BioBuild

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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. The project will run for three-and-a-half 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 (FRPs), but the sources of the raw materials are bio-based and sustainable. The bio-polyester resin used in this project is derived from sugars and the poly-furfuryl alcohol (PFA) resin is derived from agricultural waste. PFA is a carbohydrate and should not be confused with perfluoroalkoxy which also takes the acronym PFA but is a very different polymer! Furfuryl alcohol, the key raw material for the production of furan resins, has a Global Warming Potential (in terms of kg-CO_2-eq) of 1.3, compared to unsaturated polyester resin at 7.5. The fibres are flax and jute, both of which 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.

Research has shown that natural fibres have significantly lower environmental impact than glass fibres, particularly in terms of climate change and ozone depletion. 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 fibre (130 MJ/kg). Jute provides similar environmental credentials at a lower cost and reduced mechanical performance, but with better moisture resistance.

Biocomposites have been used for decades in semi-structural applications, most extensively in automotive-interior parts, but for outdoor applications they can be susceptible to long-term degradation caused by moisture absorption and bio-degradation. Use of biocomposites in structural applications requires aligned fibres (textiles) and optimised resins and fibres. 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. Treatments will also be used to improve the mechanical properties of the biocomposites. To reduce panel weight and for acoustic and thermal insulation, sandwich structures will be produced using cork, or foams manufactured from bioresins.

The result of the project will be low-cost, lightweight, durable and sustainable biocomposite building systems based on panels, profiles, frames and sandwich structures. The systems will offer low embodied energy construction of large-scale façades, support structures and partitions, with full technical and environmental validation.

Biocomposite Materials

The term 'biocomposite' describes a FRP comprising natural fibres, such as flax, jute or hemp, in a polymer matrix derived from natural materials.

Flax and other natural fibres have excellent resistance to fatigue, and good vibration damping, compared to glass and carbon fibres. The specific stiffness of flax is also higher than that of glass fibres, allowing reduced component weights when flax is used to replace glass fibre in composite materials.

However, there is still a question over the durability of these materials in an external environment. They are susceptible to moisture and microbial attack, which results in a swelling of the fibres, causing them to start to lose their reinforcing properties. This swelling can also lead to a loss of the interfacial bond with the resin, and the formation of micro-cracks, which further increase the possibility of moisture transport and uptake. BioBuild will study the effects of various fibre treatments to improve the flame resistance, mechanical properties and durability of biocomposites.

The multi-functional possibilities with biocomposites are demonstrated by the Louisiana Pavilion (shown, right), designed by Danish architects, 3XN. The project was initiated to explore building with naturally derived and energy-generating materials, creating architecture that is energy-self-sufficient and that can be disposed of at the end of its life in an environmentally friendly way.

Bio-based composite materials, made from bio-polyester resin and flax fibres, and hybrid materials incorporating a cork core, were substituted for the usual, synthetic materials. The structure will withstand typical dynamic building loads and, using CNC technology, the structure was tooled and manufactured in six weeks from the receipt of the design, showing the rapid nature of these systems.

Resin systems are being optimised for the case-study applications and for compatibility with the natural fibres.

Poly-furfuryl alcohol

PFA resin is a 100% biologically derived resin, which cures to form a thermoset polymer. Manufacture starts with furfural from the hydrolysis of agricultural waste rich in hemicellulose. The furfural is then reduced to furfuryl alcohol which is polymerized to the resin. PFA resins have good mechanical properties and excellent fire performance (UL94V-0).

Furan resins are used in foundry and refractory applications so there is already a supply chain in place for high volumes. For biocomposite applications, TransFuran Chemicals has developed BioRez and Furolite thermoset resin systems.

Bio-polyester

Hybrid unsaturated polyester resins, composed of 50% biologically derived materials have been developed. The plan is to develop 100% biologically derived bio-polyester during the course of the project. The flexibility of the chemistry of these resins allows the properties to be tuned in order to achieve high compatibility with fibres, together with flame retardancy and chemical resistance. The resins are being developed to suit the process and application requirements considered in the project.

