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GOOD PRACTICE GUIDE

Circular 2B

CIRCULAR CONSTRUCTION IN ENERGY-EFFICIENT MODULAR **BUILDINGS**

Working together for a green, competitive and inclusive Europe

EDITORIAL

The reuse of waste brings several advantages, from energy and material savings, reduction of production costs, reduction of waste and ground space, as well as promoting Circular Economy in Construction and reducing carbon footprint.

This guide is primarily intended for the main actors in the circular construction sector, but can and should also serve as inspiration for the AEC sector community so that find strategies to reduce the environmental impact of modular buildings, improving the durability.

The information contained in this guide is result of the work carried out in the project Circular2B, financed under the Environment, Climate Change and Low Carbon Economy Programme, and within the scope of the European Economic Area Financial Mechanism – EEA Grants 2014-2021.

The EEA Grants represent the contribution of Iceland, Liechtenstein and Norway towards a green, competitive and inclusive Europe. There are two overall objectives: reduction of economic and social disparities in Europe, and to strengthen bilateral relations between the donor countries and 15 EU countries in Central and Southern Europe and the Baltics. The three donor countries cooperate closely with the EU through the Agreement on the European Economic Area (EEA). The donors have provided €3.3 billion through consecutive grant schemes between 1994 and 2014. For the period 2014-2021, the EEA Grants amount to €1.55 billion.

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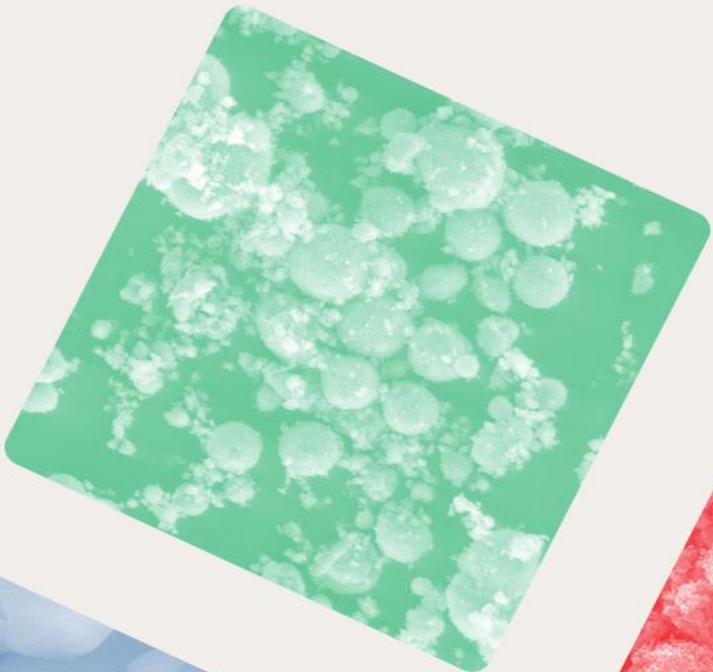
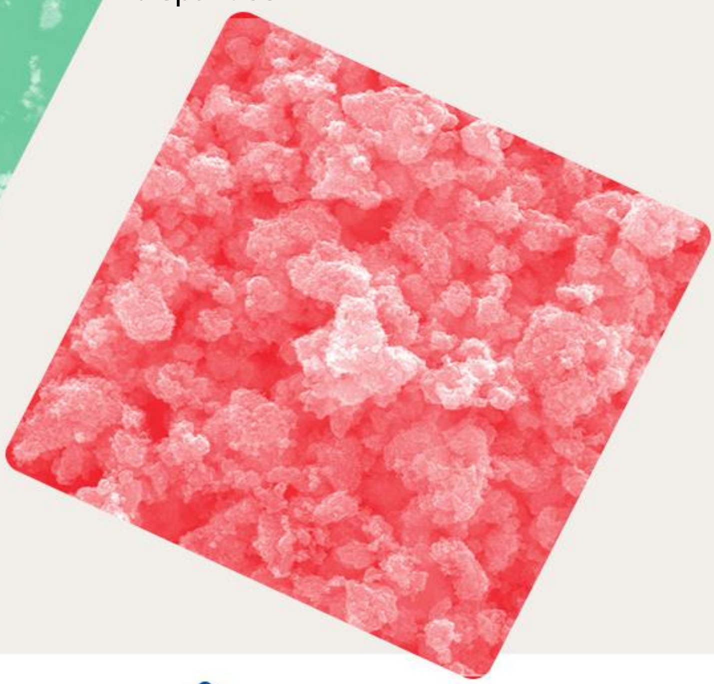
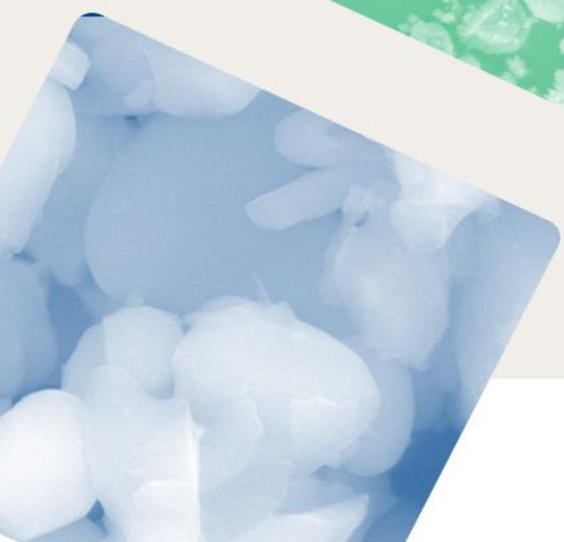
Why Circular 2B ?

