BioBuild

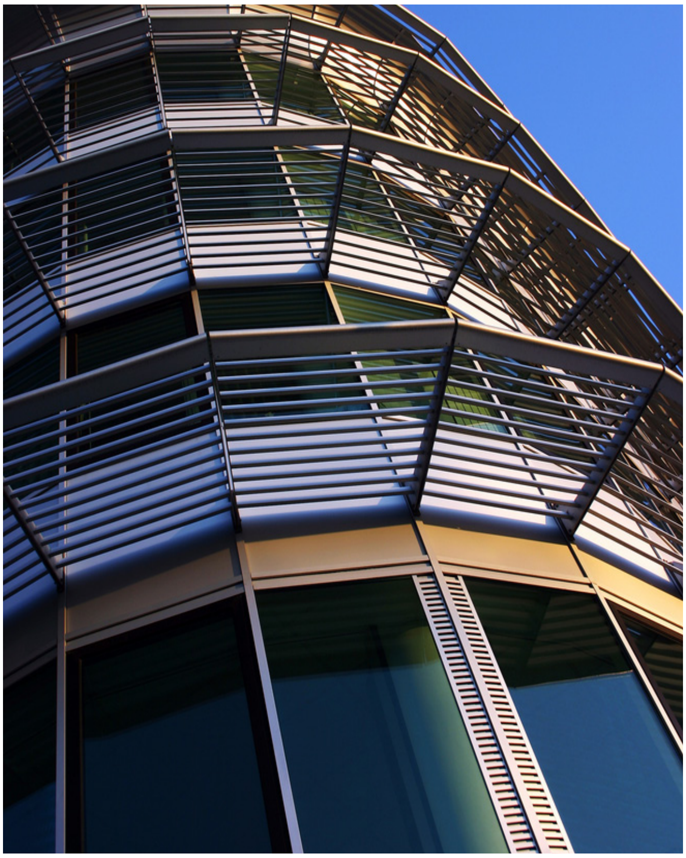
Contents

Biobuild Newsletter: Issue 2, 2014

Project Overview

BioBuild is a collaborative project part-funded by the European Commission. It has 13 partners from seven European countries and a total budget of over 7 million euros. The project will run for 3.5 years, ending on 31 May 2015.

The aim of the BioBuild project is to use biocomposite materials to reduce the embodied energy in building façade, supporting structure and internal partition systems by at least 50% over current materials with no increase in cost. This will lead to a step change in the use of sustainable, low carbon construction materials, by replacing aluminium, steel, brick and concrete in new-build and refurbished structures.



Biocomposites have the same structure as traditional fibre reinforced polymers (FRP), but the sources of the raw materials are bio-based and sustainable. The resins used in this project are derived from sugars (bio-polyester resin) and agricultural wastes (polyfurfuryl alcohol resin).

The fibres being used are flax and jute. These can grow in poor soil and have a long history of industrial application. Individual flax fibres have mechanical properties comparable to those of glass fibres, whilst having approximately half the density. Natural fibres have significantly lower environmental impact than glass, in particular in the areas of climate change, ozone depletion, toxicity and eutrophication. The energy required to produce flax fibres suitable for composite applications (9.7 MJ/kg) is far less than glass (55 MJ/kg) and carbon fibres (130 MJ/kg). Jute provides similar environmental credentials at a lower cost and reduced mechanical performance but with better moisture resistance.

Biocomposites are already used in a number of commercial applications, most notably in automotive interior parts, but for outdoor applications they can be susceptible to long-term degradation caused by moisture absorption and bio-degradation. BioBuild will develop biocomposite materials and construction products with a life span of at least 40 years, by protecting the natural fibres with novel treatments and coatings and improving the overall biocomposite properties. To reduce panel weight and for acoustic and thermal insulation, sandwich structures will be produced using cork or other biobased core materials.

The result of the project will be low-cost, lightweight, durable and sustainable biocomposite building components, with full technical and environmental validation, which offer low embodied energy construction of large-scale façades, support structures and partitions.

