The aim of the joint three-year "PULaCell" project funded by the German Federal Ministry of Food and Agriculture (BMEL) is to develop biobased reinforcing profiles for solid wood construction materials. As part of the project, several research institutes and industrial companies are developing biobased, cellulose fibre-reinforced polyurethane profiles that will make future wood-based materials stronger.

Concrete, steel and mortar still dominate the construction industry. However, greater efforts are being made towards achieving a circular economy that uses recyclable and renewable raw materials. Wood grows naturally and is renewable. It therefore plays a key role as a renewable construction building material. A wooden, 24-storey tower, 84 metres high, is currently being built in Vienna’s Seepark quarter. Once it is built, the “HoHo”, as the tower is called, will be the highest wooden building in the world. And now the city of Hamburg’s building regulations have also been changed so that the construction of wooden buildings up to 22 metres or seven floors high is now authorised.

“State-of-the-art solid wood constructions are increasingly coming to dominate urban spaces and we want to provide architects and planners with a material that can bear higher loads and be used to make wooden constructions with a sleeker design,” says Dr. Paul Heinz from Covestro Deutschland AG in Leverkusen, explaining the aim of the project. Heinz is the coordinator of "PULaCell", a three-year cooperative project, which has set itself the goal to develop biobased reinforcing segments that enhance the stability of construction elements. The project team also involves the German Institute for Textile and Fibre Research (DITF) in Denkendorf near Stuttgart, the Institut für Kunststofftechnik (IKT) at the University of Stuttgart, the Fraunhofer Institute for Chemical Technology (ICT) in Pfinztal near Karlsruhe and several industry partners.

Enhancing the stability of wood

The idea of enhancing the stability of wood with fibre-reinforced composites is still relatively new. Glass- or carbon fibre-reinforced beams made from laminated timber, which withstand significantly higher loads than conventional beams are examples of such composites. However, the project coordinated by Paul Heinz goes one step further. “Within three years, we hope to develop an economical production process for profiles made of biobased, fibre-reinforced polymers in order to replace the petrochemical products that have been used for this purpose up to now,” explains Heinz. The innovative polyurethane profiles are to be more than 90 percent biobased, contain zero additives and exhibit low flammability and good weathering resistance.

Fibre-reinforced construction elements are made by gluing together reinforcing layers with several layers of wood (e.g. beech). Reinforced laminated timber will be as light as well as a relatively strong and rigid construction material. Heinz comments on the use of beech: “Beech has the best mechanical properties of all native hardwoods, making it ideal for use as a construction material.” The forestry sector is also very eager to add value to beech wood, which up to now has far too often just been used as firewood, directly ending up in wood burners.

Beech wood as a construction material

In Germany, about 35 million cubic meters of timber and nine million cubic meters of wood-based materials (such as glued-laminated timber and cross-laminated timber) are processed every year. Softwoods account for 96% of timber used for construction and for 81% of glued-laminated and cross-laminated timber elements. Spruce and pine are the major softwoods used for these purposes. Beech therefore has a lot of catching up to do.
The profiles are manufactured using a proven technology called pultrusion. This is an automated process for producing fibre-reinforced composite profiles cost-efficiently. The fibres run continuously over a long working surface, are impregnated under pressure with synthetic resin, heated and finally pulled into shape.
The novel fibre bundles are being developed as part of the project by the German Institutes for Textile and Fibre Research in Denkendorf. While mainly glass and carbon fibres are used in the conventional pultrusion process, the researchers from Denkendorf led by Dr. Ing. Frank Hermanutz are experimenting with various biobased fibres, including fibres made of regenerated cellulose. For this purpose, spruce or beech wood is chemically digested and the cellulose obtained is spun into extremely thin (fractions of a millimetre) fibres. “We are still experimenting. As the project progresses, we will eventually find out which type of fibre is best for timber construction,” says Dr. Frank Hermanutz from the DITF. The researchers are also investigating the suitability of natural fibres such as hemp. Covestro Deutschland AG will subsequently work on the optimisation of the biobased polymer matrix into which the fibres will be embedded.

The Institut für Kunststofftechnik (IKT) of the University of Stuttgart and the Fraunhofer Institute for Chemical Technology (ICT) in Pfinztal are working to optimise various aspects of the pultrusion process. Up until 2020, a company called Sortimo International GmbH in the Bavarian city of Zusmarshausen is running a process to transfer these project developments into a pilot facility and produce the first profiles for testing.

Material cycles will be examined

The material recyclability of the new composite material will be investigated by researchers at the Fraunhofer ICT. The plan is to heat the material with glycols to try and recover the individual components. A detailed life-cycle assessment (LCA) will be carried out to assess different recycling concepts for recovering material and energy as well as the carbon footprint of the overall process.

The project is being supported by the German Federal Ministry of Food and Agriculture (BMEL) through the project sponsor, Agency for Renewable Resources (FNR).

References:
(1) http://www.hthh-wien.at/
(2) http://www.hamburg.de/bsw/presse/8947022/2017-06-13-bsw-neu-bauordnung/
(3) https://www.biooekonomie-bw.de/de/fachbeitrag/aktuell/biooekonomie-bietet-chancen-fuer-baden-wuerttembergs-waelder/
(4) DHWR Roadmap Holzwirtschaft 2025 (www.dhwr.de/docs/dhwr_roadmap_holzwirtschaft_2025_web.pdf)