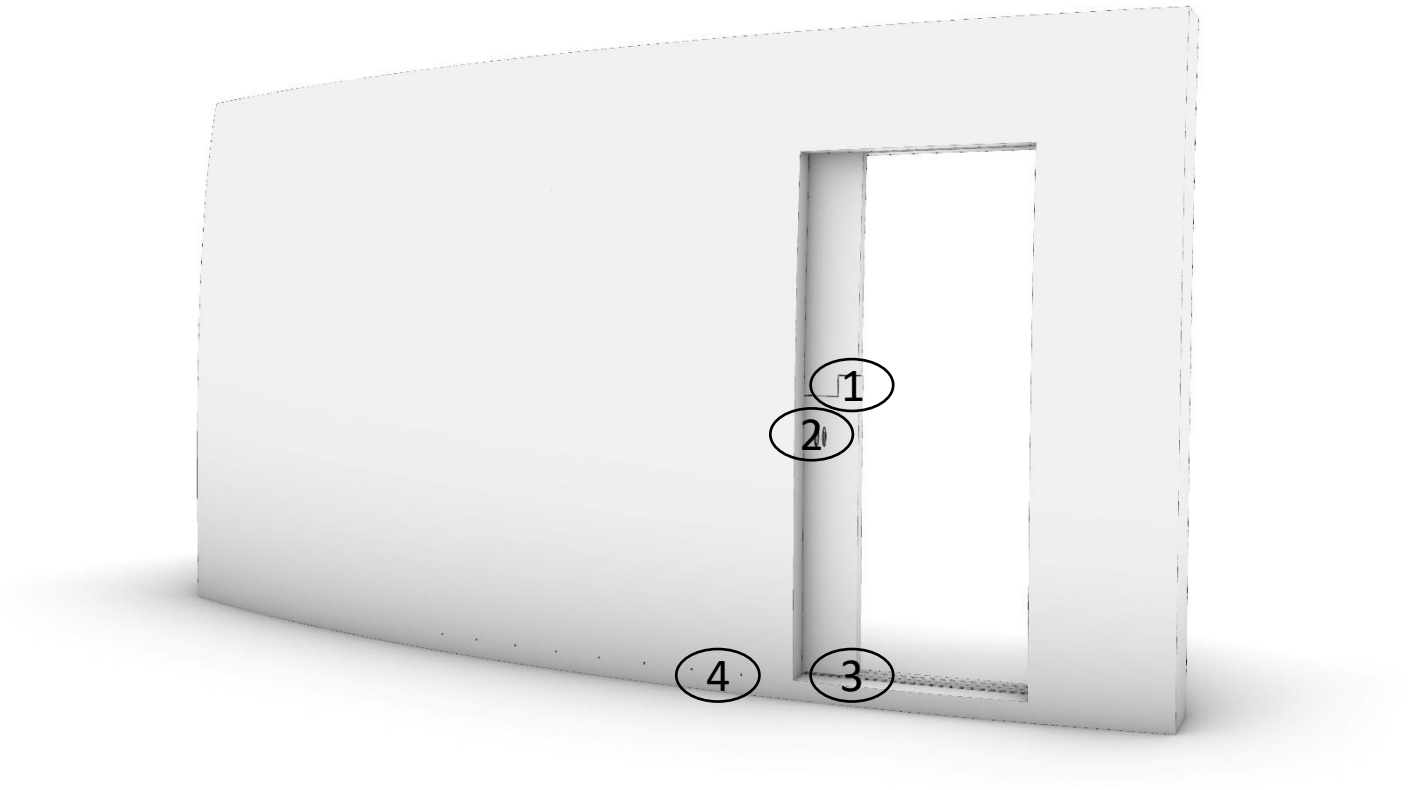
Dutch farm door



Dutch farm door

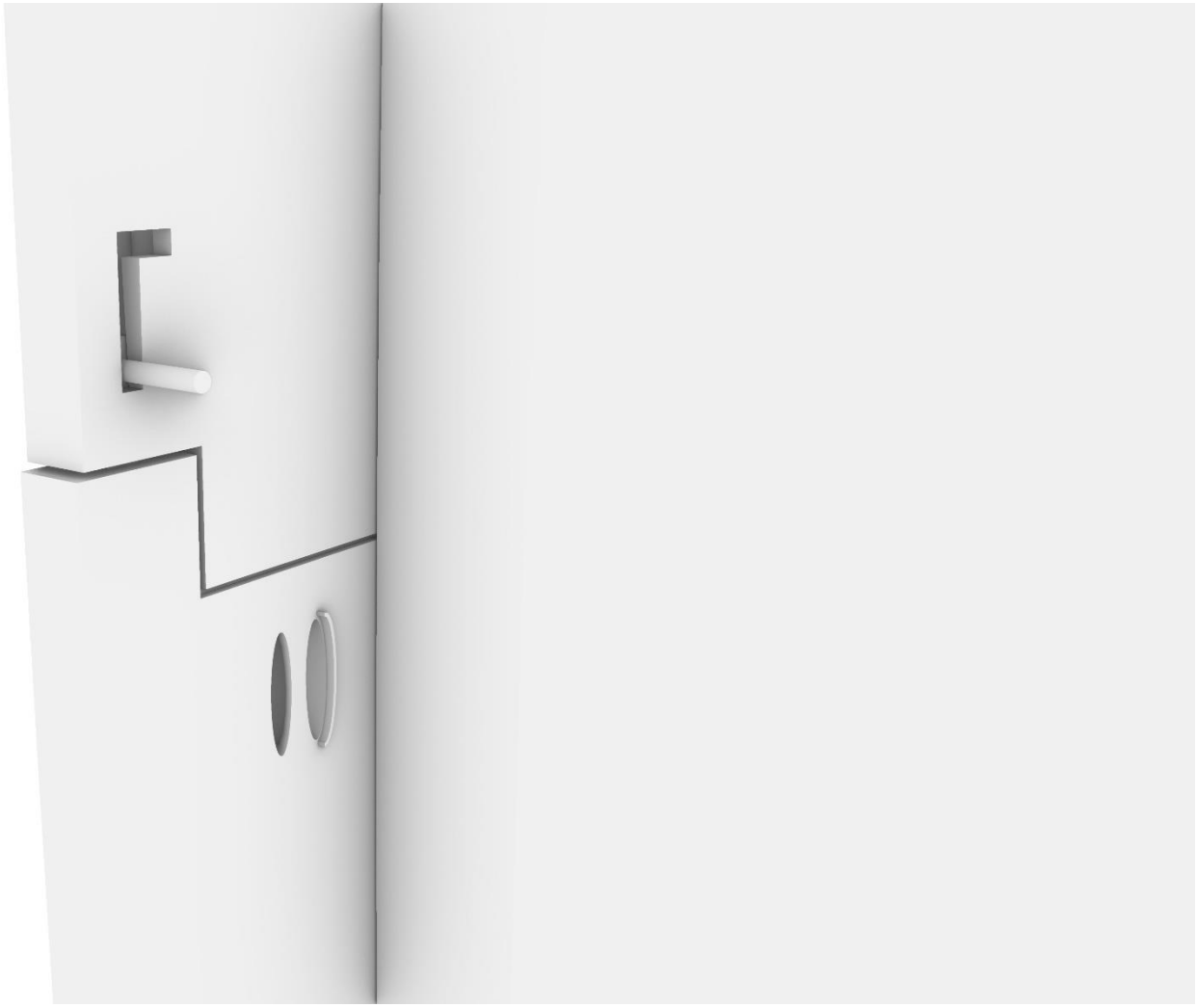


Design steps



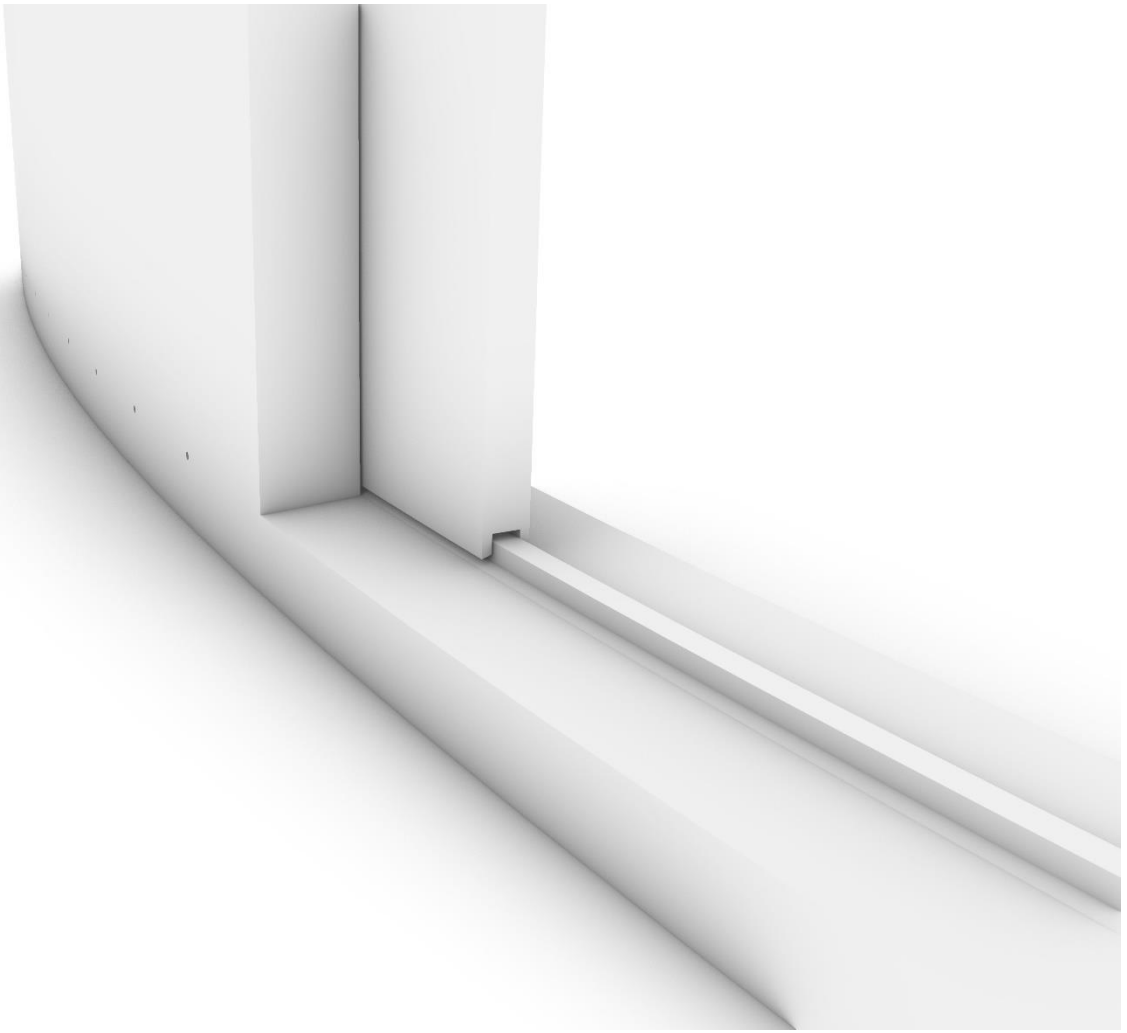
Design steps

1 & 2

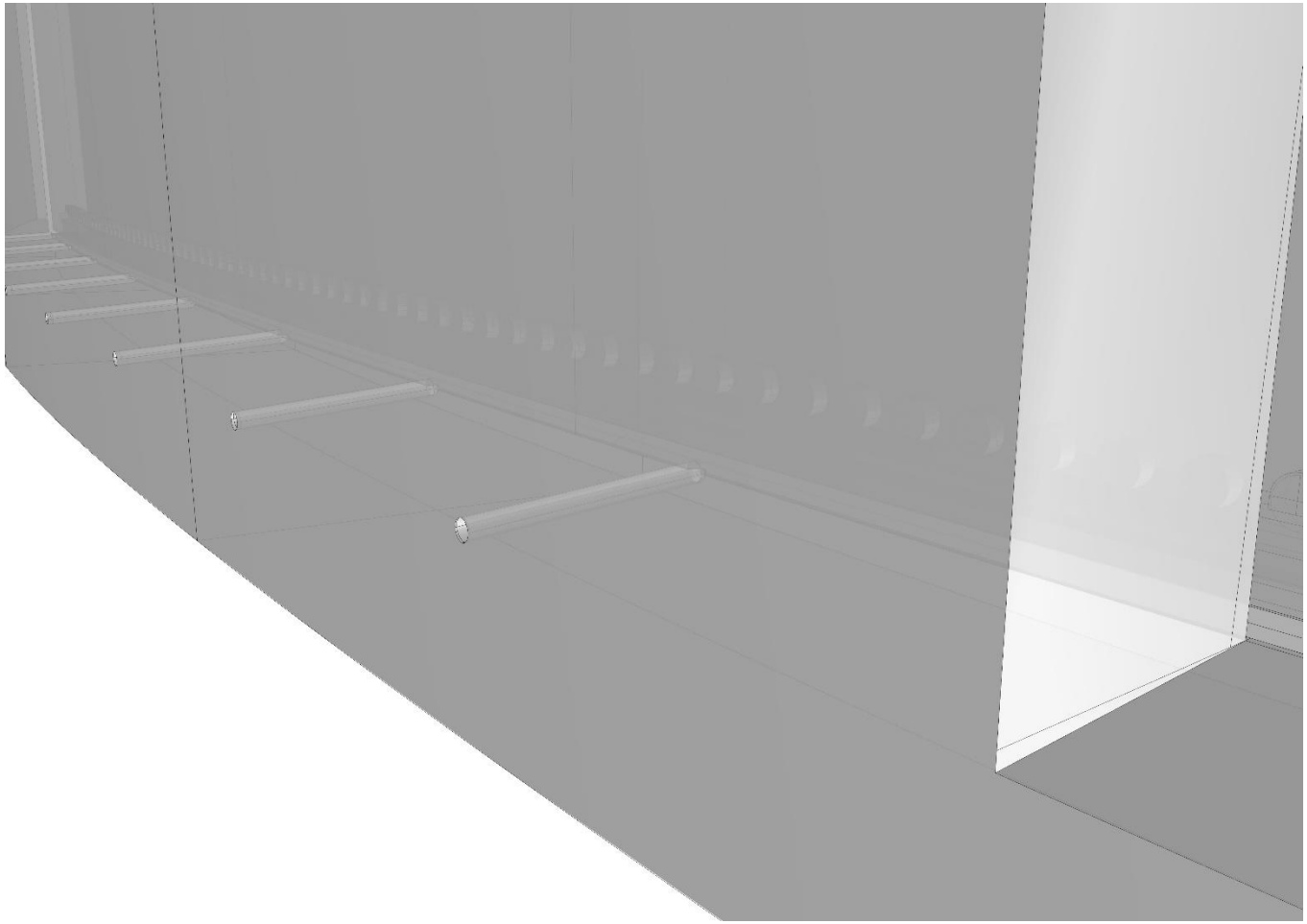