Construction Product Case Studies

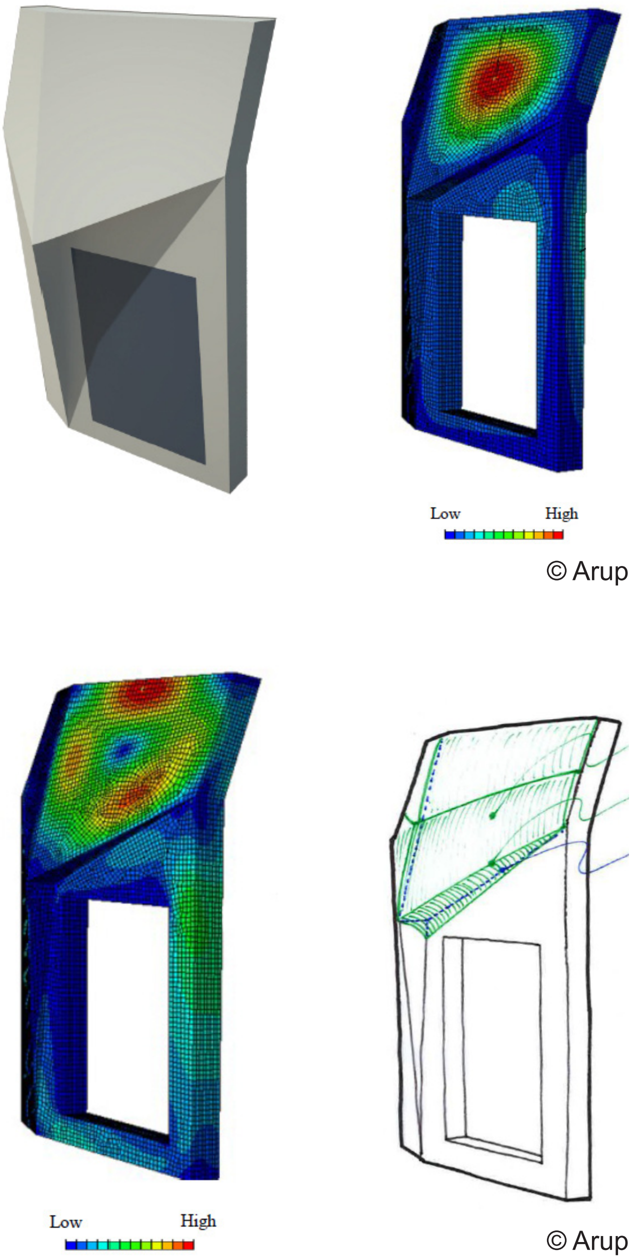
The consortium has selected four case studies to produce demonstrator components. The choice of the parts and the required performance were described in edition 1 of the BioBuild newsletter. Edition 2 updates the thinking on the designs and describes the manufacturing processes which have been chosen to manufacture the parts. The selection of the materials has been informed by the performance requirements and the results of initial QuickScan life cycle assessments to reduce the embodied energy of the parts.

External Wall Panel

The External Wall Panel (EWP) will be prefabricated in the workshop and installed on site. The BioBuild EWP can be defined as a wall element with no internal finish and an external architectural finish. The general function of the External Wall Panel is to act as part of the building envelope, separating the interior from the exterior climate. The panel includes a window. A key feature of the design is that the window does not lie in a vertical plane. This is a design aspect which is more easily achieved using composites than conventional building materials.

Current ideas for the EWP are that it will be a facetted shape which can be tessellated across the façade of the building. It will be a single storey panel. Bespoke segments may be needed at corners. A number of concepts have been drawn up. Finite element analysis carried out on some of the designs showed the effect of wind load on the deflection of the panels. It can be seen that in the centre of the top facet there is a high deflection, so the shape of this panel will be changed to introduce extra stiffness without any penalty on weight.

The BioBuild EWP will consist of an outer skin of biopolyester resin reinforced with flax fabric. This will be self-supporting. Pultrusions of hybrid glass/flax in a polyester resin matrix will be used to provide additional stiffness and strength and to enable the panel to be fixed to the structural elements of the building. Metallic fasteners will be used for convenience and because the development of bio-based composite fasteners is beyond the scope of the project



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One possible design for the EWP (top left) and finite element test results showing the effect of a uniform wind load on the deflection (top right) and rotation (bottom left) and an idea for a modification (bottom right) which is the introduction of a double curvature in the area where the deflections are high.

