

THE DESIGN AND TESTING OF PLANT-FIBRE COMPOSITE PROFILES FOR STRUCTURAL FACADE APPLICATIONS

Final thesis presentation - Building Technology Graduation Studio

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Reduce the embodied carbon of fossil-based façade systems by implementing bio-based alternatives



**What could replace these fossil-based
construction materials in the future?**

Plant-fibre reinforced composites



Plant-fibre reinforced composites



Plant-fibre

Plant-fibre reinforced composites



Plant-fibre

+



Resin matrix

Plant-fibre reinforced composites



Plant-fibre

+



Resin matrix



Seatings



Car parts

Main problem



Limited studies into low-budget manufacturing techniques for complex shapes



Limited mechanical performance data of plant fibre composites

"To what extent can plant-fibre reinforced composites be shaped into complex façade profile geometry that meet the requirements of curtain wall systems?"

What are these curtain wall system requirements?

Performance criteria



Building regulations

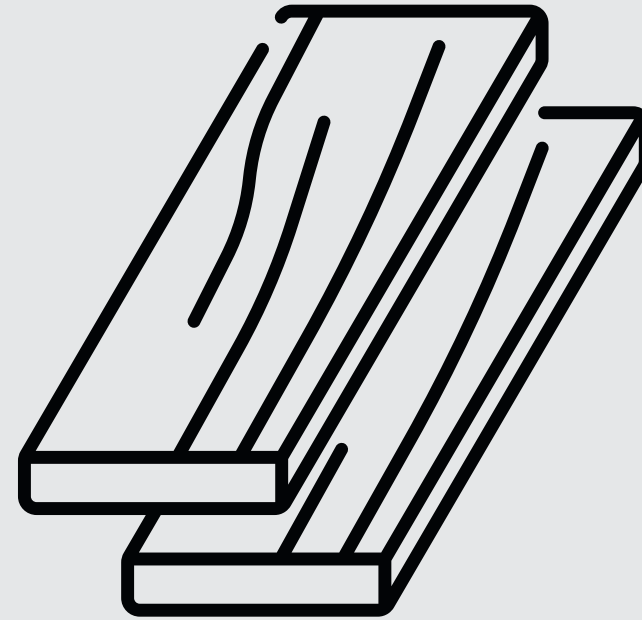
- Be able to resist horizontal windload
- Be able to withstand temperature changes

Performance criteria



Building regulations

- Be able to resist horizontal windload
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Material performance

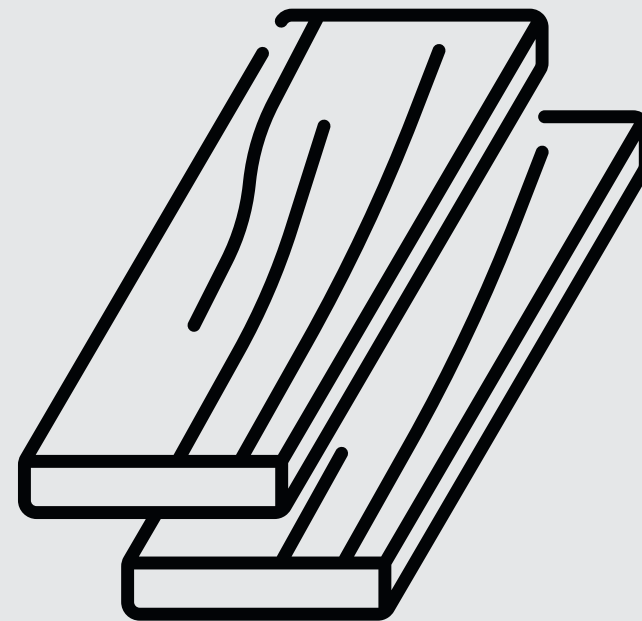
- Progressive failure
- Strength comparable to aluminum, which is mostly used for curtain wall profiles

Performance criteria



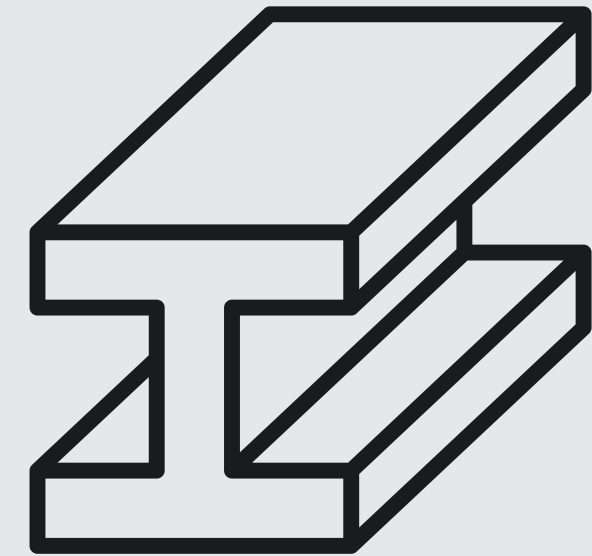
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Material performance

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Profile performance

- Reduce the CO₂ emissions by 70%
- Minimal surface errors & constant wall thickness

