Materializing the Meerlanden with Cradle to Cradle

criteria

Materials R&D lab

This report is part of the graduation lab Materials Research and Design. The aim of this lab is to apply an innovative material on the biggest scale possible.

Designing a prototype with this material is the main challenge. Also building a prototype and testing this on its properties is part of participation of this lab. The ZAPPI research program at the TU Delft is testing innovative building materials like glass, cardboard and Grancrete. This making and testing of prototypes in this project is not intended to certify a product for the market but is more the developing of innovative concepts.

Figure 1, mechanical testing of a straw board

design the Meerlanden

building

prototype
The design used for this graduation project was made by the NIBE. It is a pavilion for the Meerlanden to exhibit their activities. Earthship elements like car tires with rammed earth are used. Materials are available within several kilometers.

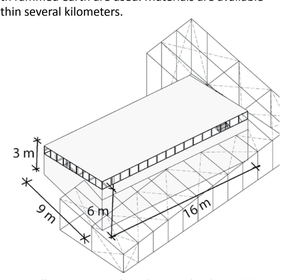


Figure 2, illustration pavilion the Meerlanden, NIBE

energy and water

Heating in winter can be solved with solar energy and waste heat from the nearby composting facility.

Figure 3, composting facilities get 60 °C, innovatiesteunpunt

Rain water from the roof and glasshouse can be collected as gray water. The roof material must not release toxic materials that would pollute the water.

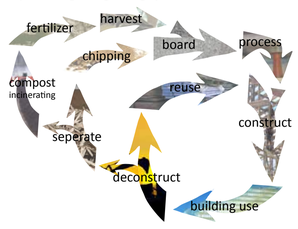
Cradle to Cradle

basics closed cycle

Hybrid materials that can not be seperated have to be avoided. Wood with UF glue is not healthy nor recyclable.

A technical material could be reused or remelted so this can have a closed loop.

A natural material could be part of a reusing, reprocessing or regrowing cycle:



future goal

Materializing a building starts with stop using "red" toxic materials.
The Cradle to Cradle Protocol says that in the next step as much as possible materials from a green, positive list can be used.
Finally the goal is to reinvent buildings. Eatable is a criteria.

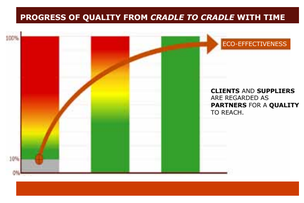


Figure 4, towards eco effectiveness, EPEA

measuring

C2C is a corporate trademark of MBDC. Certification© will always be in collaboration with them or a partner organization. The protocol has qualitative criteria for each level from silver to platinum.

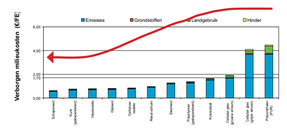
CERTIFIED CM
cradletocradle

environmental effects

Life Cycle Assesments determine the flow of emissions, land use and hindrence of a project. This information can be used to choose the option with an acceptable level of damage. Industries have inproved considerably in the last decades resulting in better air, soil and water quality. It is an optimalisation of the industrial revolution.

With the TWIN-model it is possible to combine all hidden environmental effects and put them into one monetary number. This allows comparison of different options that have the same Functional Unit.

Aim of this project is to minimize the environmental effects with the set criteria. Until we do not rely on fossil fuels and do not pollute anymore this minimizing will be needed.

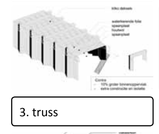


boundary

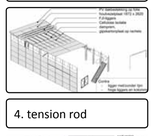
Functional Unit is 1 year of 1 m² roof with a span of 9 m:
- main construction
- finishing construction
- watertight
- acceptable amount of condensation
- minimum insulation Rc of 5 m²K/W
- minimum acoustic insulation of 30 dB

The first designing stage pointed out that should be focused on the ribs design. This has the least visual disturbance.