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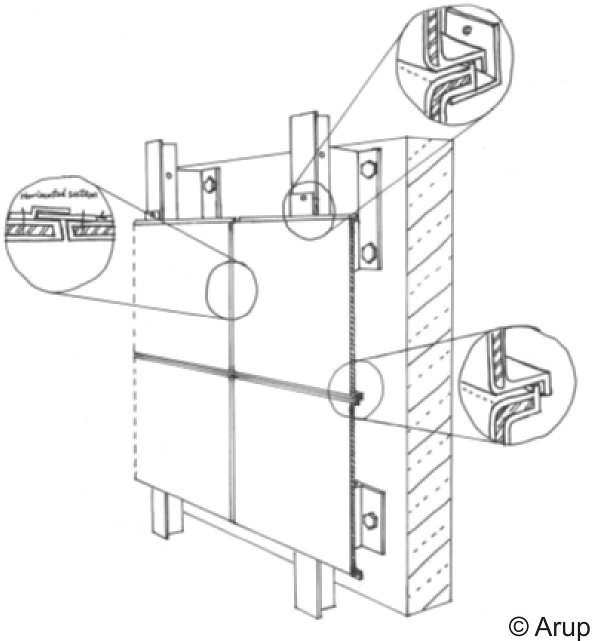
Left - Image of EWP tessellated across a façade.

Construction Product Case Studies

External Cladding Kit

The External Cladding Kit (ECK) is a system with no load-bearing function and is intended for vertical or near-vertical building envelopes. The BioBuild ECK will incorporate a substructure in biocomposites. The general function of the External Cladding Kit is to protect the wall area behind it from direct contact with the exterior environment (rain, snow, wind, impacts). One particular technical challenge for this part is the need to ensure that the edges of the panels do not provide a route for water to enter the composite and wick along the natural fibre reinforcement.

The ECK will be made from flax-PFA panels. The box section will be created by bonding a shaped profile to a flat face. This will provide stiffness and ensure that the outer face remains flat. The profile will be bolted to biocomposite pultrusions which in turn will be bolted to the structure of the building. This will reduce thermal bridging from the outer skin to the inner skin as the biocomposite pultrusion is not a good thermal conductor.



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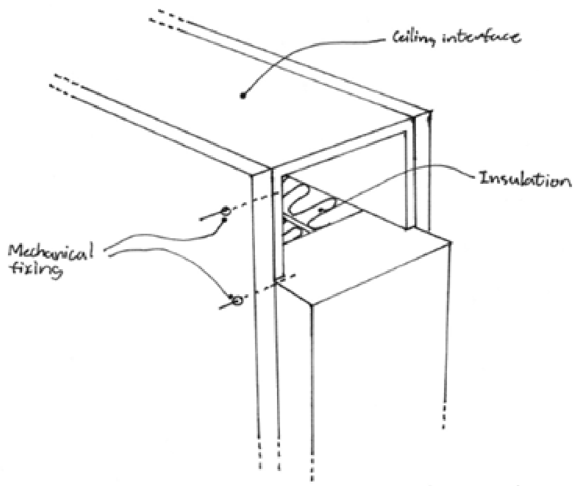
Internal Partition Kit

The Internal Partition Kit (IPK) is a self-supporting, non-load-bearing, vertical structure element used to subdivide a given floor space visually and acoustically. The BioBuild IPK includes a support structure, insulating material, a skin and any fixings needed to ensure its functionality. The IPK will focus on the market for modular interior separating walls built from repetitive prefabricated units. The advantages of bio-composite materials will be utilised to ensure ease and speed of installation, integration of functionality and low embodied energy.

The BioBuild IPK will use skins of jute-PFA. Jute has been chosen for its low embodied energy and low cost. PFA resin will be used as it is intrinsically flame retardant. For aesthetic reasons the panel will be painted with a silicate based paint. This will provide a decorative finish and an additional layer of fire protection. The interior of the panel can be filled with a variety of insulating materials.