Initial experiments

Material selection



1. Cross-stitched flax fibre cloth

Material selection



1. Cross-stitched flax fibre cloth



2. Non-woven hemp fibre mat

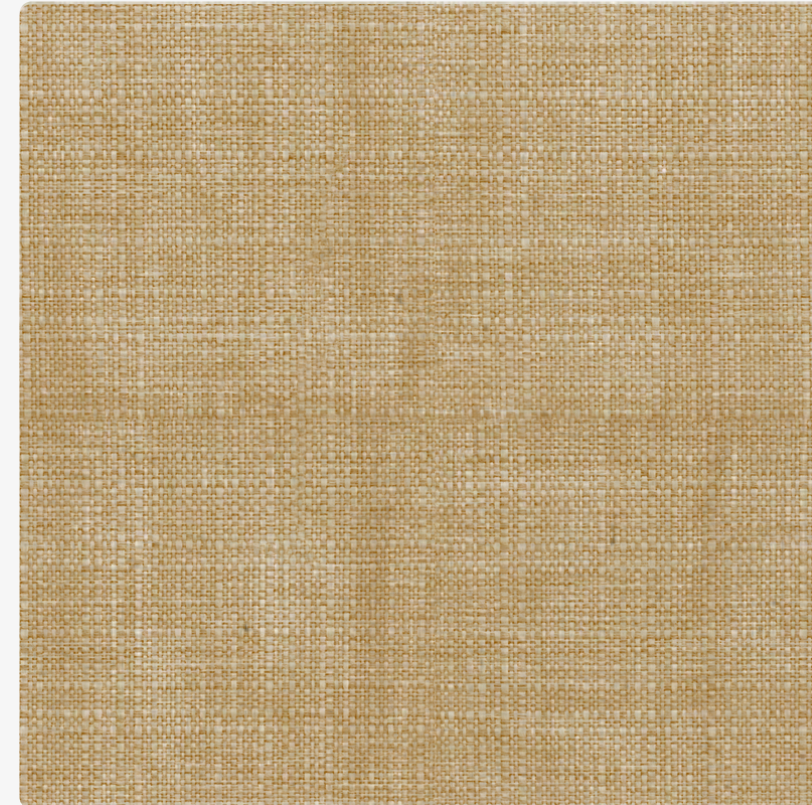
Material selection



1. Cross-stitched flax fibre cloth



2. Non-woven hemp fibre mat



3. Plain-woven jute cloth

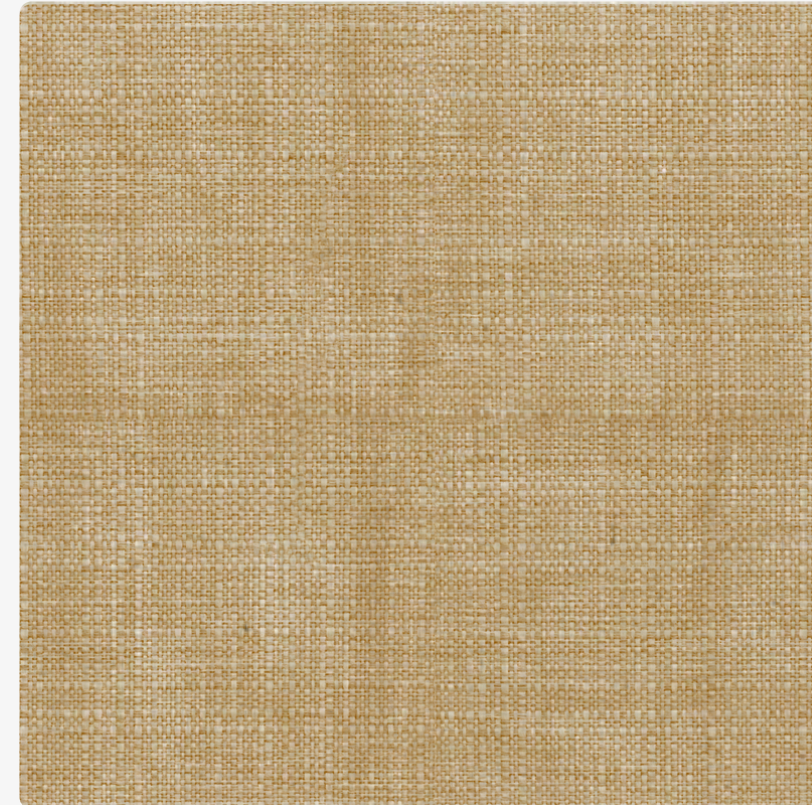
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1. Cross-stitched flax fibre cloth



2. Non-woven hemp fibre mat



3. Plain-woven jute cloth



4. Flax fibre yarn

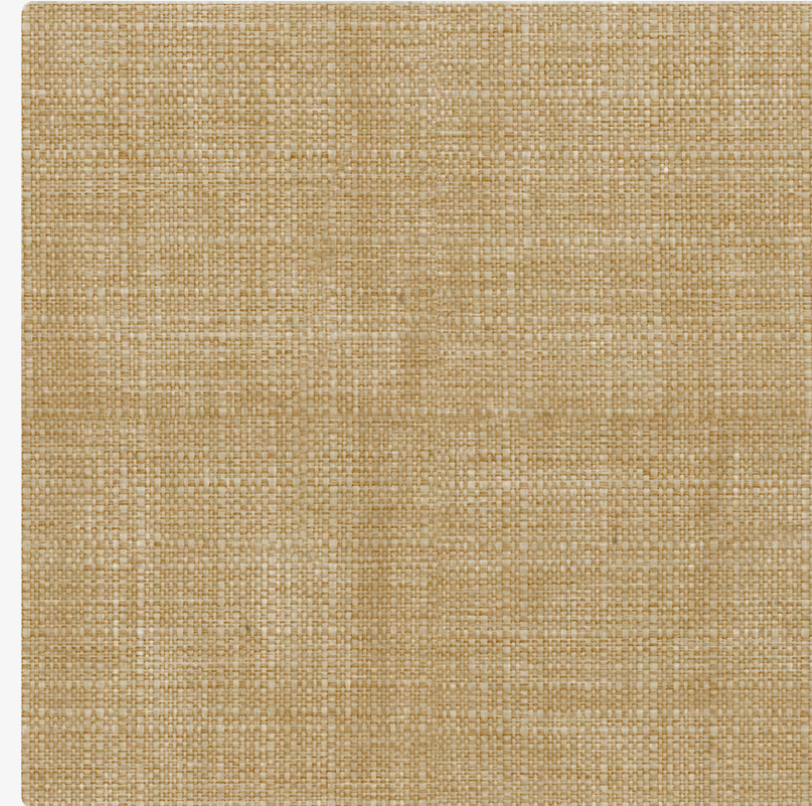
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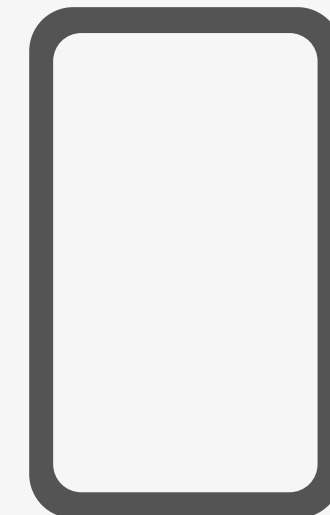
+

