PERFORMANCE OF BIO-BASED FACADES

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Abstract

The theme of this study is the testing of biobased facade panels. Agrodome and the Centre of Expertise Biobased Economy (CoEBBE) have started a study with about eight different biobased materials and will perform tests on physical and aesthetic aspects. The tests will be performed with the help of students of the University of Applied Sciences, Avans/HZ from the Netherlands. Under supervision of CoEBBE and Agrodome.

The study started with a survey of existing projects with biobased facades. The first results of this survey will be available in the spring of 2019. For the test we will use samples of the selected biobased facade panels. All of them are available on the Dutch market, but in different stages of development.

The materials in the study are made from the most suitable biobased materials for facade panels. An important material for facades is traditional wood, one of the interesting issues about wood is the biobased treatment of the wood. We will test products with different biobased preservation techniques. Another interesting material is cork, that is having a revival in the building industry. The last group is the group of bio composites, where some interesting developments are taking place.

The materials will be tested on their performance as facade panels. Important issues are resistance to the climate (heat, moisture) and the appearance in ethical perspective.

The results will be used to give information about the performance and durability to the stakeholders in the building sector and to give information to make improvements (if necessary) of the products for the producers. We also will use the results to get a better acceptance and understanding of biobased facade panels.

Keywords:
Bio-based, Facades, building materials

1 INTRODUCTION

One of the possible applications of biobased materials in the construction industry is the facade. There are several biobased materials on the market. This varies from wood applications till bio composites. You can find them everywhere. [Sandak, 2019]. In the Netherlands architects and building owners have a growing interest in biobased facades. And in the Netherlands, we have more and more experience with bio-based materials for facades.

For this study we made a compilation of 8 biobased facade products. The selected biobased facade panels are available on the Dutch market, but in different stages of development. And the products are Dutch of produced in Europe. To give an idea of possibilities that are (reasonably) local.

From all these materials we are gathering information about the performance, on physical and aesthetic aspects. Important issues are resistance to the climate (heat, moisture) and the appearance in ethical perspective.

The producers have several projects from where they have gained experience with the materials.

The materials are made from the most suitable biobased materials for facade panels. An important material for facades is traditional wood, one of the interesting issues about wood is the application, treatment of the wood. We will test products with different biobased preservation techniques. Another interesting material is cork, that is having a revival in the building industry. The last group is the group of bio composites, where some interesting developments are taking place.

The information we will gather will be used to spread this knowledge about the performance and durability to the market and to give information to make improvements (if necessary) of the products for the producers. We also want to use te results to get a better acceptance and understanding of biobased facade panels.

2 GOAL OF FACADES

The main goal of facades is to protect a building against influences from the outside.
These influences are mainly caused by the climate and weather conditions. In the Netherlands we have a relatively high moisture component in the air, due to our moderate sea climate. In our climate the facades need to protect against cold in the winter and against heath in the summer. Both not very extreme in the Netherlands, but nevertheless thermal insulation is needed.

Key criteria for the selection of the most proper facades are:

- Fire resistance
- Aesthetic
- Strength
- Weather resistance
- Environmental Footprint
- Practical issues

2.1 Fire regulations

Fire transport
In the fire regulations is the fire transport on the outside of the building the most important feature for facades. In the regulations. Like in the Netherlands this is translated for parts up to 2.5 meters and above 13 meter in fire class B according to NEN-EN 13501-1 and for other facades applications class C of D.

Fire resistance
Depending on the function and position in a building can the façade be part of the mandatory fire resistance rules. This can make some materials for facades not applicable for these functions.

2.2 Aesthetic

Architects and building owners use the facades to give their buildings an appearance that fits with their compony image. When the image that they want to show is representative the aesthetic performance is very important. The colour fastness is an important feature of a material for the architects. And also, the way the materials become older, most of the architects prefer materials that have a controllable or predictable aging process**.**

2.3 Strength

Although the facades mostly do not have a constructional function is the strength important. The facade must be capable to withstand the wind, especially when the building is high. Otherwise the protection will break and will lose its function. The facade could even come loss or fall off, which could lead to dangerous situations.

