How residual materials can become high-performance construction products

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Concrete component made of recycled aggregates and rice husk ash with rice straw insulation. Credit: Fraunhofer-Gesellschaft

When it comes to sustainable development, the construction industry faces great challenges. In the ReMatBuilt project, experts from the Fraunhofer Institute for Wood Research, Wilhelm-Klauditz-Institut,

WKI and their partners are proving that the tasks associated with this can be solved with high-performance construction materials made of recycled and waste materials. They presented their solutions to specialist audiences at the Hannover Messe Preview on February 21, 2024.

Anyone who leaves their house now often finds themselves in the middle of noisy demolition or construction and building sites impact our everyday lives, especially in metropolitan areas. It is therefore not difficult to understand that the construction industry is one of the world's largest consumers of natural resources. At the same time, the demolition of existing buildings and structures produces masses of materials that urgently need to be recycled solely from a sustainability perspective.

These are the neuralgic points from which Professor Libo Yan and his team from Fraunhofer WKI start. In the ReMatBuilt research project, the experts are developing sustainable concrete construction materials and high-performance construction elements based on construction and demolition waste as well as plant-based production residue, together with partners from industry and science.

The project partners based in Germany and China place special emphasis on practicability and quick implementability: On the one hand, as an international team, they want to take global responsibility for bio-based, sustainable economic development and identify suitable recycling and production methods for the construction sector. On the other hand, they design the resulting products and all upstream process steps in such a way that these meet the country-specific regulations. The solutions developed under these guidelines can be used easily and thus significantly increase the share of renewable raw materials in the construction industry on a global level.

"The idea of recycling construction materials and experimenting with alternative materials from nature is not new. What makes our project

unique is its holistic approach," project manager Yan explains. "We combine our knowledge of the methods and properties of the different materials in order to understand their chemical, physical and mechanical performance from the micro- to the macro-scale. This allows us to achieve a very high technology readiness level, which is an important aspect for practical application."

Less waste, lower resource consumption

When the conventional manufacturing and composition of construction materials is compared with those that the ReMatBuilt project partners are realizing, the multiple advantages of their approach quickly become clear: The experts use so-called construction rubble, in other words, old concrete and masonry waste, as well as agricultural residues to produce recycled concrete. These components are reinforced with plant-based natural fibers such as flax, supplemented by forestry waste products such as wood chips from old wood.

Conventional concrete, in contrast, contains cement and usually gravel as an aggregate. The latter is a finite resource as an aggregate, and its extraction damages the environment. In addition, it often has to be transported over long distances. Construction rubble and old wood, however, are extensively found in large amounts throughout the world in the relevant areas and have been hardly used so far. From an ecological and economic point of view, this is a very attractive substitute.

The situation is similar with cement. This binding agent among the construction materials is made from natural raw materials such as limestone, clay and quartz sand—and its production causes high carbon dioxide emissions that have been an increasing concern for the industry. The team headed by Professor Yan has succeeded in identifying a substitute material that is more than adequate: "Rice is the most common food in the world. Its husks have hardly ever been used. We have found

out that the rice husk ash that is produced by a special combustion process is optimally suited as a cement substitute."

The test results speak for themselves: The recycled cement not only saves finite ecological resources, but the components manufactured from it are lighter than their traditional counterparts and impress with additional strength, durability as well as heat and sound insulation.

As part of the project, the experts are also developing insulating materials made of plant-based waste products such as sawdust, rice and wheat straws as a resource-saving alternative to currently dominating variants that consist of crude-oil-based plastic, mineral and glass wool, or wood fibers. These sustainable insulation boards make it possible to connect the finished concrete components to form wall systems of insulated blocks. The experts have additionally designed composite systems that allow recycled concrete combined with laminated veneer and cross-laminated lumber to be used as timber-concrete composite floor slabs.

These hybrid construction elements combine the advantages of recycled aggregate concrete and plant-based construction materials. They are durable and have impressive mechanical as well as moisture and heat protection characteristics. In addition, they can be easily processed and meet fire-protection specifications. In this way, the solutions of the project partners are expanding the possibilities for cost-efficient building with increasingly strict sustainability requirements—regardless of whether for single-family homes or large building complexes.

Project manager Yan is happy about the successful collaboration within the internationally operating project group, which is now being extended thanks to the successes that they have achieved: "Our work creates economically interesting perspectives—not only for the insulation and construction industry, but also for agriculture and forestry, for example,

where production waste is now becoming valuable construction material. Our partners in recycling and machine manufacturing are in turn developing methods for optimally obtaining and further processing plant-based waste to produce the corresponding precursors."

Focusing on the human aspect

One aspect is particularly important to Libo Yan. He wants his solutions to benefit people directly and as quickly as possible. After all, there is immense potential in the results of the project partners—especially against the backdrop of the current geopolitical situation:

"Our work has the potential to make a significant contribution to the reconstruction of Ukraine," the project manager is convinced, adding, "It is horrible, but huge amounts of construction rubble are produced there every day. The country is also rich in natural resources and one of the world's largest exporters of agricultural raw materials, such as grains—wheat, corn and rice. Against this background, we are currently working hard on putting our results into application. With local industrial partners, we can significantly help the people in Ukraine to reconstruct their country quickly, economically and sustainably. We can do this with recycled concrete components and corresponding insulation made of natural materials that are all abundantly available on location."

Provided by Fraunhofer-Gesellschaft

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