Design Project – SIE 2022

Sustainable Housing: Utility of Hemp and recycled Mattress as an alternative to cement

Students: Tian Tian, Qiming Sun
Company: Cooperative Glaernisch Textile: Martin Kloeti, Erich Chiavi, Bhavish Patel; ***EPFL supervisor***: Prof. Christian Ludwig

Objectives

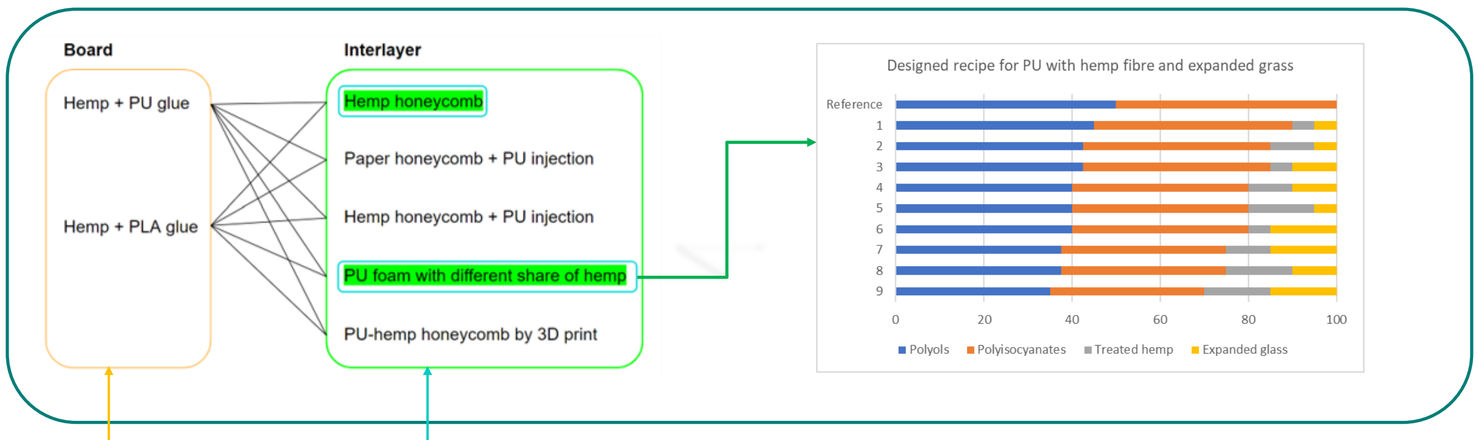
Today we are working to build a sustainable future. Considering **(a)**the high GHG emission by concrete and cement, **(b)**the large amount of waste mattress and **(c)**the potential of hemp fiber, we define the objective is:

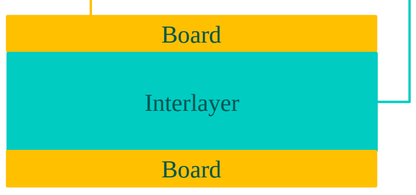
- Carry out a design of sandwich structure to combine hemp and recycle polyurethane from mattress.
- Implement an environmental and economic assessment of the design options.

Methodology

- Literature review: polyurethane recycle from mattress, hemp enforcement polyurethane foam and sandwich structure in construction.
- Material flow analysis about the design recipe.
- Cost-benefit economic assessment.

Designed Recipes





The board and core in sandwich construction are designed separately. The design of panels considers the use of hemp fibers combined with recycled polyurethane and biodegradable polylactic acid, respectively.

The focus is on the structure and material of the core material. After discussing many different options, it was decided that a honeycomb structure similar to Ecocell AG and the use of polyurethane foam reinforced with hemp fibers would be more feasible.