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Construction Product Case Studies

BioBuild started in December 2011. During the first meeting a pre-selection of case-study systems was achieved. A catalogue was established outlining European, as well as national, requirements for the selected case-study systems to form a guide for the design process.

A comprehensive overview — the Design Toolbox — outlining the selected case-study systems was established. This gives a description of each case-study system; explores the market situation; points out direct competition; and evaluates materials and processing capabilities within the consortium.

Boundary conditions, including materials processing and properties, available manufacturing processes and components ready on the market, were defined for the development of case studies. Options for manufacturing were explored in collaboration with the partners whilst also looking at possible improvements to the production processes and components. Designs were presented by 3XN and Arup. The consortium selected four case studies be produced in full scale.

External Wall Panel

The External Wall Panel (EWP) represents an opaque, self-supporting, vertical element that spans one or more floors. The panel could include a window. It is prefabricated in the workshop and installed on site. The BioBuild EWP can be defined as a wall element incorporating an external architectural finish. The general function of the EWP is to act as part of the building envelope, separating the interior from the exterior climate.

Design drivers and technical requirements

- Impact resistance Class E4: 343 J
- Vertical modules 2.6m wide, total height 6.0m.
- Installation using crane
- Include thermal and acoustic insulation within the thickness of the panel
- Rectangular windows may be incorporated
- Reduced number of nodes
- Internal/external surface finishes
- Self-shading structure

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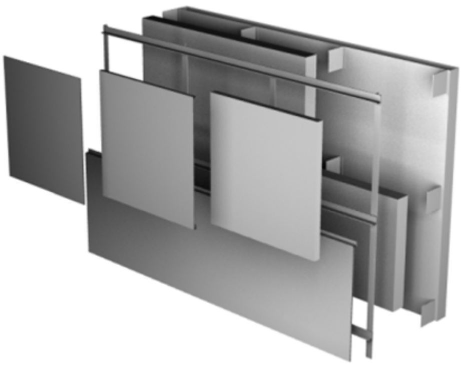
External Cladding Kit

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 may also incorporate a substructure in bio-composites. The general function of the ECK is to protect the wall behind it from direct contact with the exterior environment (rain, snow, wind, and impacts).

Design drivers and technical requirements

- Simple substructure, simple (cheap and quick) installation
- Lightweight: no heavier than 30kg (max. weight that can be handled on site by two persons)
- Flatness of the panels: 2mm/m
- Not load-bearing
- Impact resistance Class E4: 343 J
- Design should allow replacement of individual panels



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Internal Partition Kit

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The Internal Partition Kit (IPK) is a self-supporting, non-load-bearing, vertical 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 prefabricated, modular, interior partition walls. The advantages of bio-composite materials will be utilised to ensure ease and speed of installation; integration of functionality; and low embodied energy.

Design drivers and technical requirements

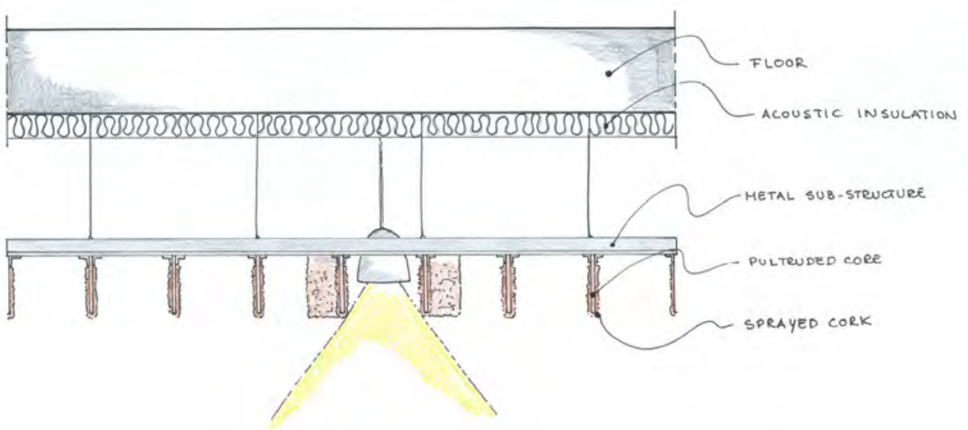
- Acoustic separation of adjacent spaces
- Simple, lightweight substructure, for ease and speed of installation
- Self-supporting panel
- Minimal use of floor space (minimum thickness)
- Impact resistance Class E4: 343 J