2.4 Weather resistance

The facades protect the buildings against the weather conditions. This implies that the materials in the facade should be able to cope with water, sand, salty conditions, extreme temperature changes, air pollution and frost conditions.

2.5 Environmental footprint

To fit in the new circular economy the environmental aspects are very important. The environmental footprint is one of the possible selection criteria. This footprint can be found in an Environmental Product Declaration (EPD). of the facade. In many countries the regulations for building permits make an EPD mandatory for materials. If a producer does not have a verified EPD this will be a handicap for the application and use of bio-based materials, because many of these materials do not have an EPD. To tackle this omission Agrodome has made several EPDs for bio-based products, like one for bamboo for the facade [Verspeek 2017]. This issue will be getting more importance for bio-based products (van der Burgh, 2016).

2.6 Practical issues:

For the building owners there are some practical issues that they need to have in view to decide which material they are going to use. For a building owner the total cost of Ownership (TCO) will be the most important. [van der Burgh, 2018] Main issues that have an influence on the Total Cost of Ownership are:

- Financial
  In the building industry price is always a very important criterium. The price question also depends on the position of the decisionmaker and his responsibilities. For the project developer the price of the purchase of the materials is very important. For the building owner is the price of the maintenance during the lifetime and the costs of the disposal of the materials is equally important. For a good decision the whole financial life cycle should be transparent.
- Weight
  The weight of the materials is important because this influences the transport and construction. It is also important for the requirements of the applicator. Can you do-it-yourself or do you need a specialized craftsman and tools.
- Construction requirements
  Some materials need an extra construction behind the panels.
- Disassembly
  Some materials are better suited for dismantling and re-use than others.
- Adaptability in shape
  Some materials are easy to bend, others are stiffer and cannot adapted very easy.

Overview

In the Netherlands we have examined eight biobased products for the facades. This selection is based upon the most recent developments for bio-based facades. We also used the database for biobased building materials [www.biobasedbouwen.nl, Agrodome 2015] and the Catalogue for biobased building materials [van Dam 2019].

In the next chapter these facades are presented in a random order.

3 THE 8 FACADE PRODUCTS

3.1 Resysta

Resysta is a biobased composite. The biobased sheet material of Resysta is made of biological waste material from the food sector which exists for 60% of rice husk, 22% of salt and 18% of mineral oil. Resysta material is resistant to sweet water, salt water and algae growth.

If the product is finished with a clear coat, then a 15-year guarantee is given for colour retention.

It is s multifunctional product and easily processable.

Fig. 1: Building with Resyta facade

3.2 ISOKURK

Isokurk is using the protection technique of the tree, the cork layer is invented by nature to protect trees against fire and physical damage. ISOKURK is an emulsion of 96% cork granulate. The natural resins of the cork ensure the strong adhesion and at the same time a very high elasticity. To create a range of colours pigments will be added in the end of the production process.

ISOKURK is a 100% biobased, 100% water resistant and for 75% vapor open product. It has thermal and acoustic insulation abilities.

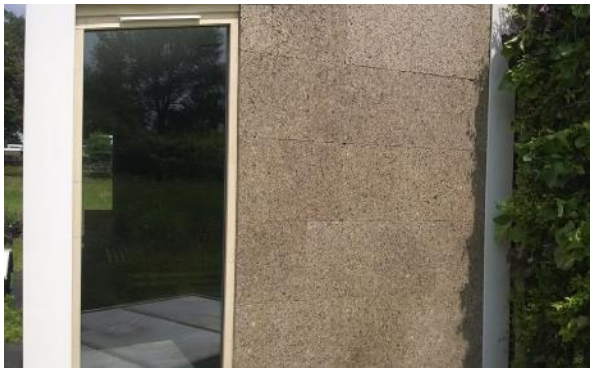

Fig. 2: Piece of a facade with ISOKURK

3.3 Nabasco®

NaBasCo stands for Nature Based Composites. In the Netherlands they produced the first biobased composite facade in 2013. NPSP has developed this concept further and in 2018 created the Nabasco 8010. Nabasco 8010 is a bio-composite that is manufactured of 33% reed or flax, 33% lime and 33% bio resin.

