Circularity for Educators

04. Materials

Biological and Technical Materials

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Materials are central to transitioning to a circular built environment: it is important to know how we acquire them, how we use them, and in particular, how we can recover them from our products and processes, thus preventing them from becoming waste in a landfill or fuel in an incinerator. An effective way of understanding material resources is to divide them into two categories: the *biological* and the *technical*. You have probably come across the Circular Economy System Diagram by the Ellen MacArthur foundation, popularly known as the “Butterfly diagram”. We will now look into each of the two material flows described in the diagram and discuss some key factors which are crucial to enable a Circular Economy in the built environment.

Biological Materials

Biological materials are products of plants, animals, and other microorganisms and therefore are regenerative materials with renewable potential. In other words, bio-based resources which, if properly assembled and managed, can be recollected at the end of their service life. They can then be used as biochemical feedstock, or input, for a next generation of resources, or for the extraction of other chemicals or substances useful to human industry. Some bio-based materials have been in use in construction for millennia: think of wood, pulp, leather, and diverse organic elements and fibres such as hemp and bamboo. Other bio-based materials have only recently started to be used and are the result of complex and innovative manufacturing processes. Bio-based polymers, such as PLA, are an example of more recently developed bio-based materials which can replace their technical counterpart in industrial and construction applications.

There are four key factors which determine whether a material can be considered part of the biological flow:

1. *Is the source of the material potentially renewable?* Fossil-based polymers are refined from oil, which does not regenerate within a timescale relevant to humans. Bio-based polymers are derived from biomass such as cellulose which, if extracted from sustainably managed sources, could in principle be infinitely renewable.

2. *Does the rate at which the material decompose and is reabsorbed by the natural environment roughly correspond to its useful service life?* A material which biodegrades is not necessarily a biological material. All materials will eventually break down into microscopic pieces - if they are left lying around for long enough – but bio-based materials will become nutrients, while technical materials will become pollutants.

3. *Does the biodegradation process release toxic or otherwise polluting substances?* Or are there elements in the product which do not biodegrade safely and without environmental damages to soil, water, wild-life, or other natural systems.

4. *Is the process of turning the bio-based products back into feedstock, or into other useful substances, practical?* Large volumes of materials, such as those used in construction, can't just be left out in the open waiting for them to biodegrade, we simply don't have enough space. On the other hand, if we use the materials as feedstock to generate derived and useful chemicals and substances, are we creating a secondary material flow which relies on the waste generated by a primary material flow? This dependence could become a system failure if the primary material is replaced by a more efficient alternative which does not generate this waste.

Technical Materials

The term *technical*, on the other hand, refers to *materials which require significant processing to become useful*, which *biodegrade over a timeframe much longer than their service life*, or which *produce pollution in the degradation process.* Many technical materials are present on Earth in only limited quantities, and do not regenerate as part of the planet's biological cycles within a timescale relevant to humans.

Most of the materials we are used to in the construction industry are part of this technical flow: Metals must be mined, separated from their ore, and refined, all of this before they can even become part of an alloy or be shaped into elements and products. The mining and manufacturing process requires chemicals and machinery which themselves can lead to ground, water and air pollution, together with other negative environmental consequences.

Since *materials in the technical flow require*, almost by definition, *a greater amount of energy* and other resources in their extraction and manufacturing, *they* also *have more "embodied" energy, a larger carbon footprint, and greater economic value.* This, together with the fact that they don't easily or effectively biodegrade, means our *best alternative is to extend their service life.*

We can be sure that both the biological and the technical flows will continue to be crucial to human development. As building product designers and manufacturers our role is to understand the strengths and weaknesses of each material from a circularity perspective, and acquire a critical understanding of how and what for each material should be used in order to facilitate future circular life options for our product.