Suspended Ceiling Kit

The Suspended Ceiling Kit (SCK) is intended for internal use only. The panels and supporting structure will be made using bio-composites and the kit will include any fixings needed for the installed system to comply with the functions specified in the Design Toolbox. The general function of the SCK is to provide a cohesive architectural surface while allowing for technical installations to be routed in the space above it.

Design drivers and technical requirements

- Open, lamellar structure
- Aesthetic design
- High speed installation with simple connections
- Lightweight
- Not load-bearing
- Possible inclusion of air-control components
- Inclusion of lighting fixtures
- Integration with the internal partition wall
- Simple connection with the substructure



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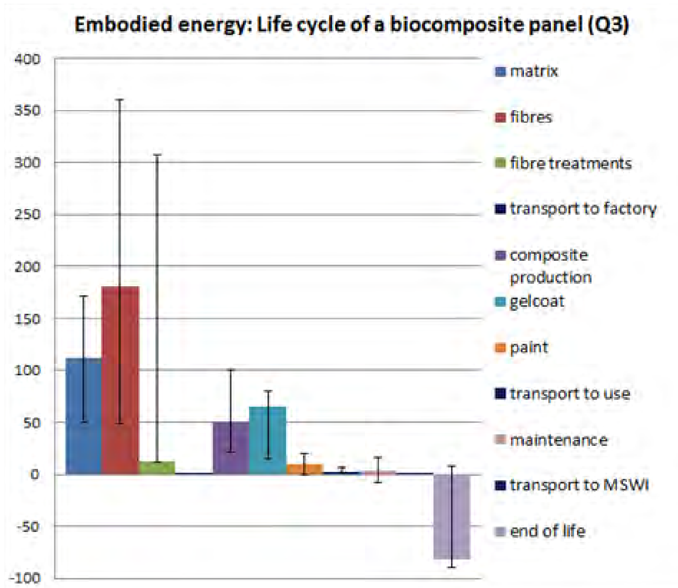
Quick Scan Environmental Assessment

The Quick Scan model is similar in structure to a life-cycle assessment and contains both generic processes which are equal for all material combinations, and variable material and energy parameters. The Quick Scan approach followed in this project enables performance-driven support of key decisions in product development. By means of a pre-constructed model, basic information from experts and a few rounds of iterative communication, important insights can be gained in the relation between choices of materials, processes and design and the environmental impact of a biocomposite-based product. This allows informed decisions and ultimately the optimisation of the product within the technical preconditions. Early assessments help to point out key parameters worth emphasising and items of minor importance which do not require profound effort.

The results so far show that the embodied energy of a biocomposite panel is mainly determined by the production of matrix and fibre preforms. Fibre treatment has a contribution too, yet its main influence is in the extension of the lifetime of the product, thereby reducing the total embodied energy substantially. In other words, it has been advised that the choice of fibre treatment should be made on the basis of its performance rather than on the basis of the environmental properties of the treatment chemicals used.