Design steps

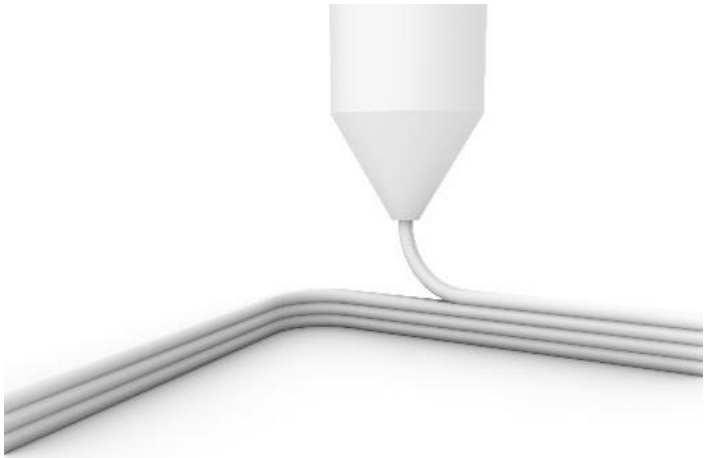
3



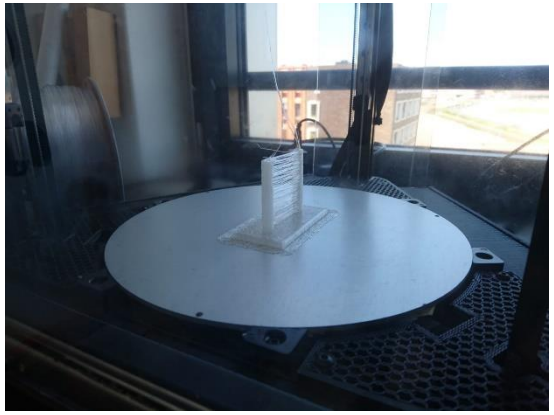
4

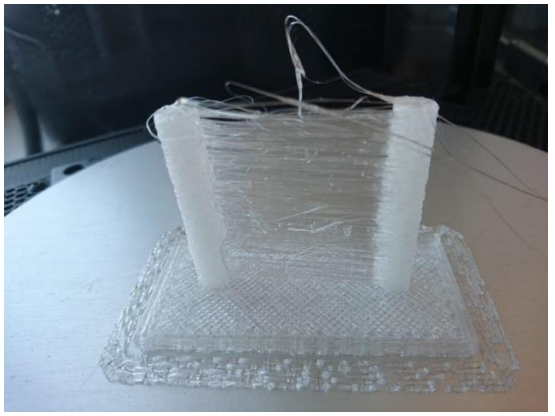


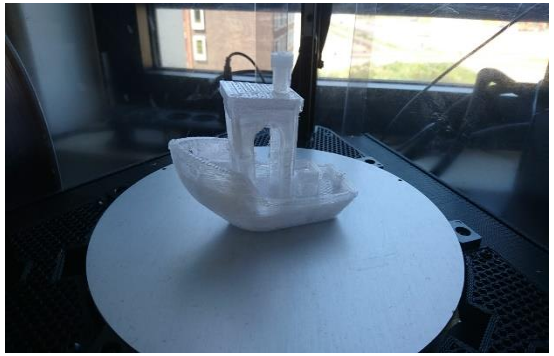
Fabrication