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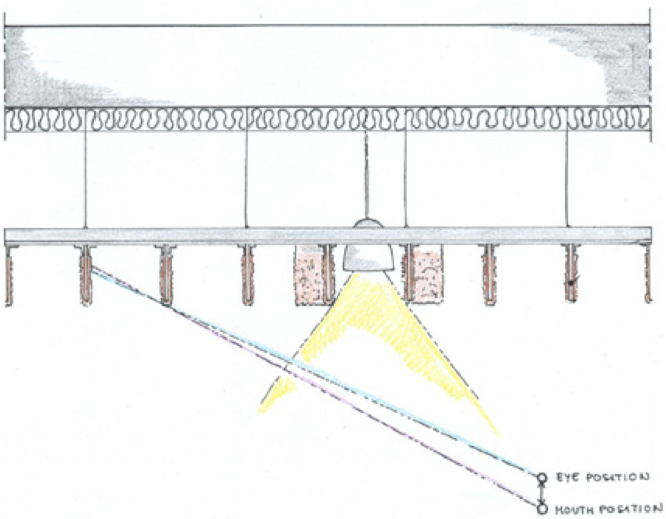
Suspended Ceiling Kit

The Suspended Ceiling Kit (SCK) is a suspended ceiling system intended for internal use only. It will consist of lamella suspended from the structural ceiling which will be made using biocomposites The general function of the Suspended Ceiling Kits is to provide a cohesive architectural surface and acoustic damping while allowing for technical installations to be routed in the space above it. The kit will include any fixings needed for the installed system to comply with the functions described in this document.

Pultrusion would be the most efficient way of producing the lamellae. However, this results in a strip which is too stiff to allow it to be bent around light fittings, etc. Vacuum infusion is therefore being considered as a means of producing the prototype. In both cases the material will be a jute reinforced bio-polyester resin. This will need to be filled with fire retardant additives to meet fire safety standards.



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Composite Manufacturing Methods

Composites can be produced in a number of ways. The four case studies will cover a variety of composite-manufacturing processes but some techniques will be common to two or more of the case studies. The methods will therefore be described by process rather than the manufacture of each case study described in turn. Some of the processes described may not be suited to high volume production but the aim of the project is to produce prototypes.

Wet Lay-up

This is the simplest way of making a composite. A layer of reinforcement is placed on a mould and the resin is applied by hand to the reinforcement. The required thickness is built up in layers. The operator needs to be sure that each layer of reinforcement is well impregnated before positioning the next layer. This method does rely on the skill of the operator but it allows use of a wide range of resins and reinforcements. In BioBuild hand lay-up will be used for the External Wall Panel. The resin will be the bio-polyester resin which can be made to cure at room temperature by varying catalyst levels. Trials will be required to determine the best level of catalyst to allow a sufficiently long working time whilst achieving full cure in a reasonable timescale. Cure may be accelerated by heating the moulding. Wet lay-up has been chosen because the resin will need to contain a significant amount of filler. A pattern will be machined in MDF and from this a composite mould can be created.

Resin Infusion

Resin infusion is a very common way of producing composite parts. It is used for boat hulls and wind turbine blades and is also used as a method of producing façade panels. The reinforcement (brown) is placed on a tool or mould (grey). This mould may have been coated with a gelcoat prior to introducing the reinforcement. Either way, the mould needs to have been treated with a suitable release agent. A layer of peel-ply and/or release film is then applied to the reinforcement (brown). On top of this resin flow media is positioned (orange). This is often a mesh, netting or coarse fabric through which the resin can flow. Additional resin flow pathways can also be created (purple). The peel-ply separates the reinforcement from the mesh. The top layer is the impermeable bagging material (red) which is fixed to the tool using an adhesive mastic (blue). This creates a “bag”. The bag is then evacuated and resin is allowed to flow in. The resin will have been pre-mixed to have an appropriate pot life and gel time. Care needs to be taken with the set-up to ensure an even flow front so that the filling is uniform. Once the bag is full of resin the inlet & outlet ports are sealed and the resin left to cure. Oven curing is an option if the oven is large enough to accommodate the mould.