The embodied energy of the BioBuild products differs amongst the case studies (see pages 4 and 5). In the cases of the IPK and ECK, the BioBuild design now scores lower on embodied energy than all reference materials. In the case of the external-wall elements, the embodied energy of the BioBuild products is somewhere in between the two reference materials, while GRP is often the highest. The case of the suspended ceiling is an exception. Due to the specific design that was assumed for the calculations, the preliminary BioBuild product has an extremely high embodied energy compared to the reference materials. On the basis of this result, the design of the SCK has been shifted towards a different ceiling market segment where a bio-based product can compete in terms of environmental impact.

BioBuild products are expected to have much higher water- and land-use than the other materials. During the project, the consequences of choices of resins and fibres for water- and land-use will be taken into account, to help minimise the environmental impact of the product to be developed.

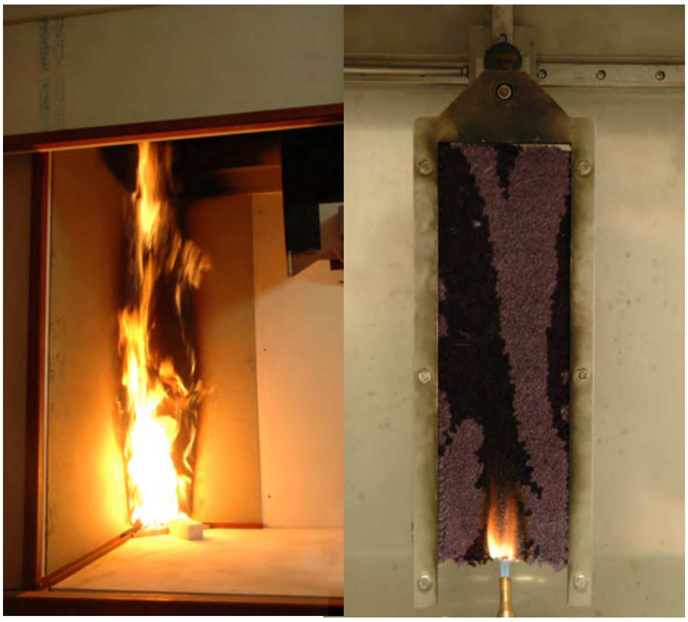


Evaluation of Systems

The performance of systems, materials and processes developed will be demonstrated by the evaluation of representative test specimens. The evaluation of the systems is based on the Performance and Standards Requirements, prepared early in the project, where the available materials have been analysed for basic mechanical performance, environmental impact and compatibility. Furthermore the performance targets to be fulfilled by the product have been established.

The following guidelines and standards are followed for the assessment of Biobuild products: ETAG 016: Parts 1 & 3 (External Wall Panels); ETAG 034: Parts 1 & 2 (External Cladding Kits); ETAG 003 (Internal Partition Kits); and EN 13964:2004+A1:2006 (Suspended Ceiling Kits).

The testing program is informed by the Construction Products Regulation (CPR) and will provide the input necessary for the elaboration of a European Assessment Document (foreseen in the CPR) and, in due course, the creation of a European Technical Assessment. The testing programme, which will be carried out by LNEC, depends on the specific product but typically is organised according to the following requirements.



- Safety in case of fire (reaction to fire and fire resistance)
- Hygiene, health and environment (e.g. watertightness, vapour permeability, release and/or content of dangerous substances, dimensional variation)
- Safety and accessibility in use (e.g. wind-load resistance, mechanical resistance, impact resistance, hygrothermal behaviour, safety against personal injuries by contact)
- Protection against noise (direct airborne sound insulation, sound absorption)
- Energy economy and heat retention (thermal-insulation properties, air permeability)
- Sustainable use of natural resources (e.g. resistance to deterioration, robustness and rigidity, identification of materials and products)

Panels, profiles and assemblies will be built to industry standards and the early results will be fed back into the development programme to provide the data needed to optimise the end products. Due to the innovative character of the products developed in this project, some standards may need to be adapted to the biocomposite materials.

Project Partners

Contact

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