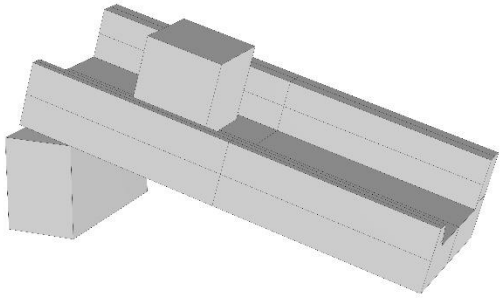
Fabrication



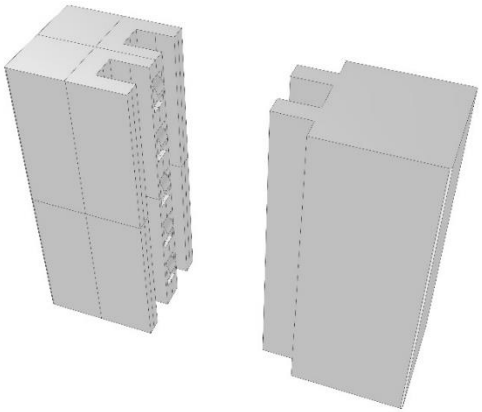




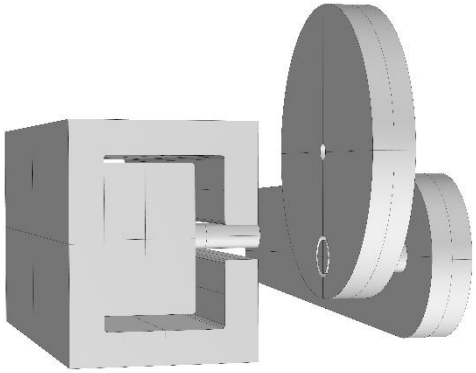
Small scale tests



Sliding test

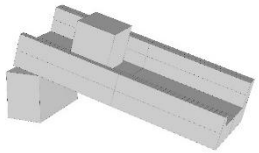


