SB&WRC Projet

R&D Protocol– Prototype 1

September 2018
Abstract of the project

The SB&WRC (Sustainable Bio&Waste Resources for Construction) project, an undertaking of more than two years, aims to conceive, produce and test three innovative, low-carbon, thermal insulation materials from agricultural co-products and recycled waste. The project is supported by the development program Interreg VA France (Channel) England and its budget, estimated to be 1.8M€, is co-financed by the ERDF (European Regional Development Fund) for 69% (1.26M€ contribution).

This project, led by Nomadéis, is carried out by a cross-channel partnership which gathers academic research laboratories, private research and consulting companies, manufacturers and professional non-profit organisation of the building sector:

- Nomadéis;
- Veolia Propreté Nord Normandie;
- University of Bath;
- Ecole Supérieure d’Ingénieurs des Travaux de la Construction de Caen (ESITC Caen);
- Construction21;
- UniLaSalle;
- University of Brighton;
- Alliance for Sustainable Building Products.
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1. Introduction

The SB&WRC project aims to design and produce three prototypes of thermal insulating materials for buildings, made from biobased and waste-based raw materials. The three prototypes will be produced from underused renewable resources available in the Interreg zone: rapeseed and maize stalks, textile (duvet) and wheat straw. The main objective is to obtain materials whose carbon footprint is at least 25% less than conventional insulating materials such as mineral wool. The research and development process also aims to produce economically competitive insulation, primarily in terms of energy efficiency but also of indoor air quality, sustainability.

The Work Package 4 aims to produce and characterize Prototype 1, the insulating material based on agricultural by-products from rapeseed or maize. First of all, this report presents a manufacturing protocol for producing the prototype, followed by the raw material characterization protocol (lab-scale) corresponding to the work module 3. Finally, this report presents a protocol for characterizing physical, mechanical, hygroscopic and fire properties of the prototype. All these parameters were chosen to be compared with commercial materials. This protocol describes the procedure to be followed for the different tests and the schedule.
2. Manufacturing of the prototype 1

The prototype will be used as a non-load bearing material for a wall application. The aim is to replace the polystyrene, part of Placomur®. The bulk density must be as low as possible but must allow a correct behavior during transport, a dimensional stability. The dimensions proposed for the prototype are 300 x 300 x 25 mm\(^3\), but they could be change, depending on the manufacturing and testing.

To select the formulation and the plant raw material most suitable for the realization of a thermal insulating material, the following criteria were retained: technical criteria (lightness of the final material, low thermal conductivity) and an economic criterion (supply capacity in raw material).

![Figure 1: Thermocompression process for the manufacturing of the prototype.](image)

The technology chosen for the manufacturing of the prototype 1 is the thermocompression. It is a technology that exists on an industrial scale in the production of particleboards and controlled within the Unilasalle research unit. The chosen formulation undergoes compression and heating simultaneously at a temperature and a time chosen according to the type of the constituents of the formulation in a mold designed to the desired dimensions (Figure 1).
3. Characterisations of raw materials

3.1 Physical properties

- **Bulk density** (kg.m\(^{-3}\)): The bulk density of plant-based material is defined as the ratio of its mass to its volume. This test is performed according to the procedure implemented by the RILEM TC 236BBM.
- **True density** (kg.m\(^{-3}\)): The density of the solid part of the straw can be measured with an helium pycnometer. This test is performed according to the procedure implemented by the RILEM TC 236BBM.
- **Moisture content** (%): The moisture content is calculated from the gravimetric measurement of the mass loss after drying at 105 °C (until a constant mass) on the mass of the dry matter. This test is performed according to the procedure implemented by the RILEM TC 236BBM.

3.2 Chemical properties

- **Biochemical composition**: Determination of parietal components (cellulose, hemicellulose, lignin, extracts) should be performed by Unilasalle according to AFNOR XPU44-162 based on the procedure of Van Soest (1991).
- **Thermogravimetric Analysis** (TGA): Determination of the stability temperature of the material. The rate of temperature increase is 10 °C.min\(^{-1}\).

3.3 Hygrometric properties

- **Water absorption** (%): ratio of the amount of water absorbed in 48 hours on the amount of dry matter. This test is performed according to the procedure implemented by the RILEM TC 236BBM.
- **Sorption-desorption isotherms**: the gravimetric method can be used to determine the sorption capacity of a material. After drying at 50 °C, the sample of agriculture byproduct is placed at different relative humidity (RH) values (the first step at increasing value of RH and then decreasing value of RH) while keeping a temperature consistent. The moisture content of the material is calculated for each step. These tests are performed with a DVS (Dynamic Vapor Sorption), using the same procedure as Hill et al. (2010).
4. **Characterisations of prototype**

4.1 **Physical properties**

- **Apparent density** (kg.m\(^{-3}\)) : the apparent density of a material is defined as the ratio between its mass and its volume.
- **Bulk density** (kg.m\(^{-3}\)) : the density of the material is defined as the ratio of its mass to its volume.

4.2 **Mechanical properties**

- **Bending strength** (N.mm\(^{-2}\)) : a force is applied at a given speed in the middle of the sample.

4.3 **Thermal properties**

- **Thermal conductivity** (W.m\(^{-1}\).K\(^{-1}\)) : the density of the heat flux is measured for a consistent difference of temperature by means of a heat flow. The test is carried out with samples conditioned at 50% relative humidity but can be performed at different humidities.

4.4 **Hygrometric properties**

- **Water absorption coefficient** (m\(^3\).s\(^{-1}\)) : corresponds to the mass change of the specimen whose lower surface is in contact with water.
- **"Moisture Buffer Value" (MBV) (gm\(^{-2}\).% RH\(^{-1}\)) : One side of the material is exposed to a cyclic relative humidity that allows the evaluation of a regular rate of adsorption-desorption of moisture per unit surface, according to the Nordtest protocol (Rode et al., 2005).

4.5 **Fire resistance**

- **Small flame ignitability** : involves applying a flame for a given time on the lower edge of a sample of materials. This test is performed according to ISO 11925-2.
5. **Schedule of the Project**

The following Gantt chart shows the manufacturing time of the prototype and the tests to be performed.

<table>
<thead>
<tr>
<th>Manufacturing</th>
<th>April 18</th>
<th>May 18</th>
<th>June 18</th>
<th>July 18</th>
<th>Aug. 18</th>
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*Figure 2: Gantt chart of the project for the manufacturing and analysis for the prototype.*

6. **Conclusion**

This document presents an R&D protocol for prototype 1 of SB&WRC project. The values obtained after applying this protocol will then be compared to the specifications defined in the design sheet in order to validate the list of specifications.
References

AFNOR XP U44-162, Amendements organiques et supports de culture - Caractérisation de la matière organique par fractionnement biochimique et estimation de sa stabilité biologique.


EN 322, Wood-based panels - determination of moisture content.

EN1363-1, Fire resistance tests. General requirements (2012).


The SB&WRC project is part of the Cross Border European Territorial Cooperation (ETC) Program Interreg VA France (Channel) England and benefits from financial support from the ERDF (European Regional Development Fund)