Epoxy resin

+

- Oven curing
- Vacuum bagging
- Compression moulding

+

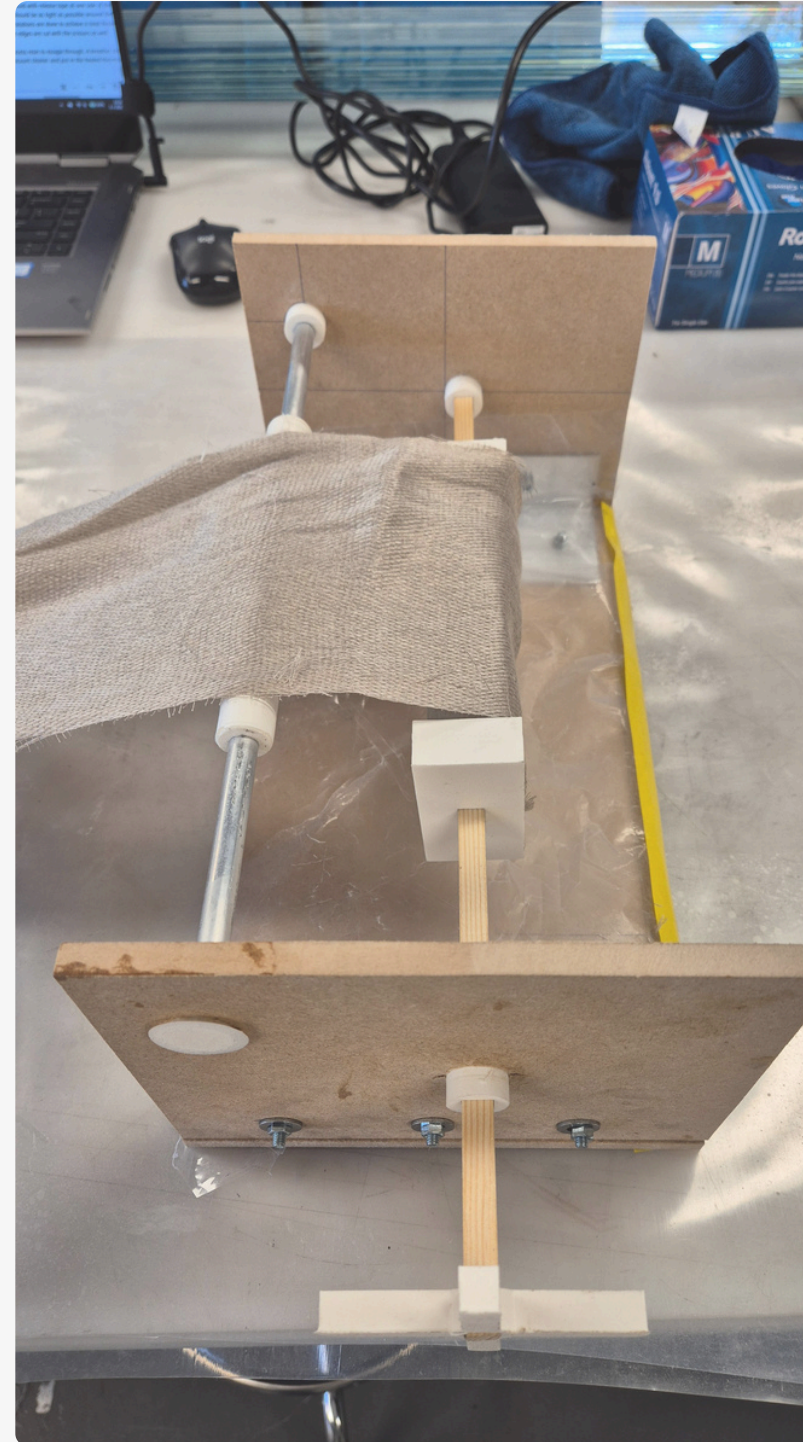


Initial experiments

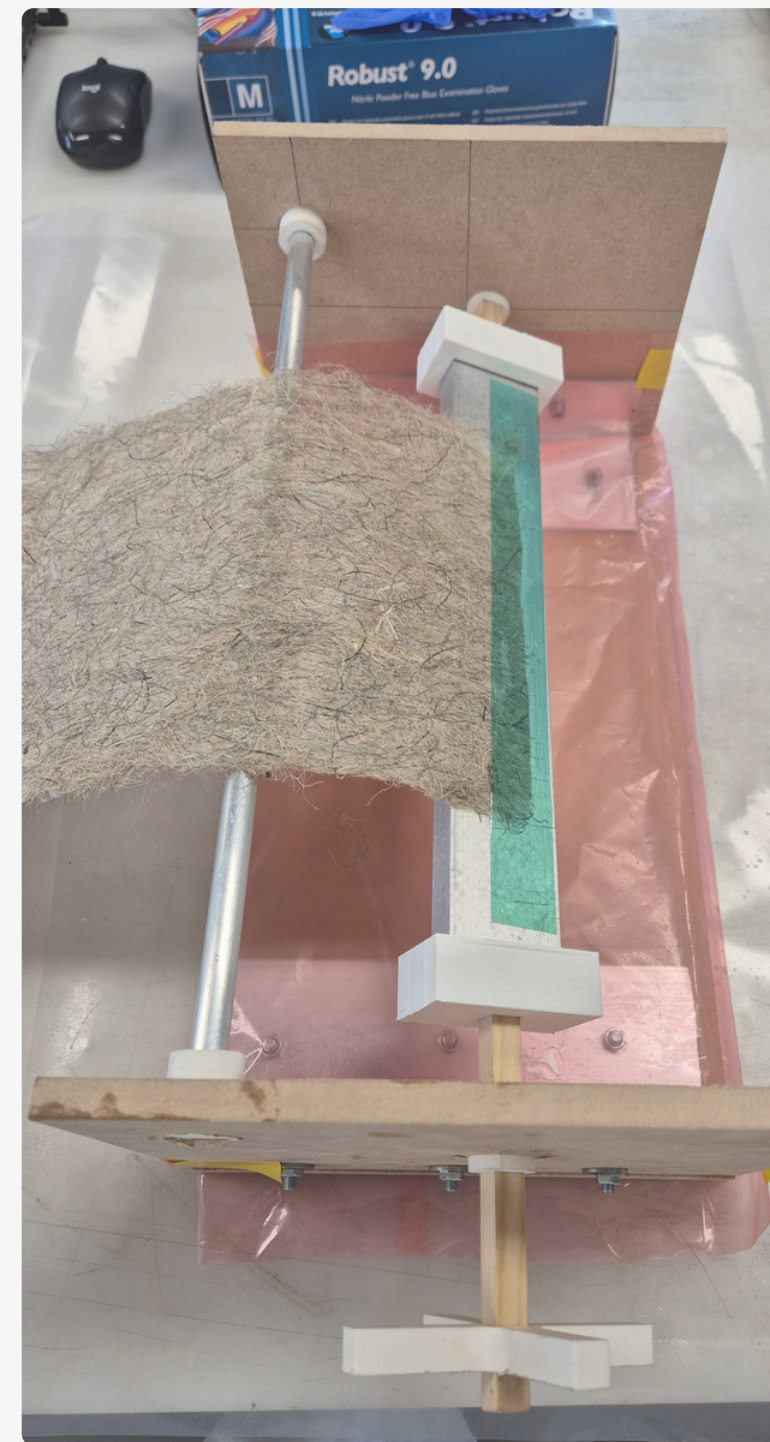
Manufacturing initial samples