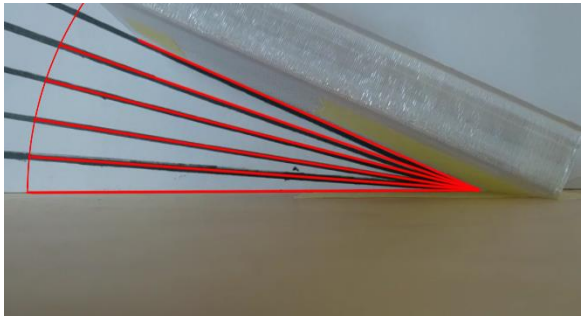
Roller test

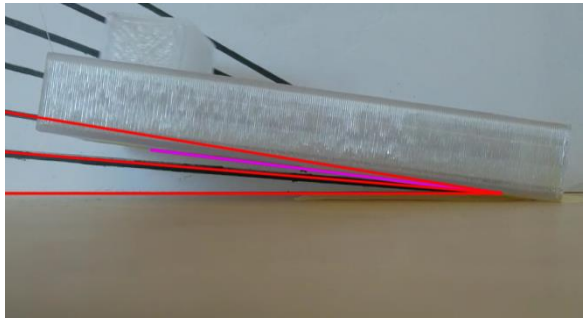


Wear test

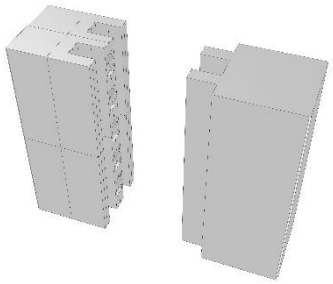
Sliding test

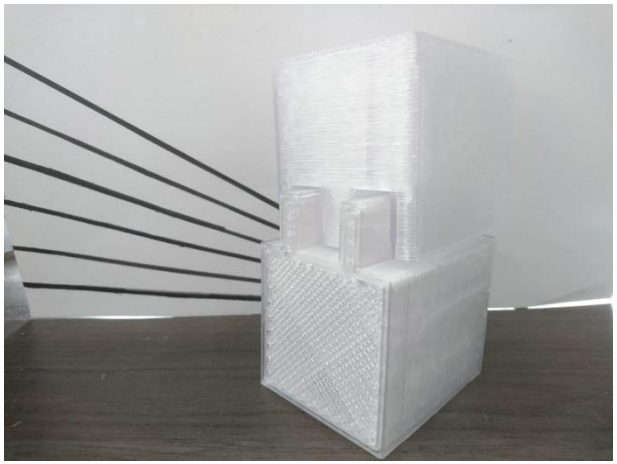


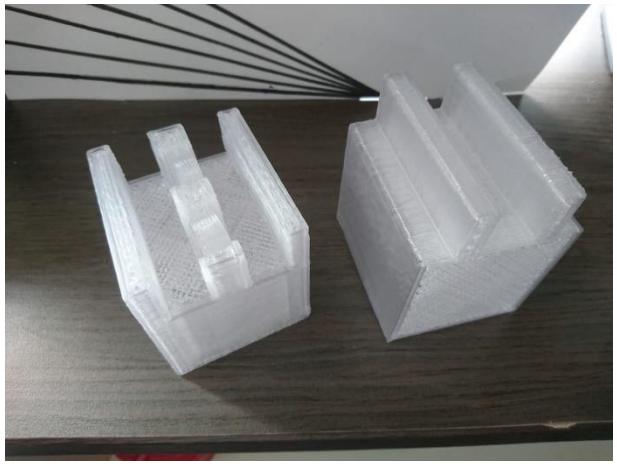