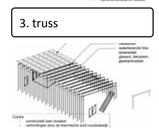
1. curved



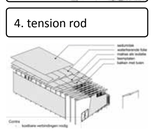
2. ribs



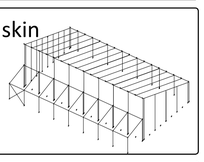
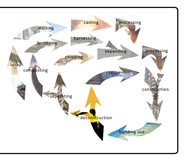
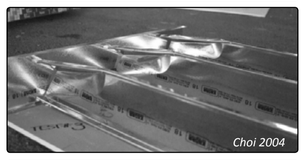
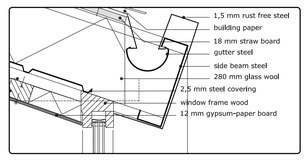
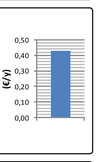
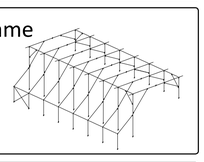
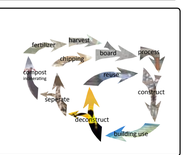
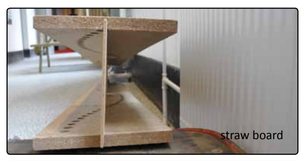
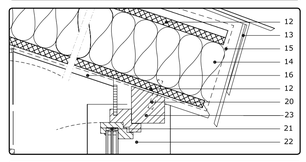
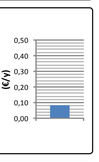
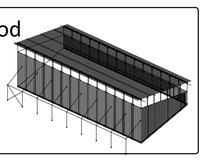
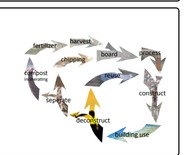
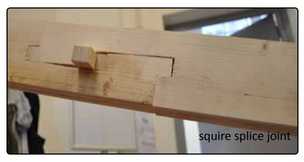
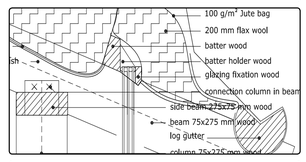
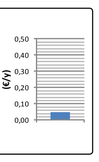
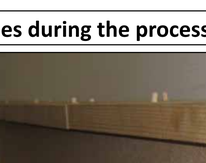
3. truss



4. tension rod



alternative designs

	existing system	use time and possible reuse	Cradle to Cradle materials	construction dimensions	detail for disassembling	Life Cycle Assessment	comparison
technical 	 *Plannja*	reusable: 3 times time before scrap: 100 years 	weight: aluminium fels clad 2,27 kg/FU alu SF19 insulation 0,65 kg/FU corrugated steel 9,36 kg/FU IPE220 /4m beam 5,55 kg/FU **total 17,82 kg/FU**  *SF19*	 Bouwenmetstaal.nl		aluminium fels clad 0,078 €/FU alu SF19 insulation 0,012 €/FU corrugated steel 0,122 €/FU IPE220 /4m beam 0,052 €/FU **total 0,26 €/FU** 	function: o (meets the criteria) LCA index: 19% (0,05/0,26*100%) C2C bonus: o (no added value) **total index: 19%**
steel - wood 	 *Flex-Frame*	reusable: 2 times before seperating: 70 years 	wood shingles, FSC 14,40 kg/FU plate straw 18 mm 8,10 kg/FU glasswool 260 mm 14,00 kg/FU corrugated steel 9,00 kg/FU C360 steel beam 12,21 kg/FU gypsum board 12mm 1,56 kg/FU **total 61,77 kg/FU**  *wood shingles*	 *Choi 2004*	 1,5 mm rust free steel building paper 18 mm straw board gutter steel side beam steel 280 mm glass wool 2,5 mm steel covering window frame wood 12 mm gypsum-paper board	wood shingles, FSC 0,050 €/FU plate straw 18 mm 0,006 €/FU glasswool 260 mm 0,022 €/FU corrugated steel 0,183 €/FU C360 steel beam 0,138 €/FU gypsum board 12mm 0,030 €/FU **total 0,43 €/FU** 	function: o (meets the criteria) LCA index: 13% (0,05/0,43*100%) C2C bonus: o (no added value) **total index: 13%**
stressed skin 	 *Enviroboard*	reusable: 0 times before seperating: 35 years 	wood shingles, FSC 14,40 kg/FU jute fixation mesh 0,20 kg/FU kenaf core flanges 30,80 kg/FU kenaf core web 28mm 3,08 kg/FU kenaf insulation 200 21,00 kg/FU loam finishing 12mm 14,40 kg/FU bee wax vapour barrier **total 84,08 kg/FE**  *extruded kenaf*	 straw board	 12 13 14 15 16 12 20 23 21 22	wood shingles, FSC 0,045 €/FU jute fixation mesh 0,026 €/FU kenaf core flanges 0,022 €/FU kenaf core web 28mm 0,004 €/FU kenaf insulation 200 0,002 €/FU loam finishing 12mm 0,004 €/FU **total 0,08 €/FU** 	function: o (meets the criteria) LCA index: 56% (0,05/0,08*100%) C2C bonus: + (heat recovery - compost/ burn) **total index: 56% +**
wood frame 	 *Courtesy*	reusable: 2 times before seperating: 70 years 	EPDM-membrane 1,41 kg/FU flax wool 200 mm 10,00 kg/FU batters 60x50 /0,6m 1,13 kg/FU beams 2x 75x275/2m 11,34 kg/FU jute closing sacks 0,60 kg/FU loam finishing 6mm 12,20 kg/FU **total 38,88 kg/FU**  *loam finishing*	 squire splice joint	 100 g/m² Jute bag 200 mm flax wool batter wood batter holder wood glazing fixation wood connection column in beam side beam 275x75 mm wood beam 75x275 mm wood log gutter	EPDM-membrane 0,023 €/FU flax wool 200 mm 0,014 €/FU batters 60x50 /0,6m 0,003 €/FU beams 2x 75x275/2m 0,007 €/FU jute sacks 0,072 €/FU loam finishing 6mm 0,002 €/FU **total 0,05 €/FU** 	function: - (bracings occupy the room) LCA index: 100% (0,05/0,05*100%) C2C bonus: + (heat recovery - compost/ burn) **total index: 0% +**
solid wood 	 *Inholz*	reusable: 0 times before seperating: 35 years	SBS 2x 3,5 mm mech. 4,90 kg/FU solid wood 280x1000 126,00 kg/FU wood fibre 110mm 6,00 kg/FU **total 138,90 kg/FU** *SBS bitumen*	overlapping solid wood	natural stone gravel finish SBS bitumen 120 mm wood fibre board roof 75x275 mm wood RVS gutter window frame, fixed	SBS 2x 3,5 mm mech. 0,110 €/FU solid wood 280x1000 0,256 €/FU wood fibre 110mm 0,130 €/FU **total 0,50 €/FU**	function: o (meets the criteria) LCA index: 10% (0,05/0,50*100%) C2C bonus: + (heat recovery - compost/ burn) **total index: 10% +**