Nabasco® is a biobased and circular material based on waste fibres (reed) from nature reserves, circular lime that is extracted by softening water and a biobased resin based on waste materials of biofuels. It's strong, form-retaining, light weight, low maintenance and durable.

The sheet material can be worked well with various techniques, such as engraving, milling, laser cutting and water cutting.

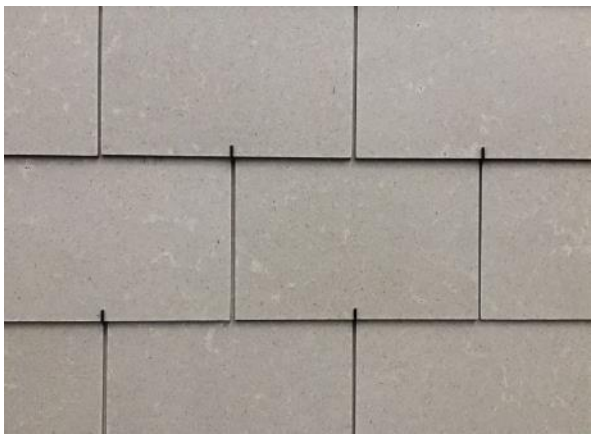

Fig. 3: Slates made of Nabasco®

3.4 Cempanel

Cempanel is a composite of wood with cement. This product combines the strength of wood fibres with the protection capacity of the cement against moist conditions. The Cempanel 'basisplaat' (basic board) has a natural colour (cement grey till yellow-ich) and consist for 52% of wood fibers, 38% cement, 9% water and 1% wood mineralization materials.

Cempanel is a vapor open cement-bound wood fiber board. It is moisture and frost resistant and also resistant to acid, fungi and insects.

Fig. 4: The white parts are cladded with Cempanel

3.5 Xyhlo

Xyhlo Biofinish is a sustainable and 100% environmentally friendly solution for the protection of wood, this bio-based product is based upon a fungus and creates a living protection against outside influences.

It works very well in particular for outdoor applications. For the Biofinish you first apply a natural oil and then a harmless and naturally occurring fungus.

With Xyhlo native, less durable wood species can be protected long term**.** Biofinisch is CO2 neutral or climate neutral. It is a mat, black, living protective layer with the ability to heal itself in case of minor damages. This coating is low maintenance.

Fig. 5: The black wooden parts are coated with Xyhlo

3.6 Nobelwood®

The base for Nobelwood is Spruce from European orogen. The producer modifies the wood with biopolymers from the waste biomass of cane sugar stalks to make NobelWood®.

The pine wood is dreched with biopolymers dissolved in water. The technology is clean, safe and reliable. After drying and polymerization, the originally soft softwood is durable, strong and stable. It looks and behaves like teak. NobelWood® is 100% organic, from responsible forestry.

You can use NobelWood® as a facade panelling without further treatment. With wood oil or other similar products, you can protect the wood against aging and dirt.

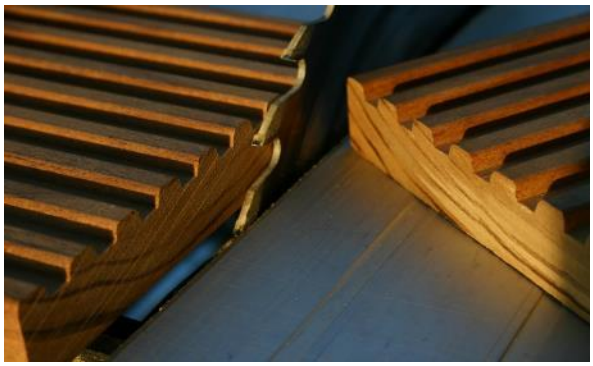

Fig. 6: NobelWood® planks

3.7 Robinia

Robinia (Black locust) is a tree and the wood has a durability class 1 to 2. Robinia is called the hardwood of Europe. For a facade it can be applied without coating. This wood has a lifespan of around 20 to 25 years, hen in contact with the ground. It is the most durable wood that can grow in our climate. And very suited for a facade.