In BioBuild resin infusion may be used for the External Wall Panel, if the filler loading is such that the resin can be infused without the reinforcement filtering the filler. It is also under consideration for the suspended ceiling kit. Liquid resin infusion gives better control over fibre/resin ratio than hand lay-up. It is quicker, because the resin is not introduced until all the reinforcement is in place. Therefore the resin can be allowed to gel much more quickly. There are also far fewer emissions of volatile organic compounds in this process compared to hand lay-up.

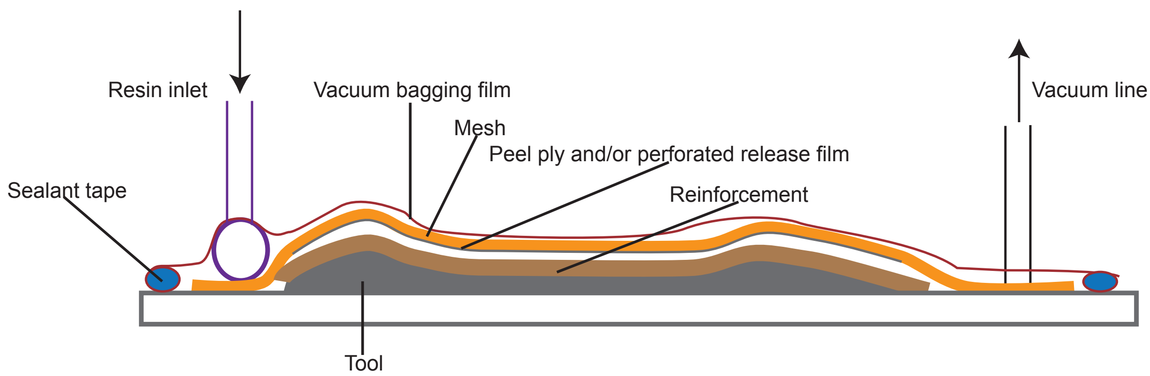

Diagram of the resin infusion process

Composite Manufacturing Methods

Pultrusion

Pultrusion is a way of making continuous profiles. The reinforcement is dipped in the resin and is then pulled through a heated die. The reinforcement has to contain a high proportion of fibres aligned along the profile so that these carry the material through the die. This creates profiles which are very stiff in the longitudinal direction. Chopped strand mat is typically used to provide strength in the cross direction.

Since the resin is impregnated into the reinforcement and then cured immediately afterwards the process works best with polyester resins. These can be catalysed such that they cure rapidly at elevated temperature and they do not contain or evolve any volatiles during cure. It is possible to pultrude with polyfufuryl alcohol resins but the water has to be evaporated in the die so the line cannot run as fast. In BioBuild we will be making pultrusions using a bio-based polyester resin. The pultrusions currently being produced have a glass core and a woven flax skin. Experiments with a unidirectional flax core have started.

Pultruded profiles will be used as supporting structures for the EWP, IPK and ECK. The suspended ceiling kit may be made entirely from pultrusions.