The project aims to respond directly to the objectives defined in the MFEEE 2014-2021, combined with the current national strategies, in line with priority areas such as Energy, Habitat, Materials and Raw Materials, and also Advanced Production Systems and Human Capital and Specialized Services, through the development of eco-sustainable materials (including nanomaterials) by recycling waste and incorporate it in modular construction systems with high energy efficiency.

It is intended, therefore, to contribute widely to the promotion of Circular Economy and decarbonisation, within the main areas of activity of the Environment Program. In addition, the production on an industrial scale of environmentally sustainable but also more economical solutions will contribute to the improvement of living conditions, reducing economic and social disparities.







What is the objective of this guide?

This guide is intended to be a source of inspiration and help for decision-making in the field of waste recovery improvement in a perspective of circularity by design, with improved durability and energy efficiency, using green approaches.

The pertinence of this guide is enhanced by the applicability of the main improvements to modular construction components.

The implementation of the proposed good practices could contribute to the reduction of CO_2 emissions, CDW and industrial wastes, building energy needs and housing acquisition costs.

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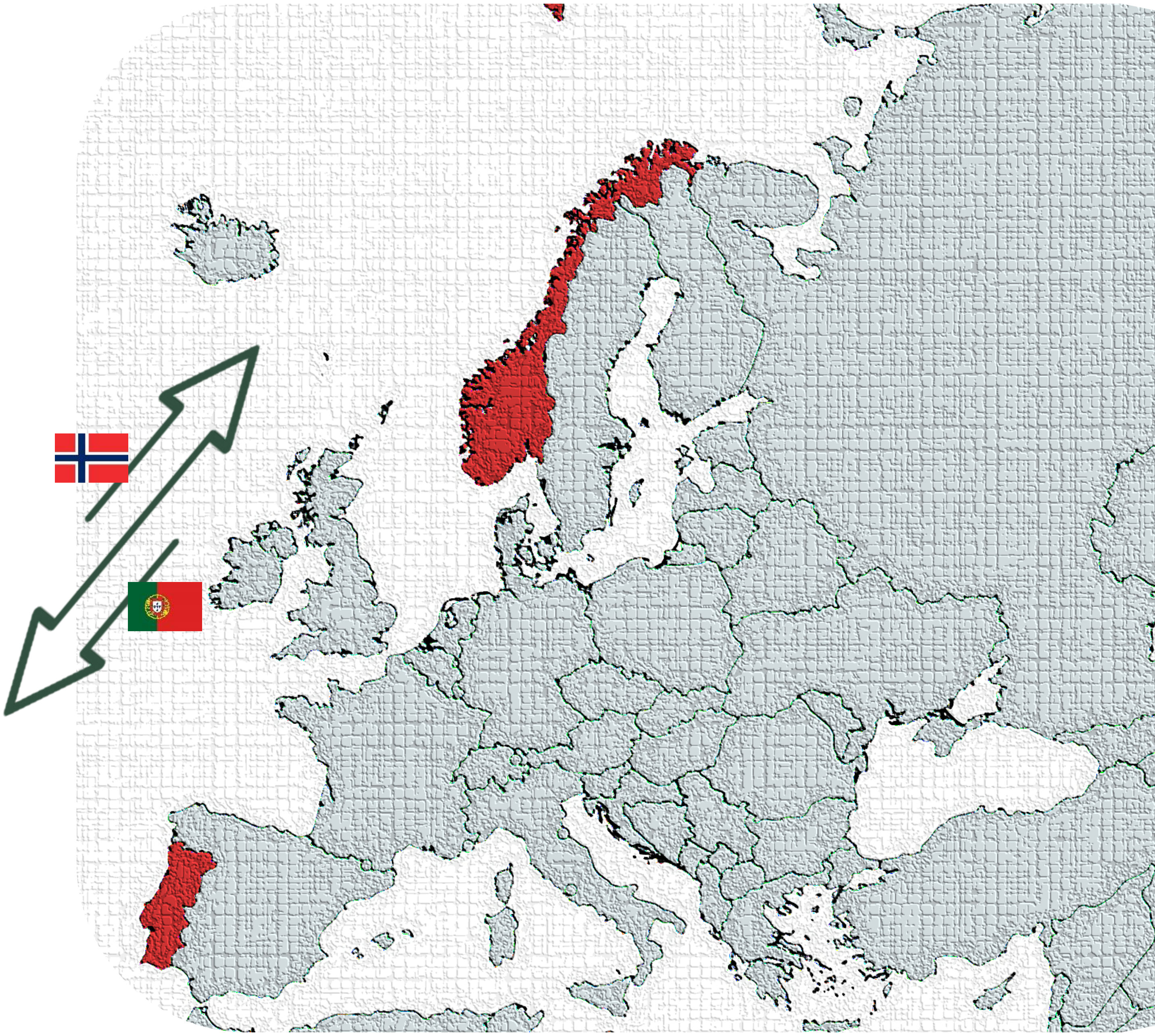
BILATERAL RELATIONS



