02. Circular Definitions

Integrating regenerative materials in circular building products

Dr.-Ing. Olga Ioannou
Assistant Professor, Chair of Building Product Innovation
Department of Architectural Engineering + Technology (AE+T)

Following the circular design canvas methodology, there are several approaches to making building products more circular. One of them is to reconsider their materiality. There are multiple reasons for doing so: for one, *we are consuming a lot of materials in construction, namely technical ones like concrete, plastics or metals.* The numbers are dazzling; over the past century, the production of anthropogenic mass has exceeded earth's biomass marking a shift from using mostly biomass in the beginning of the 20th century to mostly minerals by the end of it. At the same time, new materials continue to be generated and made available in construction. Nevertheless, even though sustainability criteria have been established for building materials since decades, these do not necessarily score the highest in the overall performance criteria hierarchies. Additionally, *the complexity of materials usage has increased, lengthening the roster of critical elements.*

Circularity brings materiality centerstage. It does so by focusing on prolonging the lifecycles of existing abiotic or technical material resources to ensure these can remain functional during their entire expected service life. But circularity is also fostering the development of new materials for which natural, and biological or biotic resources are used giving way to a new generation of eco-friendly building materials. This is not directly reflected in the R strategies heuristic framework as the three R strategies related to smart manufacturing, namely Reduce, Rethink and Refuse do not account for the nature of the resources considered. In the case of natural materials like earth or biotic materials like hemp or flax, circularity rather borders with the principles of *regenerative systems that encourage a holistic and ecological worldview, promote diversity and reflexivity, and foster agency in the interaction between human and non-human actors.*

This is mostly mirrored in the fact that the making of such building materials is situated in the crossovers of the disciplinary fields of *material science, structural and mechanical engineering and architectural and industrial design* with knowledge domains that are not traditionally consulted like *biology*, and *agroforestry,* but also *art* and *crafts.* The latter further emphasizes the systemic character of the transition to a circular built environment and marks the re-weaving of the artificial world with the natural one. Afterall, regenerative systems are founded on the belief that humans can form autopoietic systems with nature and follow living systems principles as nature does.

Current trends in biotic building materials' research

Current research on building materials made with natural or biological/biotic resources varies. *One direction consists of revisiting and revising*

previously used natural building material resources like for example earth or wood, that over the years have become obsolete. Material research in this case focuses on retracing or improving material composition to increase these materials' technical performance and thus broaden the range of their potential applications. These material-based explorations are further supported by the parallel development of a new aesthetic vocabulary to increase user acceptance and/or the optimization of the fabrication technologies to modernize and upscale production. Examples of such practices include *rammed earth construction and raw earth bricks,* the *integration of log timber in structures,* or *straw thatching for roofing or cladding*. These applications become very relevant in the circular paradigm for many reasons. Firstly, they enable building with locally harvested materials. Also, these raw resources' processing usually requires limited energy consumption during production. In the case of earth made products, waste excavation material can become a valuable new resource.

A second line of research on building materials is opening to an entirely new range of material configurations using biotic (renewable)resources. These resources can come from food waste in the form of beans, shells or pits, from production crops like wheat or from agricultural residues like plant leaves or stems. Assuming different granularity through processing and mixed with resins, these material resources can produce different types of bio composites with functionalities comparable to those of conventional technical materials. Biomass such as sugar beets is also used to produce biobased and even biodegradable polymers which in turn can be used as resins to produce fully biobased composites.

Lastly, a third branch of new materials research is looking into living materials like algae, bacteria, or mycelium. Despite the challenges associated with long-term viability and user acceptance, such material resources can already be developed as blocks or insulation panels, or coatings. What is particularly interesting about these materials apart from the fact that they can grow, and regenerate so they can react and adapt to any environmental changes. But what is most important is that they can self-heal. Which in turn ensures durability over time and low cost and low energy maintenance.

Developing building materials using natural, biotic or living material resources can follow the conventional application-driven processes of designing and making where material composition follows application requirements; however, an incremental body of research is now focusing primarily on the unique qualities of these material resources and the lived experience of working with them. However, the unknownness of these material resources behavior heavily conditions how we research them. Explorations that take these new resources qualities as the starting point for any further research is called *material-driven research*.