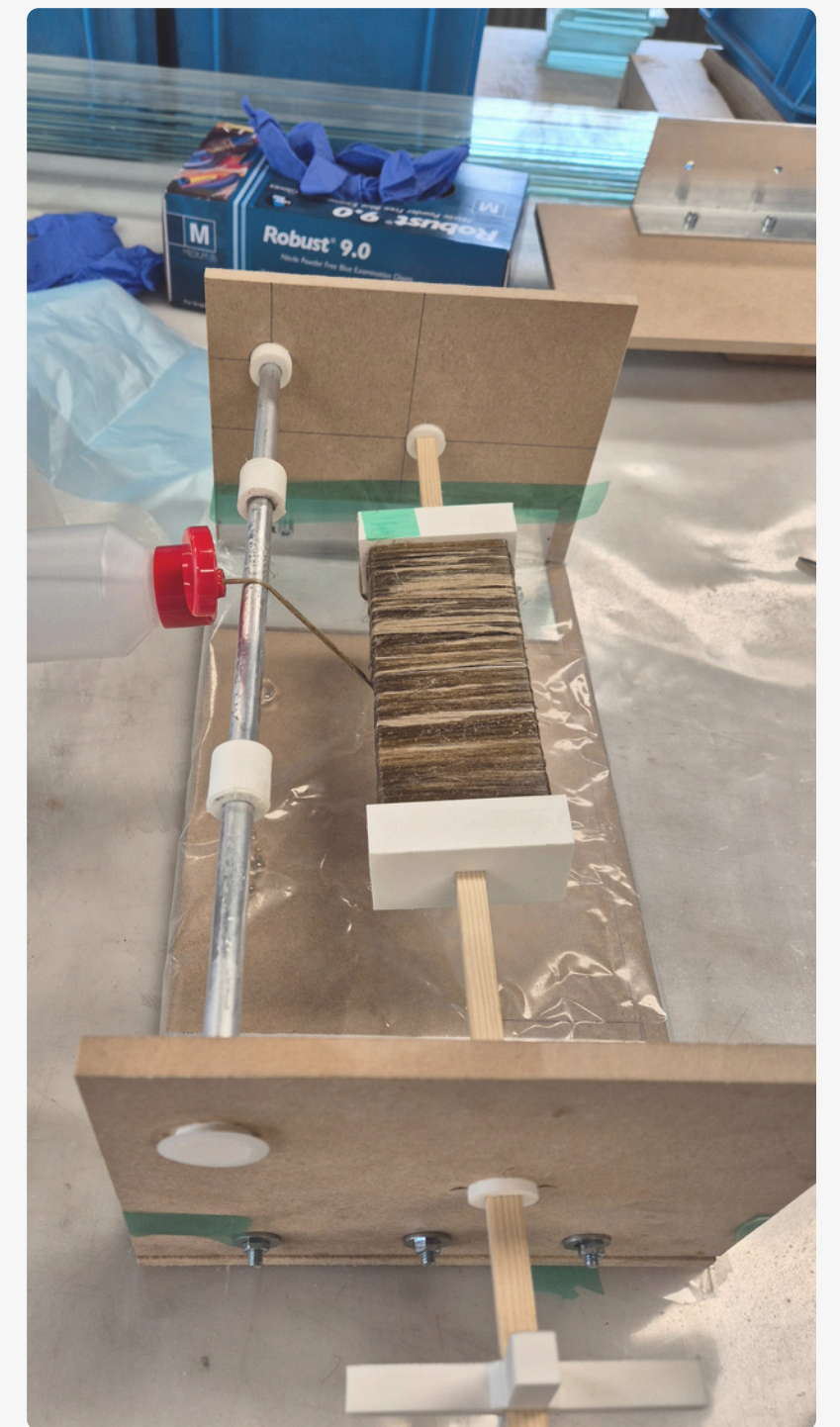
Set-up



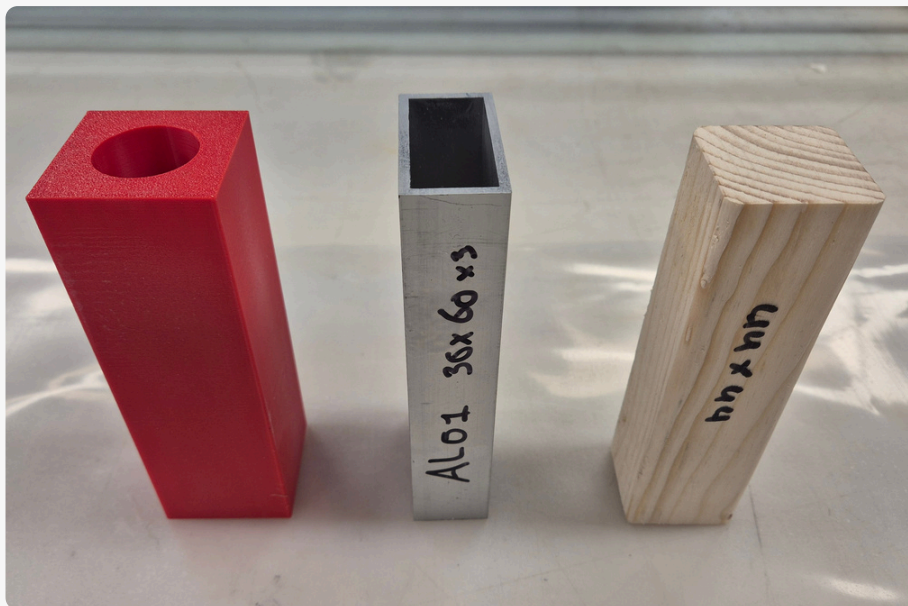
Cross-stitched flax fibre



non-woven hemp fibre
mat



Flax fibre yarn



Mould materials

Results of initial experiments



