Energy
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Project

Hybrid load-bearing structures

Beech – a miracle wood: how concrete can also be made stable without steel

Beech – a miracle wood: how concrete can also be made stable without steel

Instead of being reinforced with steel, the concrete used in ceiling constructions could in future be reinforced with wood. This would make the construction process more environmentally friendly and sustainable.

Beech has been underutilised as a construction material until now. *Source:* iStock

At a glance

- Concrete structures require reinforcements made from steel. These could be replaced by beech wood.
- A new pre-coating means that beech wood can now be better used in combination with existing industrial adhesives.
- Thanks to a new connection system for the wooden panels, the wooden structures can also withstand two-dimensional loads – previous systems were only uniaxially load-bearing.

Buildings are currently responsible for 40 % of global energy consumption. At present, building expenses primarily stem from their operation. However, using energy-efficient construction methods, as envisaged under Energy Strategy 2050, it will be possible to considerably reduce this energy consumption. As a result, so-called “grey energy” that is used for the production of materials and the construction process is increasingly coming under the spotlight. Steel-free building structures offer an opportunity to reduce grey energy. This is because the production of steel is a very energy-intensive process. An alternative to steel is wood. It also stores CO2 and could thus contribute to reducing CO2 emissions into the air.

The prodigy among the woods is beech. This is because it is very strong and also a widely available raw material in Switzerland. Until now, however, beech has primarily been used as wood fuel, with softwoods dominating the area of timber construction. Beech therefore offers untapped potential.

In this sub-project, researchers from ETH Zurich have investigated how beech could be better used in combination with concrete and thus replace steel. They did so on the basis of ceiling constructions. In these wood-concrete composite ceilings, beech panels assume both the function of formwork and reinforcement and allow for a significant reduction in concrete and steel reinforcement compared to reinforced concrete flat ceilings.

So-called wood-concrete composite ceilings consist of wooden elements which are connected to a concrete slab in a shear-resistant manner. Compared to pure wooden ceilings, concrete increases the stiffness and mass of the ceilings. This in turn improves the vibration behaviour, sound insulation and fire protection – thus making the building component more suitable for use.

However, such hybrid constructions also have some disadvantages: they can usually only be loaded on one axis, which makes supporting elements such as beams and walls necessary. This restricts architectural design freedom. In addition, large quantities of fasteners are needed to hold the concrete and wood together. Such connections also lead to high local stresses being placed on the material and can suffer from corrosion.

The researchers have therefore investigated how wood-concrete could become cheaper, more resilient and more sustainable.

Wood that can be better bonded to concrete

For the development, the researchers used boards made of laminated veneer timber. In the first part of the research project, they developed a coating that better prepares wood for the liquid adhesive. It should adhere well to the wood surface so that the liquid concrete, which is poured over it afterwards, forms an optimal bond with the wood.

The researchers used a so-called sol-gel surface modification for this purpose, which is easy to apply in the form of a spray. This coating has three effects at once: firstly, it makes the surface of the wood more water repellent. Secondly, the layer prevents the adhesive from being absorbed too much by the wood. Thirdly, the coating enables a better bonding of the adhesive. Tests with coated and uncoated wood have shown that the treatment can improve the mechanical properties of the wood-concrete composite. However, optimisations of the coating process are still required and the long-term behaviour of the wood-concrete structures bonded in this way was not yet part of the project and will have to be investigated in further projects.

Wood that can withstand two-dimensional loads

In the second part of the research project, the researchers investigated ways of making beech wood panels able to withstand two-dimensional loads. The connections between the veneer wood panels are of central importance here. Five different connection types were analysed. For example, an attempt was made to use concrete to direct the tensile force onto steel reinforcements. Another variant works via wood-to-wood connections. A third variant was to form the connections using glued-in threaded rods. The tests showed that this third variant is the most effective.

Cheaper and faster

The methods developed in this project make wood-concrete constructions biaxially resilient, i.e. more stable and thus suitable for a wide range of applications. Wood concrete is also becoming cheaper and more energy-efficient. This is because both the new bonding method and the panel connections using glued-in threaded rods reduce the use of steel. Construction with such wood-concrete is also faster than that with reinforced concrete. This makes the hybrid building material a competitive alternative to reinforced concrete.

Produkte aus diesem Projekt

- Beech wood concrete hybrid structures
  Date of publication: 15.11.19
- Enhancing the performance of beech-timber concrete hybrids by a wood surface pre-treatment using sol-gel chemistry
  Date of publication: 06.09.18
- Timber-mortar composites: The effect of sol-gel surface modification on the wood-adhesive interface
  Date of publication: 01.10.18
- A straightforward thiol–ene click reaction to modify lignocellulosic scaffolds in water
  Date of publication: 15.11.19
- Verbundprojekt "Energiearmer Beton"
  Date of publication: 20.12.16

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