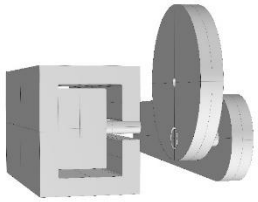
Roller test



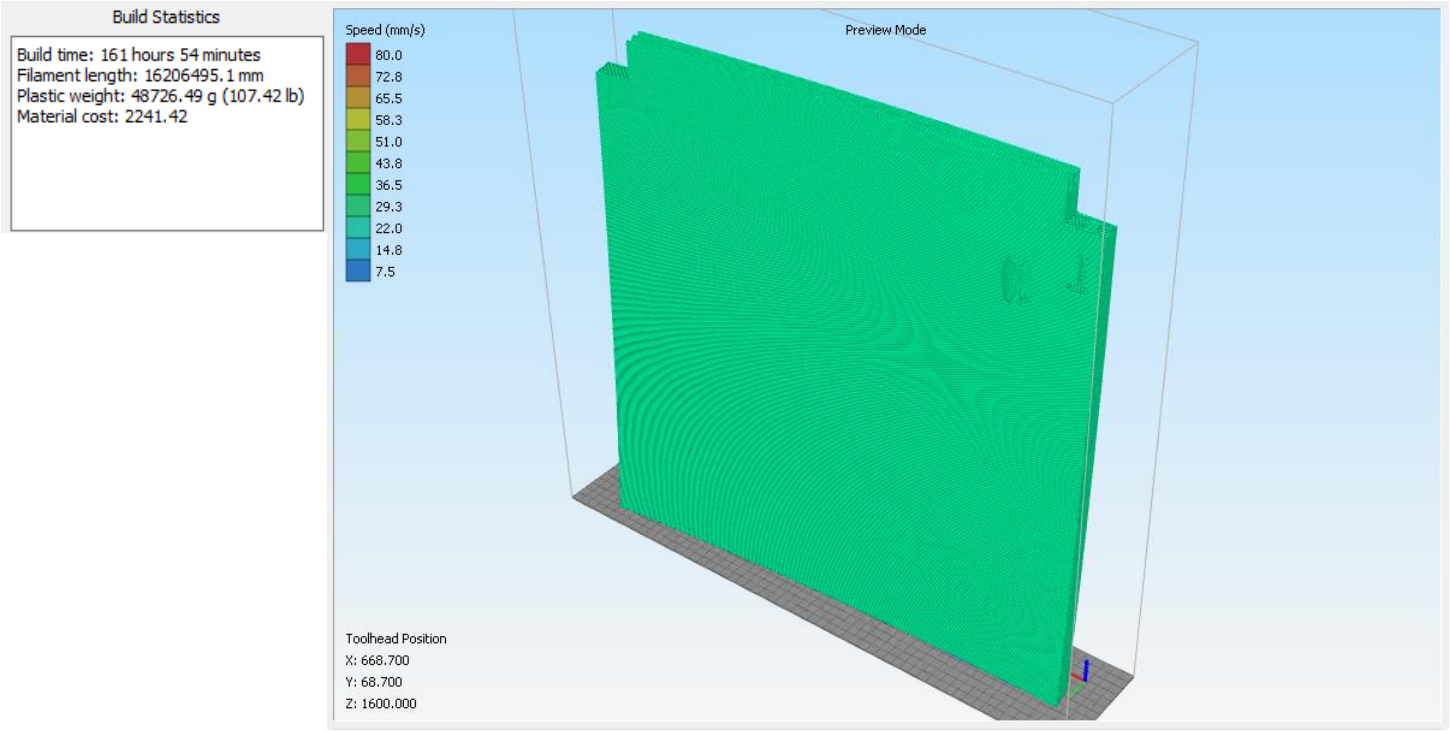




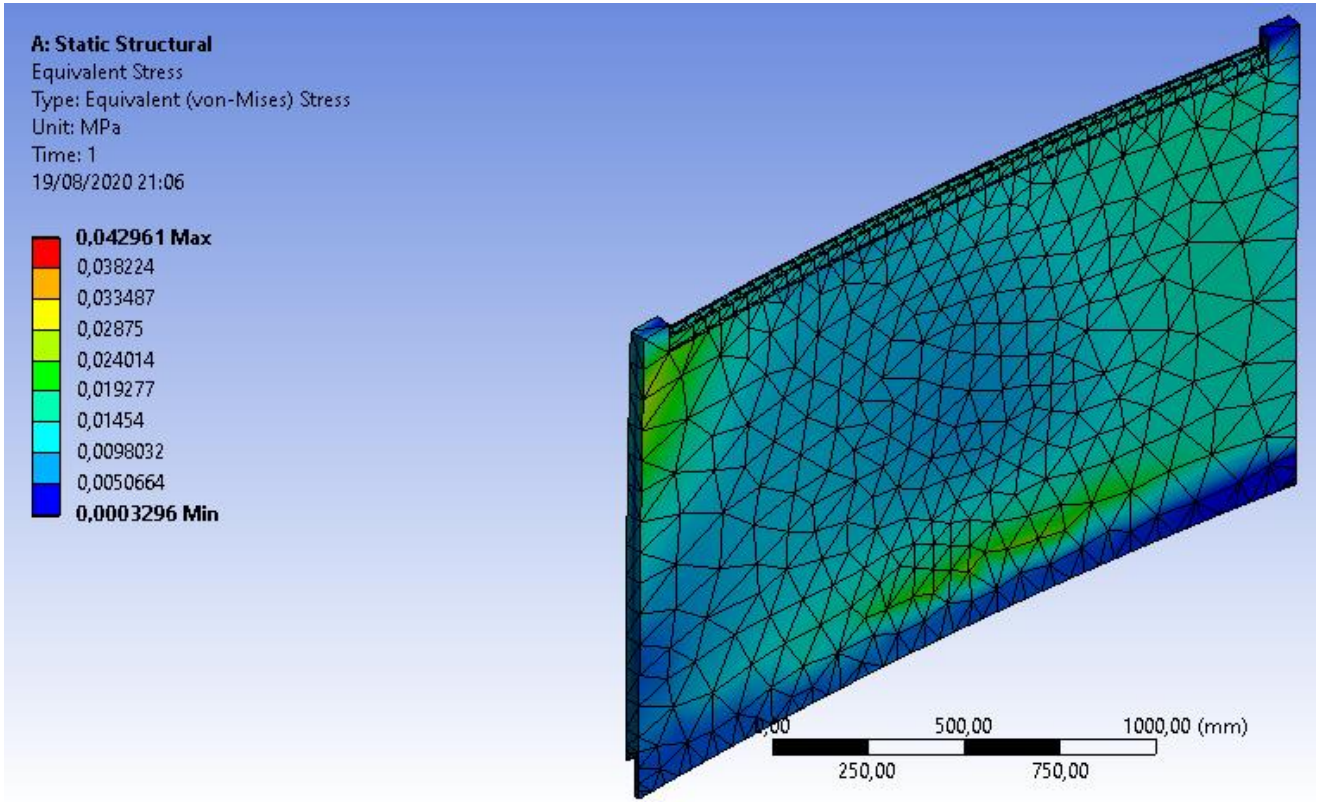
Wear test



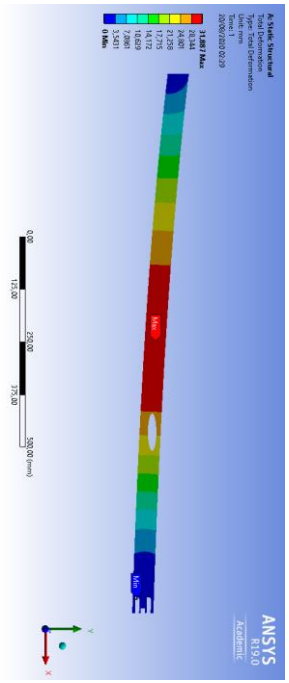
Weight estimation