Results of initial experiments



non-woven hemp fibre mat



Results of initial experiments



non-woven hemp fibre mat



Cross-stitched flax fibre cloth

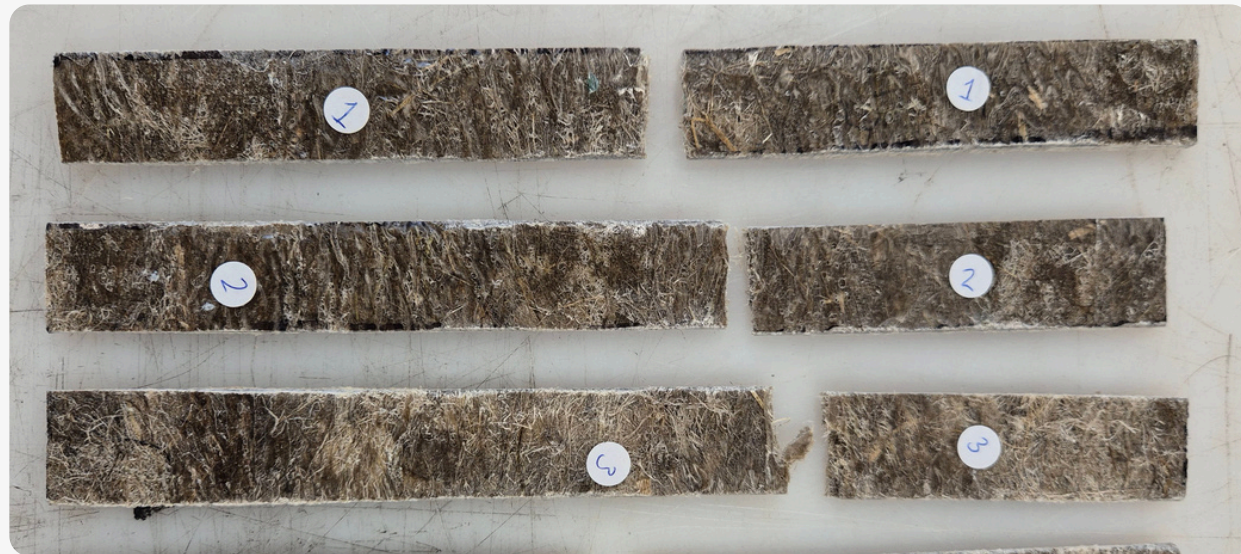
What is the strength?

