05. Design

Design Principles

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Waste and pollution are consequences of decisions made at design stage where around 80% of environmental impacts are determined. This is when the resources necessary to manufacture a product are usually identified. Weight falls onto design then to make sure circular principles are accounted for and that components, assemblies or even buildings can serve the circular objectives of the R strategies: especially those related to prolonging products' and buildings' life span as well as those related to their smart manufacturing. Although *standardization* and *modularity* have been around for quite some time, they still constitute two of the basic design approaches that can facilitate circular design.

Design for standardization

Standardization is the process of establishing rules and norms to guide the creation of a good or service based on the consensus of all the relevant parties in the industry. *A standard defines what something should do or perform.* Standardization may include requirements for *mechanical resistance and stability; fire safety; hygiene; safety and accessibility in use; protection against noise; energy economy and heat retention. Standardization* has lots of *benefits* for products: first and foremost, it *is a way of ensuring that all products operate the same* and therefore have definitive parameters. In a way, standard design *rules for better quality designs.* Moreover, standardization *contributes significantly to minimizing the total number of total parts used in a product.* It also *reduces time and costs* and can *enhance interoperability where products from different companies can be used interchangeably.*

Standardization is important for circular design because *by standardizing materials, you define conditions for recycling and by standardizing products you define conditions for connections.* Furthermore, *if connections between elements are standardized, the dimensions of the elements do not necessarily need to be.*

However, some major *challenges* do exist: for one, circularity requires the *reuse of secondary material streams*. This puts a lot of pressure on standardization systems: *how can one account for the performance of a product or a component that has been used already?* Standardization becomes even more challenging for reused structural components or for new functionalities for materials that originate from non-building material streams like household plastic. Another bottleneck relates to *standardizing the performance of new biological materials:* their competitiveness in the market relies on delivering reliable components of controlled durability with minimum maintenance needs and life cycle costs.

Modular Design

Modular systems are composed of separate, standardized units that can be applied and connected together but remain independent from one another. A product system can be considered as modular to the extent that it has separable subsystems that can be combined in different ways to configure product variants. *The obvious advantage of using modules is that they can be replaced individually without affecting the whole.*

Modularity can apply to *volumetric or non-volumetric elements:* in the first case the module refers to an enclosed space, whereas in the second, the module refers to a building component or assembly.

Construction activities have traditionally been carried out on site causing problems to variability, complexity, transparency, and benchmarking. This is why modularity is now increasingly related to prefabrication and off-site manufacturing that allows for quick assembly and provides with an alternative to the shortage of skilled labour.

Modular construction contributes to circularity in several ways. In the case of prefabrication, *modularity can reduce operational energy and also material waste*: in the controlled environment of a factory materials are better protected and much less likely to get damaged than in a construction site. The *potential reusability of detachable components raises the resale value of building parts* that can be replaced, recycled or moved according to need. However, this might be challenging due to the generally long lifespan of buildings: *by the time they are finally released from a building, modules can become outdated.*