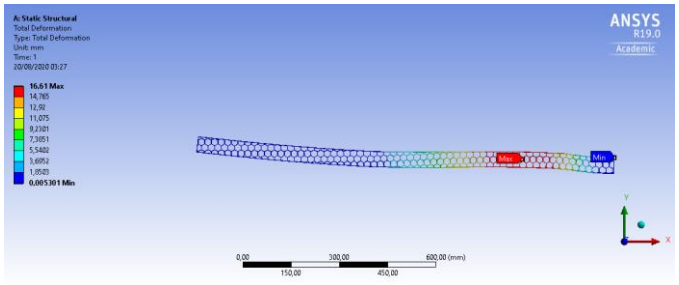


FEM 3D

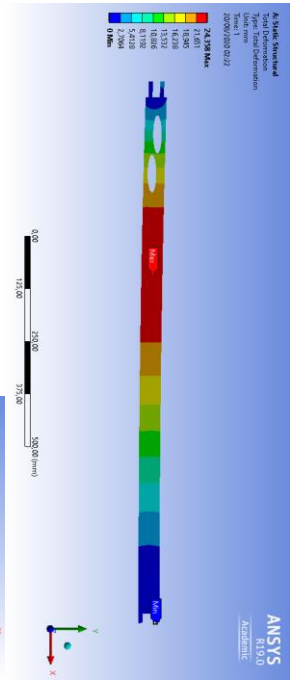


FEM 2D

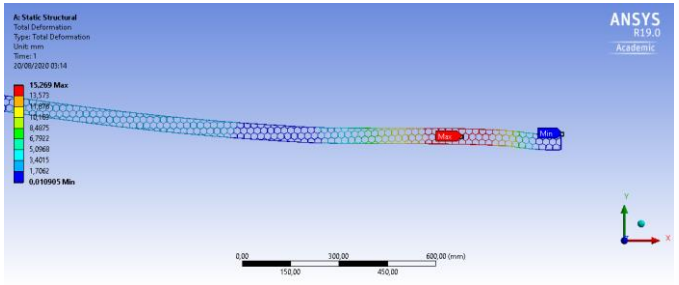




Top panel 20% infill



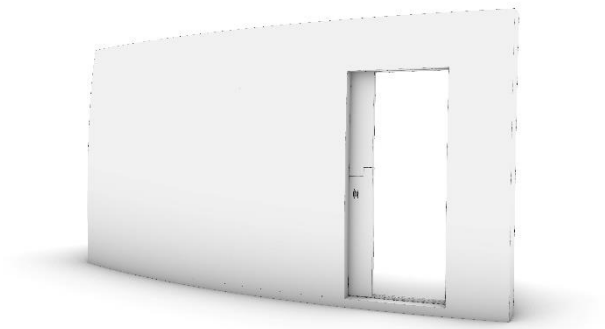
Bottom panel 20% infill



Conclusion

Research question:
How can an openable surface be included in a mono material 3D printed tiny house, using FDM 3D printing?

- Internal sliding system
- Farm door
- Wheels for layer orientation



Reflection

- Two underestimated challenges
  - Complexity of multicurved surfaces
  - Importance of maintainance
- Suggestions for follow-up research
  - Topologically optimized infill
  - Full scale of the completed tiny house

The end