Mechanical tests

Tensile tests at the Faculty of Mechanical Engineering



1. Cross-stitched flax fibre cloth



2. Non-woven hemp fibre mat

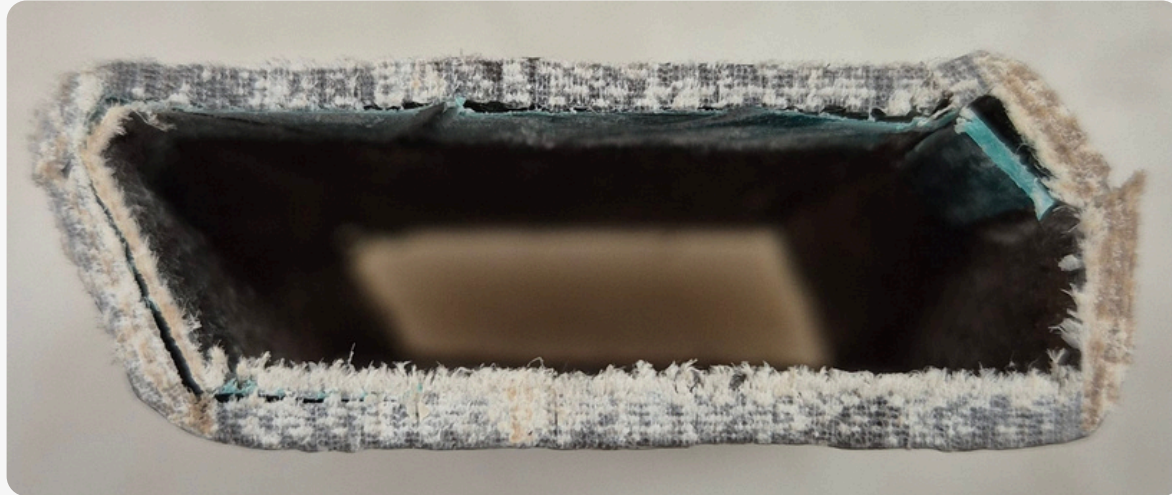


Mechanical tests

Three-point bending test at the Thinklab



1. Cross-stitched flax fibre cloth



2. Non-woven hemp fibre mat



Results of the mechanical tests



1. Cross-stitched flax fibre

- progressive failure
- Thermal expansion comparable to steel
- Strength comparable to structural timber



2. Non-woven hemp fibre mat

- Brittle, sudden failure
- Thermal expansion comparable to aluminum
- Strength is halve of that of the cross-stitched flax fibre



