Biocomposite pedestrian bridges; design, production and end of life

Alwin Hoogendoorn, January 26th 2017
a.hoogendoorn@avans.nl
Contents

• Introduction
• Materials selection & testing
• Biocomposite bridge design
• Prototyping 2 m sample
• Production of a 14 m bridge
• End of life
• Conclusions
Projects and project teams

4TU Lighthouse project: “B3 Fully biobased biocomposite pedestrian bridge”

SIA Raak MKB project “Biobased Bridge; Biocomposites for civil and building applications”

Made possible through support of:

27 parties involved: truly a joint effort
Composite materials exhibit many special features.

Biocomposites may exhibit additional advantages:

- lower density;
- higher stiffness & fair strength;
- good shock absorption;
- lower health risks during production;
- decreased use of fossil oil;
- (sometimes) biological degradation;
- easier end of life applications.

Feasibility project started in 2014 (www.biobasedbrug.nl)

AIM: feasibility for fully biocomposite pedestrian bridge using regionally grown flax fibre.
Introduction with a short filmclip
Calculations and material testing (material testing: InHolland construction calculations: InH, Avans, TU/e)

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<th>Materiaal</th>
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<th>S</th>
<th>Strength [MPa]</th>
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<th>Elong. [%]</th>
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Bridges have to be beautiful... f.i. Moses bridge by Ro & Ad
At the same time the bridge needs to be feasible and producible.

“Conventional” design: Braided flax beams (students Hein & Stephan)
• Research by design; 45 studenten ontwikkelen prototypes (feb-juni 2016; 8 teams)
• Several prototyping & testing phases
• V shaped beams attractive result
Practice makes perfect
(workshop at InHolland)

Learning how to handle flax; learning vacuum infusion production methods
Design of 14 m bridge

Abacus deflection modeling at TU/e

Work in progress: topologic design optimization

Computer determines:
UD or non-woven, fiber direction & thickness (TU/e)
Mechanical stress calculations

Compression stress all ULS:
- 9.9 MPa

Tension stress all ULS:
14.3 MPa

biobased T 4

Tests results Mani Elhamanian TU/e

Stress (MPa)

Strain (%) 2.5%
Vacuum infusion (introduction)
Vacuum infusion (example)
Huge practical knowledge gained:

- Production in multiple steps
- High resin temperatures
- Connections methods
- Pathway grevel
- Paint and coatings

Pieces were cut for mechanical testing on multiple locations.
Production of fullsize 2 m sample (July 2016)

Materials applied:
- Non woven flax / hemp
- Woven bi directional flax
- PLA biofoam
- Cork / Steam expanded cork
- Bio epoxy resin (56% bio)
Production steps followed (sep-oct 2016)

1. Only support ramp (mould)
2. Shaping the biofoam core
3. Positioning inserts (wood, cork, composite prefab parts)
4. Protecting the core
5. Wrapping the core and inserts in fibre mats
6. Placing injection hoses and support materials
7. Bioresin injection!
8. Mounting and finishing

- Load test in Rosmalen (500 kg/m2)
- Transportation to Eindhoven TU/e campus
- Monitoring with glass fibre sensors
Shaping the PLA biofoam core

Laser cutting of PLA biofoam as core material for 14 m bridge
Resin injection Strategy

approx 400mm
Hurdles towards realisation a.o.:
-Demands conc. railing by Municipality
-Additional funding: Mun. Eindhoven, Province Noord-Brabant, SIA biobased bridge project
-Not enough manpower: Willem I & Bossche Vakschool joined
-Hot bioresin, late delivery from south of France
14 m bridge construction in CoE BBE workshop Rosmalen

2m prefab construction part

8 weeks with 5-20 students/day; 3-4 professionals

7 days/week
Load test 500 kg/m² (October 2016)

Loading:
7 x 950 kg in watertanks

Deflection Measurement results

FE Abacus Model

Glass Fibre strain measurements

Preparing Glass fibre sensors between two layers UD fibre material

FE Abacus deflection prediction: 52 mm
Actual measured deflection: 34 mm
Chemical recycling of the biocomposite materials

Objective is to recover the epoxy resin (15 euro/kg). Pathway is quite easy (cooking at 150°C in a biofriendly solvent).

Before cooking

After cooking in non-toxic solvent

Pieces of NATO airplane (pretreated sample)

Dissolved bio-epoxy resin
The projects on TV...

Just some examples:
Enlightenmentz finale (2x)
June 2016: Studio 040, Brabantsdagblad etc.

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Conclusions & recommendations

Proof of principle for a fully biocomposite bridge was achieved!

City council of Eindhoven already reserved money for a biobridge number 2 at Marienhage Eindhoven.
Additional interest: Army, Tiettsjerksteradiel, België

Still further optimisation needed with regard to product price i.e. smarter production & lower labour cost.

Chemical recycling of biocomposites seems promising.

Research needed into long term biocomposite behaviour (f.i. 50 years)
Questions?

a.hoogendoorn@avans.nl