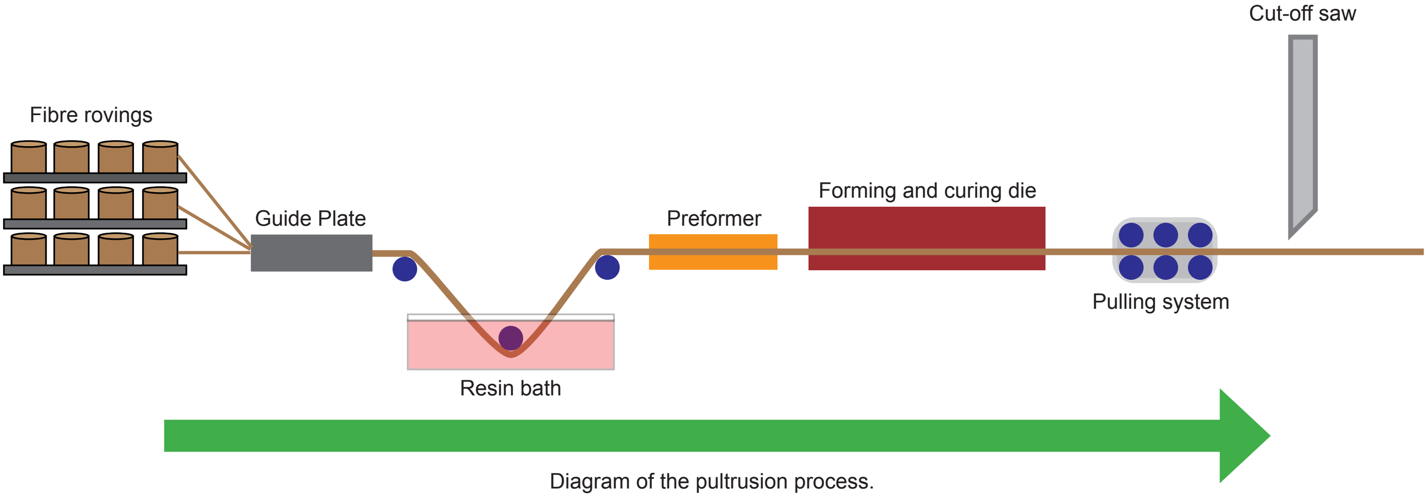

Diagram of the pultrusion process.

Pre-Pregging

A pre-preg is a pre-impregnated fabric. This is an intermediate. Pre-preg is soft and flexible and is made into a rigid composite article by the application of heat and pressure. In BioBuild pre-preg is made with the polyfurfuryl alcohol resin. This resin is supplied as a solution in water. The natural fibre fabrics are dipped in the solution and then the water is evaporated. Resin pick-up can be controlled either by nip rollers or by changing the concentration of the solution. The resin in the pre-preg is only partially cured, so the impregnated fabric can be draped over a mould and then heated to set the resin hard. When a polyfurfuryl alcohol resin polymerises it liberates water. One of the technical challenges in the project is ensuring that this does not result in void formation within the laminate.

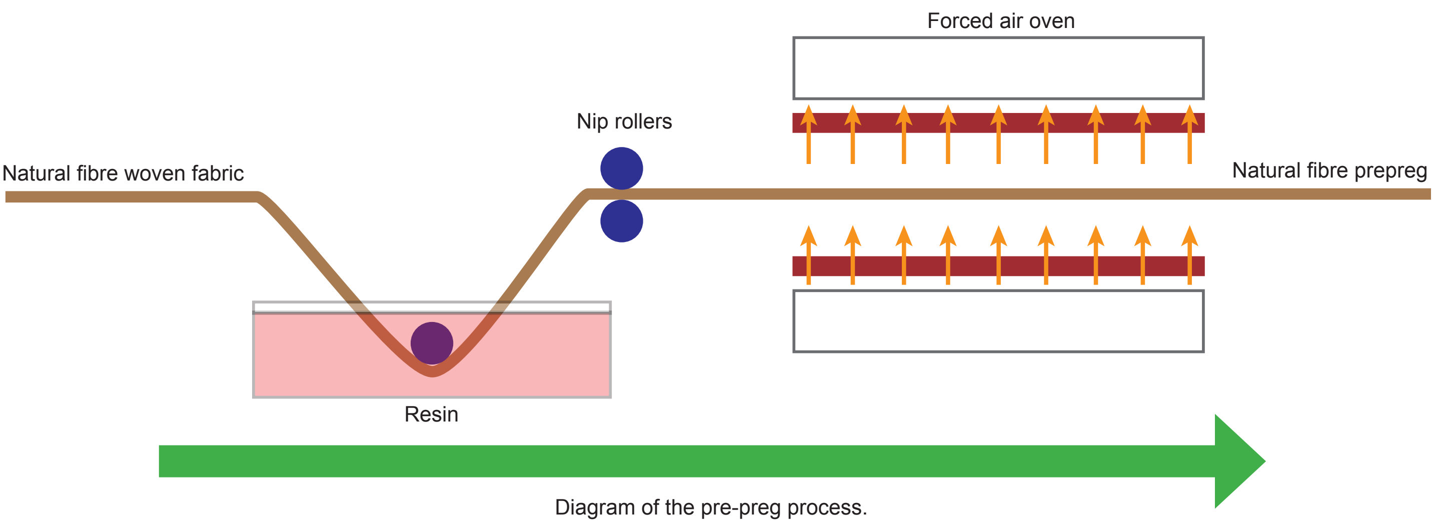

Diagram of the pre-preg process.