Manufacturing the final profile geometry and facade model

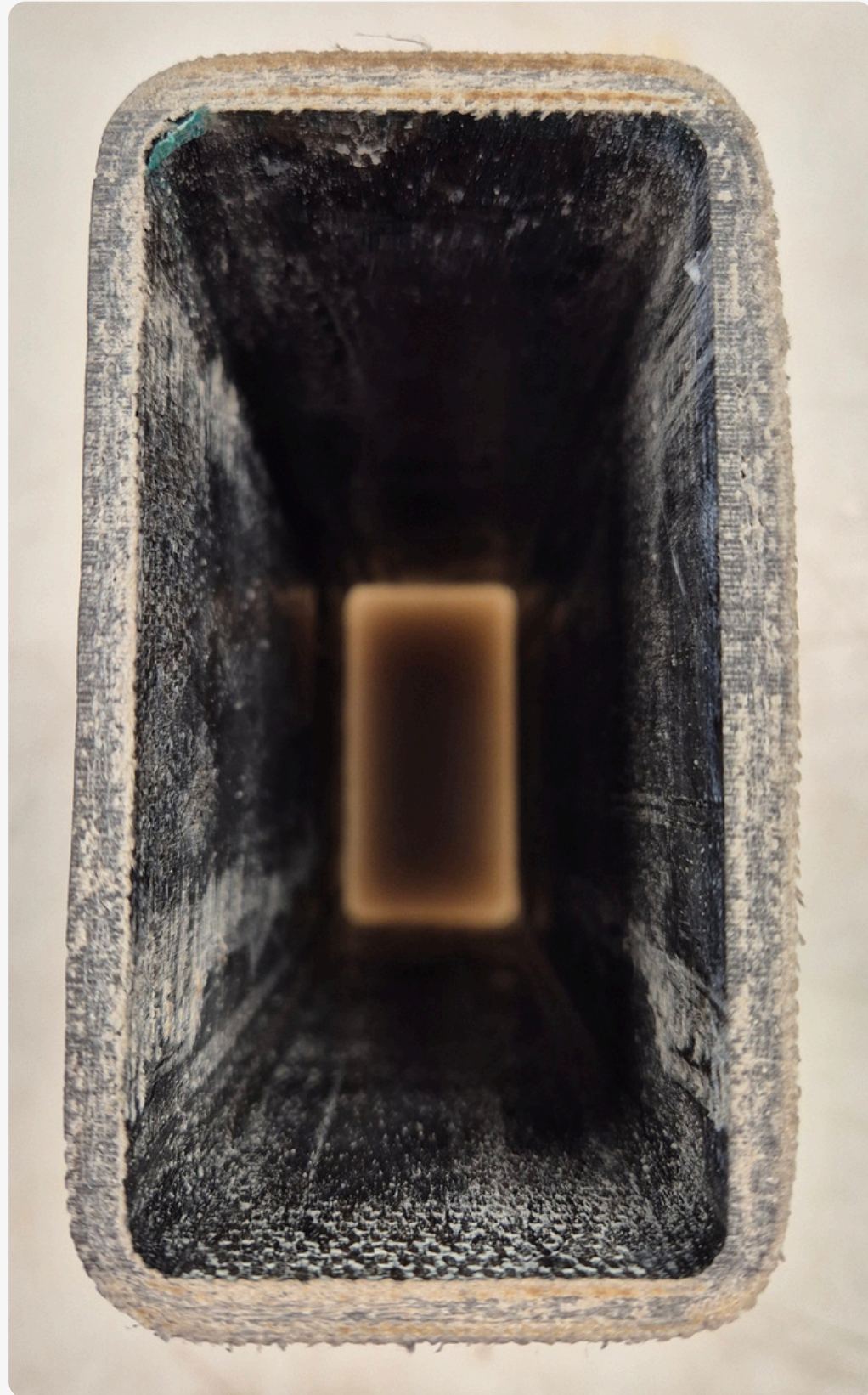
Manufacturing the final profiles



Video

1. Mixing the epoxy resin

Manufacturing the final profiles



Manufacturing the facade model



Manufacturing the facade model



non-woven hemp fibre mat



Manufacturing the facade model



non-woven hemp fibre mat



Cross-stitched flax fibre cloth

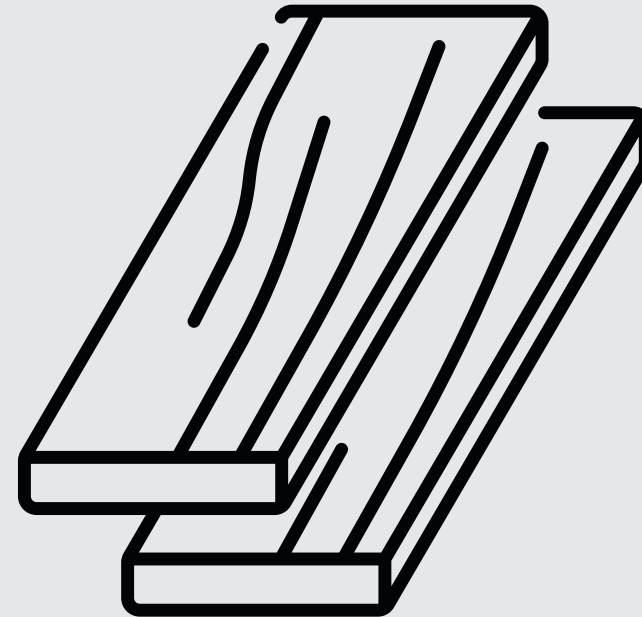
What about the performance?

Relation to set performance criteria



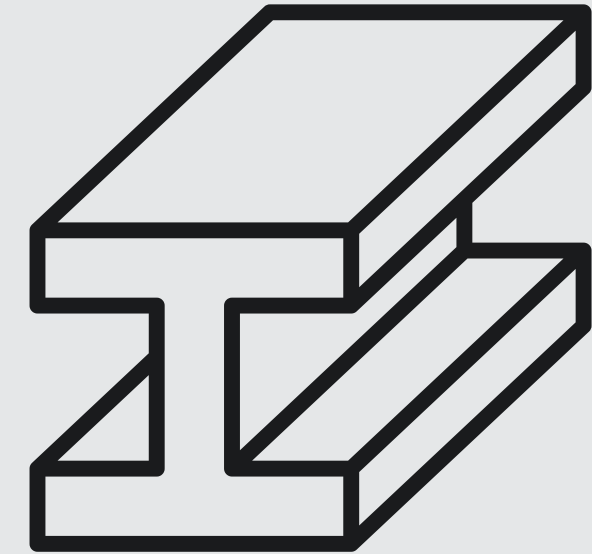
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Profile performance

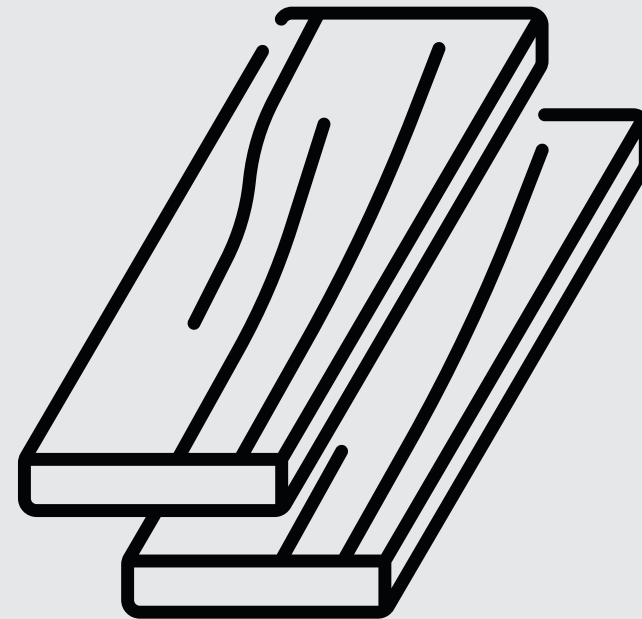
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- Minimal surface errors & constant wall thickness