prototypes during the process

conclusions

reflection

All alternative designs have a closed cycle of materials. pollution reduced as much as possible with LCA.

There is no design with only biosphere materials. A pure technosphere design is possible within the criteria. Good detailing is essential for a seperation of bio- and technosphere materials.

further research

technical:
- aluminium foil or vacuum insulation
- window frame air tight

steel-wood:
- construction with less cold bridges

stressed skin:
- kenaf core extrusion
- moisture and long term effects on kenaf core
- market and feasibility investigation
- connection of wood shingles without steel nails

wood frame:
- hinge performance of squire splice joints

solid wood:
- overlapping short solid wood parts
- side beams or steel reinforcement

design choice

Because of not fitting the functional unit the wood frame is not chosen as final design. Instead the stressed skin with kenaf core tubes are the best option in total.

A tube element consists of extruded kenaf core (1) filled with kenaf bast fibre insulation (2), finished with bee wax (3), jute fabric (4) and loam plaster (5).

The connection of the wall to roof also has demountable connections. The wall tube elements (1) have loadbearing web parts (2). Wood side beams (3) lay on the webs and connect different tube elements. The roof tube elements (4) are placed on the wood side beam with dowels.

Foundation exists of recycable asphalt concrete (C-fix) elements. Structural behaviour of this material is between concrte and asphalt. So it is less strong but with similar elasticity.

Illustration on the left is of material cycles of the stressed skin design.
The biosphere cycle has on top the harvesting of kenaf plants (srdc.gov.au). At 1 o'clock can seperation of core and bast be seen (mitsubishi-sec.co.jp). Next are core fibres that are processed at 3 o'clock. The extrusion machine produces a tube that is wrapped with jute fabric and placed on site (Stramit). At 10 o'clock are the composting piles (trefgroup.com) and at 11 rowing of new plants (kenafibers.com).
The technosphere cycle has demolition at 9 o'clock, seperation 8 o'clock (recyclingaction-yorkshire.org.uk), transport at 7 o'clock (vliko), melting at 6 o'clock (agc-solar.com), floating at 5 o'clock (agc-solar.com), cutting at 4 o'clock and placement on sita at 3 o'clock.

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overview