Naturally Robinia wood, also known as Robinia pseudoacacia, has a high resistance against degradation by insects and wood deterioration.

Tests have shown that Robinia absorbs water relatively slow and releases water relatively quick. For facade carpentry, this means that the wood remains dry.

The wood of Robinia is very dense, therefore is the speed of fire transport low.

Without coating the wood will turn from light (honey colour like) to grey in a natural way.

(van der Burgh, 2009)

Fig. 7: A new facade of black locust wood

3.8 Polypyrrole (new development)

SIA RAAK and Saxion University of Applied Sciene looked together with many other SME's at the possibilities and advantages of using PolyPyrrole on wood.

Sustainability in construction is very important for the future and needs to be improved in the next 50 years. Therefore, they investigate different possibilities to make constructions more sustainable and environmentally friendly. This coating is already proven to be successful, but there is always room for improvement. Polypyrrole is based on the formation of connections between the pyrrole molecules. Different experiments were carried out, such as the influence of flame retardants on the reaction between wood and Polypyrrole.

It is a new way that looks promising that is why we spend a bit more attention to this project in our paper.

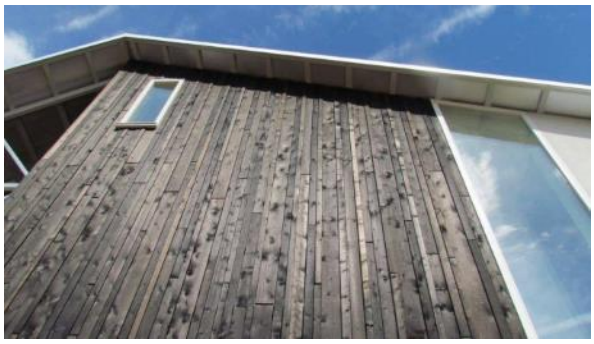

Fig. 8: A silky black facades of PolyPyrrole

Polypyrrole is a polymer with special properties. Applied on pinewood, it provides a nice black colour, in combination with a longer lifespan and mould resistance.
Polypyrrole is a polymer that is used, inter alia, in the medical sector and that is non-toxic and even occurs in blood. Polypyrrole has many special properties.

Other interesting properties are still being investigated:

- It has a preservative effect because it forms long chains. It extends the service life and limits maintenance.
- Price-wise interesting for spruce wood.
- Shrinking and swelling behaviour is limited.
- It is somewhat fire-retardant, combined with additives it is possible to achieve fire class B.
- It also has current conductivity. That is small. It is especially suitable for signal current.

Two components
The ingredients are linseed oil and Pyrrole. The linseed oil-based Pyrrole combination polymerizes quickly. After application, the monomer pyrrole oxidizes to Polypyrrole. Long chains are formed during this polymerization. The Polypyrrole is thus mechanically anchored in the wood. But we also see a chemical reaction occurring, which we are investigating further.

Research project
This project has since been continued in the form of a RAAK SME project, in collaboration with the Saxion School of Business, Building & Technology. Saxion, TNO, Mevo Houtindustrie and Innovita jointly investigated the possibilities of application in construction.

Scaling up / in production
The parties involved now think they have mastered the production process so far that they can start purchasing machines to bring the material to the market early next year. [Saxion, 2018]

Tab. 1: Overview general information about the 8 materials

Table Properties of bio-based facades in the survey

Name	Form	Main Material	Other	Bio-based	Color	Since	Source	Company
Rysysta	Tiles, planks	Rice shives	Salt, resin	60%	Various	Discovered 2004	Waste	Germany
ISOKURK	Sheets	Cork	Resin	100%	Brown	1966	Virgin	Portugal
Nabasco	Tiles, sheets	Reed or flax	Resin, lime	66%	Various	2018	Waste	Netherlands
Cempanel	Sheets	Wood fibres	Cement	53%	Various	30 years	Virgin	Netherlands
Xyhlo	Coating	Fungi	Linseed oil	100%	Black	2018	Virgin	Netherlands
Nobelwood	Planks	Wood	Impregnated	100%	Brown	2015	Virgin	Netherlands
RobiniaWood	Planks	Wood	-	100%	Naturel	1996	Virgin	Netherlands
PolyPyrrole	Coating	Pyrrole	Linseed oil	100%	Black	2017	Virgin	Netherlands