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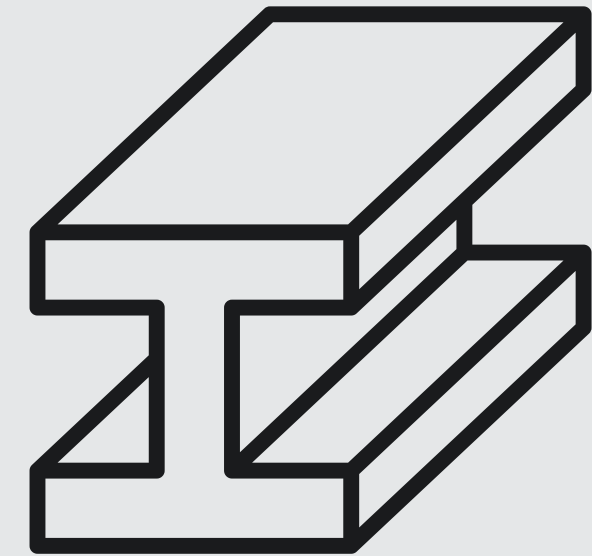
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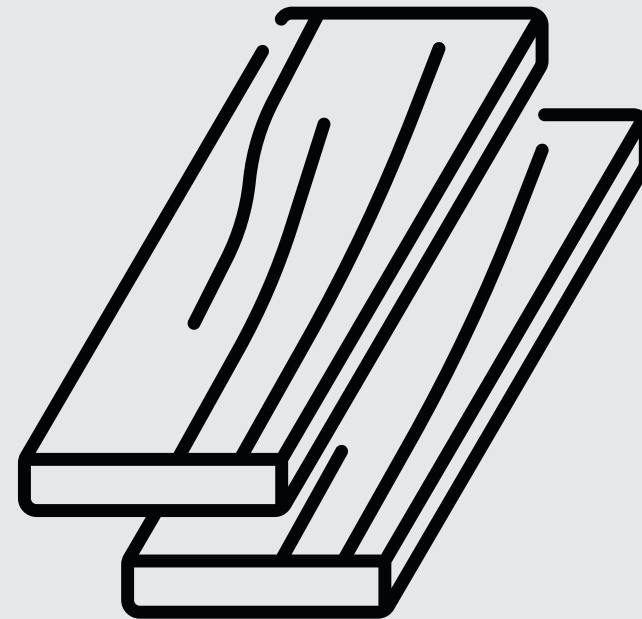
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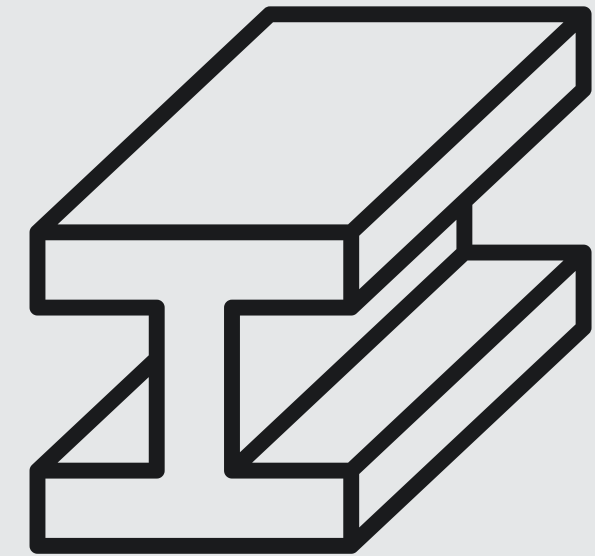
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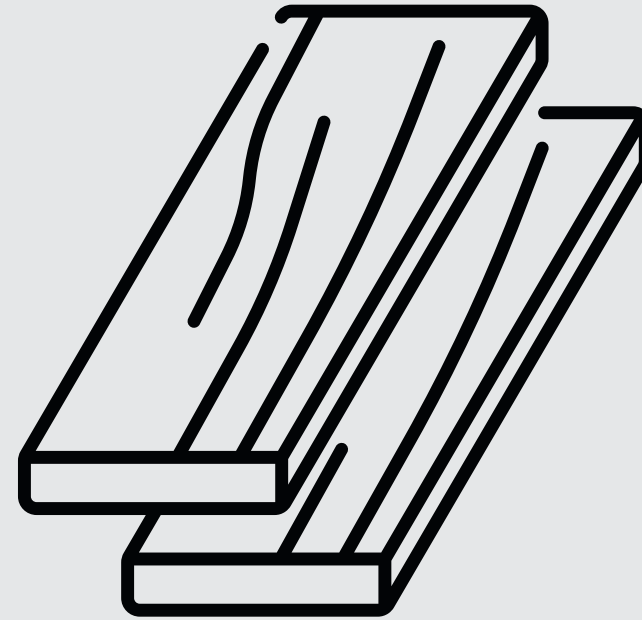
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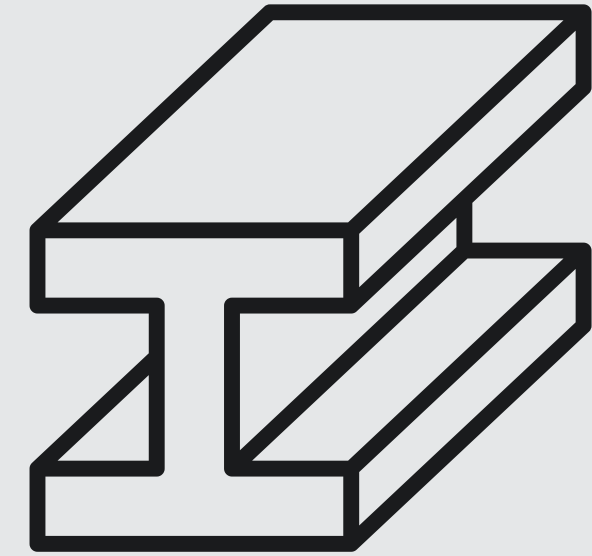
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Overall conclusion

"To what extent can plant-fibre reinforced composites be shaped into complex façade profile geometry that meet the requirements of curtain wall systems?"

- Manufacturing of the complex profile geometry is possible with low-budget materials and standard equipment.
- The profiles do not yet constitute a direct, drop-in replacement for aluminium curtain wall members for now.
- Study is a successful proof of concept with great potential for future implementation and future carbon reduction in façade design.



