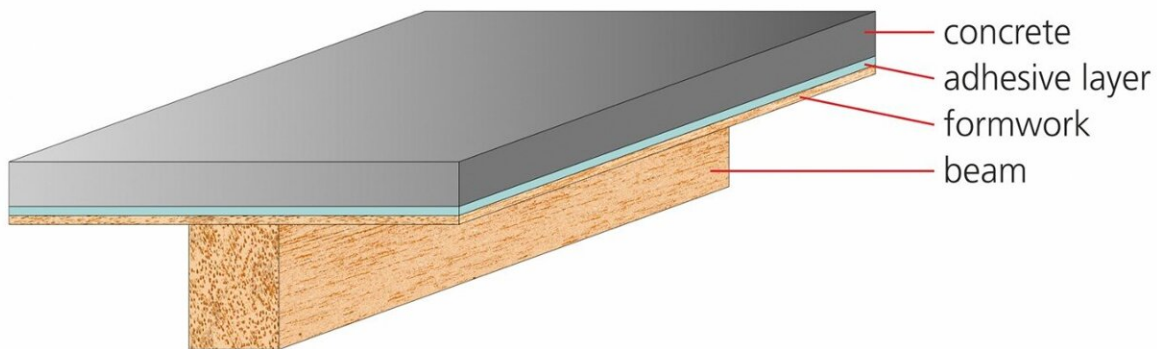


# Hybrid timber systems: The new reinforced concrete for the 21st century

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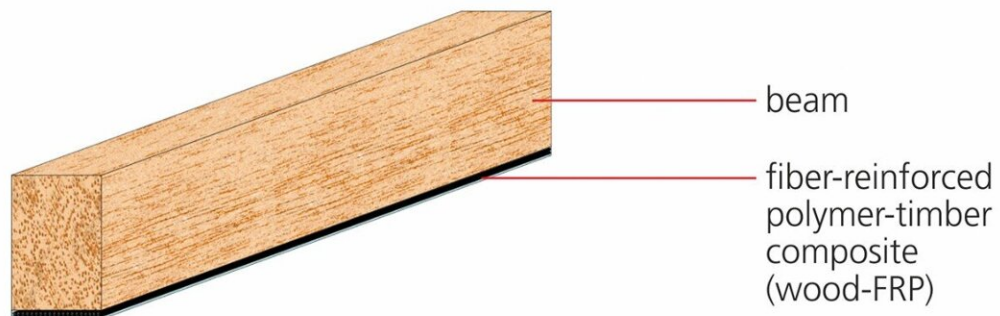
An example of timber-concrete composite (TCC) for slab application. Credit: Fraunhofer-Gesellschaft

Reinforced concrete is durable and robust but has a large CO<sub>2</sub> footprint. Timber, on the other hand, is sustainable and absorbs carbon, although it has inherent negative properties. Hybrid timber systems, by contrast, combine sustainability and strength. The Fraunhofer Institute for Wood Research, Wilhelm-Klauditz-Institut, WKI develops suitable adhesives and tests the long-term stability of the hybrid timber materials.

Nowadays, buildings and other structures consist mainly of masonry, steel and concrete. Reinforced concrete in particular guarantees high overall stability—after all, it combines the high compressive strength of

concrete with the high tensile strength of steel. Moreover, reinforced concrete is highly durable, even in changeable weather conditions. But there is a drawback: Huge amounts of energy are required to manufacture, process and recycle reinforced concrete, releasing a lot of CO<sub>2</sub> in the process. The long distances covered in transporting the [raw materials](#) worsen the CO<sub>2</sub> footprint once again. Timber, on the other hand, grows back quickly and is therefore far more climate-friendly. It is also available locally. What's more, the "feel-good factor" is usually greater in timber houses than behind concrete walls. But here, too, there is a catch: Timber is nowhere near as robust as reinforced concrete. In particular, the tensile and compressive strengths perpendicular to the direction of the fibers are comparatively low. Furthermore, timber is characterized by a high variability of properties and hygroscopicity. However, when timber is combined with other materials, the mechanical properties of the overall structure are greatly improved. When used in combination with fiber-reinforced polymer composites or concrete, it is even possible to use wood species and grades that were previously unsuitable for the [construction industry](#). This could broaden the scope for climate-conscious and environmentally friendly forestry.

## Long-term behavior of timber-hybrid materials



An example of FRP-timber composite (wood-FRP) for beam application. Credit: Fraunhofer-Gesellschaft

While several recent studies have looked into the short-term behavior of such timber-hybrid materials, little is known about their long-term behavior. And this is what is of fundamental importance when it comes to construction materials. A group of young researchers now wants to close this gap and, with the guidance of Fraunhofer WKI in Braunschweig, is now investigating the long-term behavior and durability of these hybrid timber construction systems. The project is funded by the German Federal Ministry of Food and Agriculture (BMEL) and the body responsible for the project is the German Agency for Renewable Resources (FNR). "Our aim is to significantly increase the proportion of timber used in building construction—timber construction has a small share of the German construction market, around 10 to 15 percent," says Prof. Libo Yan, Senior Scientist and Junior Research Group Leader at Fraunhofer WKI. If it could be ensured that hybrid construction materials would withstand wind and weather conditions over a long period of time, there would certainly be a surge in the popularity of this construction material. Researchers from all over the world—as many of them women as men, as Yan proudly explains—are investigating combinations of timber and concrete as well as timber that gains additional rigidity from carbon fibers or flax in a polymer matrix. As for the combination of timber and concrete, the team developed a new way to combine the materials. This is usually done mechanically, i.e., using steel nails, steel plates and steel nets. "By joining the materials using polyurethane or epoxy resin, we can reduce the weight of the timber hybrids and speed up the production process by up to 15 percent," Yan says.

Even if it may sound contradictory—we are talking about long-term

tests, after all: Short-term tests are carried out at the start of the studies. This is because long-term tests over a period of 20 years are both too expensive and too protracted; ultimately, the aim is to open up the possibility of using the new [construction materials](#) as quickly as possible. For the short-term tests lasting hours or days, the researchers bond the materials, such as concrete and timber. They then clamp the outer timber sections and apply a defined force to the concrete. How much force is required to destroy the adhesive layer and tear apart the material composite? The research team is developing a theoretical model using both these and other measurements. To do this, they are also examining the microstructure of the adhesive joint using a microscope. "We want to establish a correlation between the macroscopic behavior and the microstructure," Yan says. "We also go down to the chemical level in the process: For example, in what way do the chemical components change at the interface? In this way, we can systematically improve the properties of the hybrid materials."

## **Long-term outdoor testing**

To validate the model created and capture reality as accurately as possible, the researchers are now following up their short-term tests with longer-term studies. For this purpose, they expose five- to six-meter-long hybrid panels to wind, rain and sun in the open air for two years. How badly will they be affected by this? Does the model predict this coherently? "We can use the results to fine-tune the model," explains Yan. Once the model has undergone this practical comparison, the researchers will use it to predict long-term behavior and calculate how the [timber](#)-hybrid materials will behave over a period of 50 years. In this way, the research team can establish a basis for using the materials in the [construction](#) industry in the future.

Provided by Fraunhofer-Gesellschaft

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