Composite Manufacturing Methods

Compression Moulding

In compression moulding the precursor material is simultaneously heated and compressed such that it flows to adopt the shape of the mould and then sets hard. In BioBuild the precursor material will be a pre-preg of natural fibres and polyfurfuryl alcohol resin. The sequence of operations is shown schematically below. The pre-preg is loaded into the mould which is then closed. The mould is heated, so that the resin in the pre-preg goes soft and flows. The raised temperature also restarts the polymerisation. The moulding sits at temperature for a few minutes to ensure that the reaction proceeds to completion. It is then cooled under pressure prior to removal.

The BioBuild internal partition kit will use flat panels which have been made by compression moulding. The ultimate aim will be to produce panels which are 2.4 x 1.2 m in size as this is an industry standard size.In BioBuild we will also be using continuous compression moulding. This is a technique which allows long profiles to be made from a short mould. The press opens and closes at intervals and each time the press is opened the material is advanced a short distance. This process is being carried out by the Institut für Verbundwerkstoffe (IVW) to make the profiles which will be combined to make the external cladding kit.

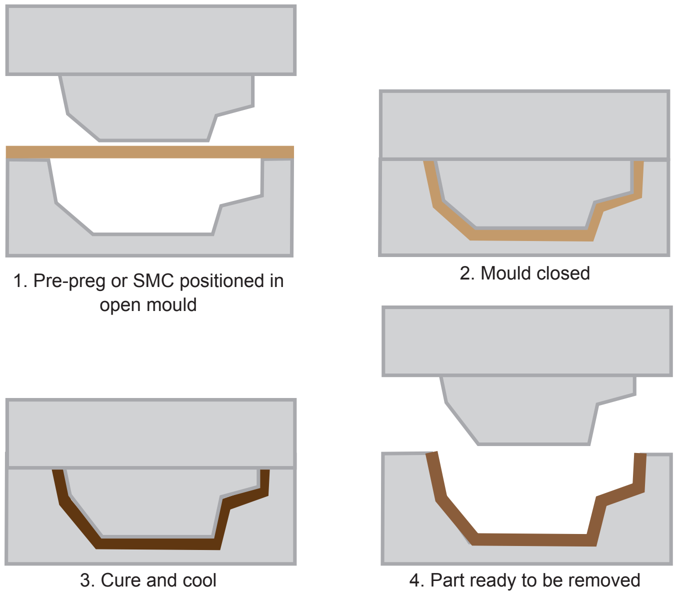

Diagram of the compression moulding process.


Compression moulding machine at IVW.

Review of IIG Meeting

BioBuild has established an Industrial Interest Group. This group will be kept informed about the progress of the project and will be able to steer the project such that it can generate outputs which are relevant to the construction industry. The first meeting of the Industrial Interest Group was hosted by LNEC (National Civil Engineering Laboratory) in Lisbon, Portugal. This meeting gave delegates the opportunity to meet the people involved with the project and learn about the work being done. A series of presentations was made and this was followed by a tour of the laboratories. The presentations were as follows.

- Welcome to LNEC, Jorge Grandao Lopes, LNEC;
- Introduction to the BioBuild Project, Anthony Stevenson, NetComposites (co-ordinator);
- The BioBuild Case Studies, Guglielmo Carra, Arup;
- Environmental Quick Scan as a decision support tool, Rene Gijlswijk, TNO;
- Manufacturing with biocomposites, Jovana Dzalto, IVW; and
- Treatments to combat weathering, Boke Tjeerdsma, SHR.

It has been decided to re-run this meeting but this time it will be hosted by SHR in Wageningen, Netherlands. This will enable us to reach a wider audience. More details about this event can be found here:

http://www.biobuildproject.eu/Events/IndustrialInterestMeetingSHRNetherlands.aspx

BioBuild

Project Partners

Contact

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