Tab. 2: Overview important technical information for biobased facade materials

Table Properties of bio-based facades in the survey

Name	Weight	Durability	Fire resistance	Vapour diffusion resistance	Shape retention	Colour retention
Rysysta	1.460 kg/m³	Needs research	Euroclass B1	7,22 N/MM²	Needs research	Good
ISOKURK	105 - 125 kg/m³	Needs research	Euroclass E	5 N/MM²	Needs research	Aging to grey
Nabasco	1,71 g/cm³	Needs research	Class 2 - S1-D0	Needs research	Good	Needs research
Cempanel	Appr. 1.250 kg/m³	Needs research	DIN 4102-1 B-s1, do	Needs research	< 1,5%	-
Xyhlo	-	Maintenance require	Needs research	Needs research	-	Good
Nobelwood	360-550 kg/m³	Class 1	D-52, D0. Available in B	Needs research	-	Aging to grey
RobiniaWood	Appr. 750 kg/m3	Class 1-2	Needs research	Needs research	Good	Aging to grey
PolyPyrrole	Needs research	Maintenance require	Needs research	Needs research	Needs research	Needs research

3.9 Other facade materials

There are more types of biobased facades. Most of them are wooden products. We don't have the ability to look at all of them within this study.

Some other products are:

- Thermally modified wood
- Acetylation of wood
- Bamboo
- Durable wood species: Douglas, Larch
- Vegetation walls
- Preserved wood: with different kind of biobased substances

4 SUMMARY

The biobased facades are still relatively new, except for wooden facades. Wooden facades have proven already to be able to perform their function over a long period. Although the research is still in progress, we can already draw some general conclusions. The critical point for wooden facades is the aesthetic performance. Due to the natural aging process. The new biobased coatings and preservation methods seems to give a good perspective to improve the lifetime of the facades and can be useful to preserve the colours of the wooden facades.

The new bio-based composites do not have a long history. The adaption to weather conditions will be a big

challenge for these materials. An important factor to be considered is the right technique for the way the panels are attached to the building.

Further research will help to get more insight in the behaviour and performance of the biobased facades. The most Important aspects are the technical performance (amongst others. Fire resistance, strength) and aesthetic aspects during the period that the facades are used. Other aspects that are interesting are related to the maintenance and end-of-use phase, to get more insight in the Total Cost of Ownership.

5 FOLLOW-UP RESEARCH

The study started in 2019 and will be continue for the coming years. The study will amongst others be part of a project in the European Interreg 2Seas program to support of this follow-up research. The results will be used in the project “Circular Biobased Construction Industry (CBCI)”, duration 2019 – 2021. In this project there are also researchers from KU Leuven and the University of Bath involved together with Avans and HZ from the Netherlands.

During this project students of Avans University of Applied Science will research several technical and aesthetic aspects of these products.

Important aspects will be independent tests of fire behaviour, strength of the materials in the lifetime. Maintenance intervals, developments of maintenance materials. Also, a better view on the end-of-life scenarios. Based upon this we can create new or better insights in the Ecological footprint of the various options. And last but not least transparency in the Total costs of ownership.

The results will be tested and communicated with stakeholders in the building sector from France, UK, Belgium and the Netherlands.

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- Cemplaat: http://www.cemplaat.nl/producten/cempanel-basisplaat/
- Xyhlo: https://www.xyhlo.com/
- Polypyrrol, Saxion
- Robinia: robiniawood www.robiniawood.nl
- Nebasco®: http://www.npsp.nl/oplossing.asp?ID=471

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