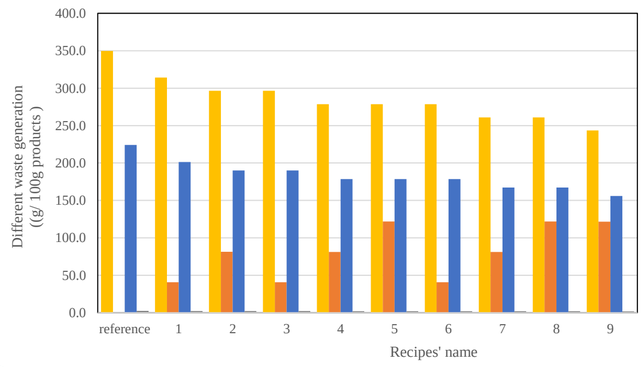
Then we focused on the proportion of hemp fibre in polyurethane foam. The expanded glass is introduced to increase the thermal insulation. As we find in literature, either too much or too little additives will result in degraded performance. We designed 10 tests to get the best one, and the reference is the pure polyurethane foam.

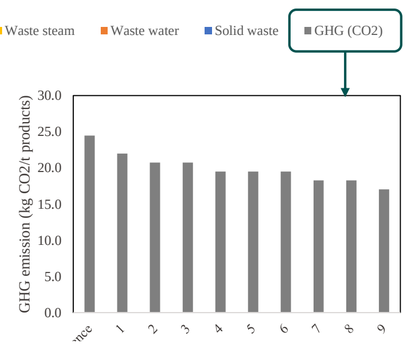
Recipe Selection

Material Flow Analysis

The MFA results show that

- The solid waste, waste steam and GHG emission, generated from mattress split, PU hydrolysis and PU production, decrease with the decrease of PU contents.
- Wastewater for hemp soften change with its content.



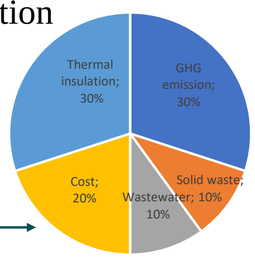


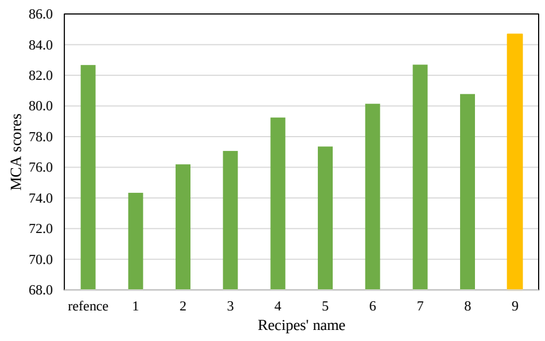
Multi-Criteria Analysis

Integrated different criteria

- Thermal insulation
- GHG emission
- Solid waste
- Wastewater
- Cost

Weights



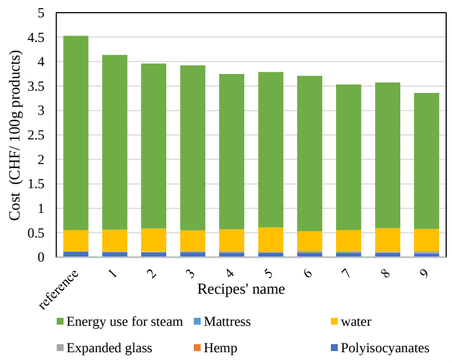


Recipe 9 with the most contents of hemp and expanded glass has the best performance, because its advantage in GHG emission, solid waste generation and cost. Recipe 1 shows huge difference because of no waste water generation, which is an absolute favorable condition.
Here is an example if we give more weights on the GHG emission and thermal insulation due to concern of the climate change and energy saving. There are also interesting results if we care more about cost since it is a new industry.

Economic Analysis

3 main costs: raw materials, energy consumption and waste treatment.

- More hemp content leads to less cost.
- Recipe 9 is the cheapest because of the most hemp content.
- Energy consumption occupies the largest part, because 288 °C of steam is needed in PU hydrolysis.



Conclusion

PU-hemp foam is a valid material for the future sustainable building

- Solution to decrease mattress waste and reduce the environmental footprint
- Addition of hemp fiber help the integrated performance of PU foam in general according to the MCA analysis.
- Good building material for replacing cement: Lower density, Better thermal insulation, Lower GHG emission (9000 times) and similar price, when using vertically pressed columns as reference units.
- A housing model with live and constant loads will help to increase the accuracy of comparison between PU-hemp foam and cement.