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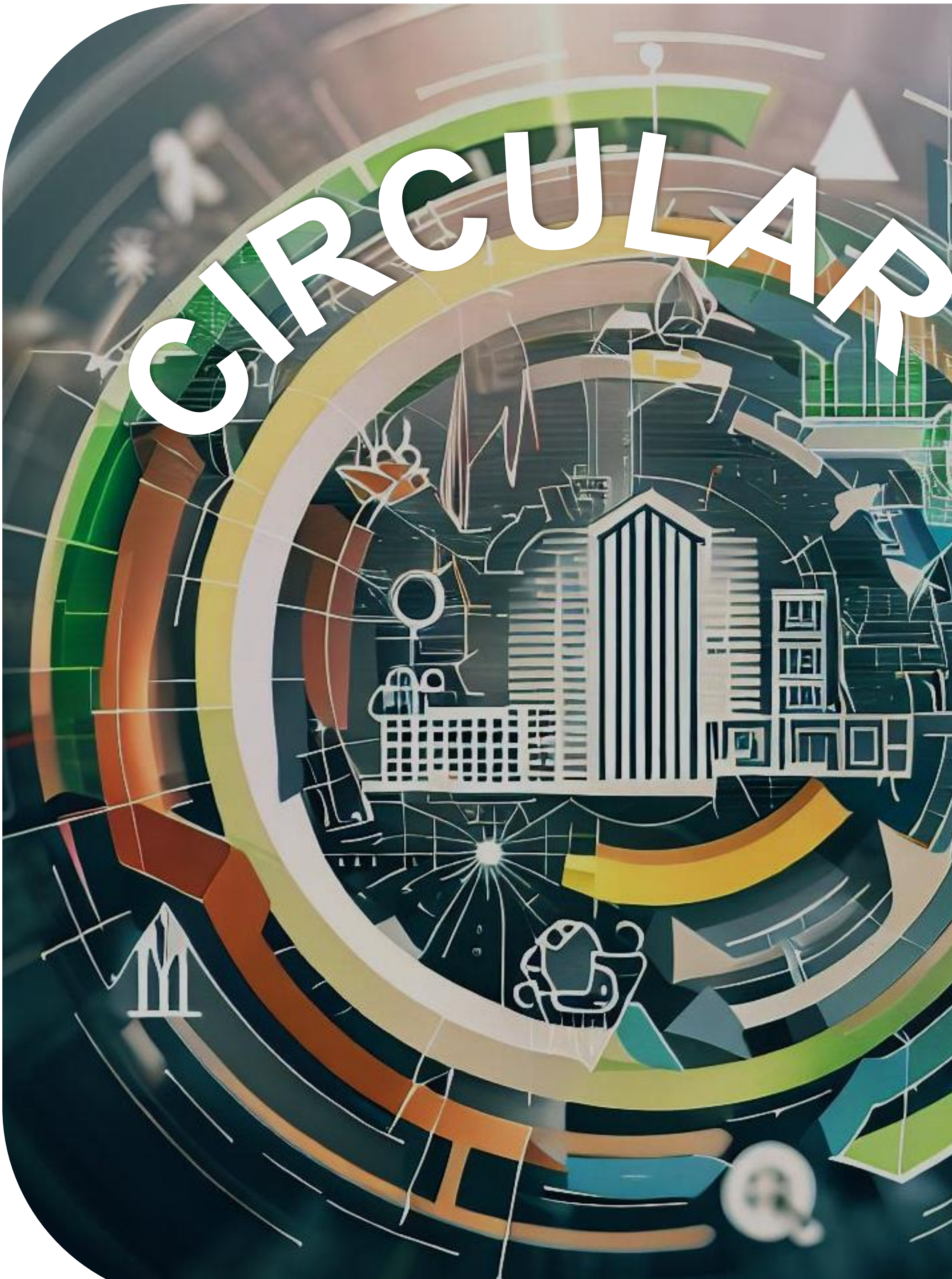

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Circular construction

The Circular Construction concept is a direct application of Circular Economy principles to the Architecture, Engineering, Construction and Operation (AECO) industry. It contributes to the elimination of waste and emissions, by recycling materials and remanufacturing or reusing construction components. The huge dimension of the AECO sector has an enormous potential to contribute to the desired transition from a linear to a circular economy and set the path to a sustainable future.

The strategies to enforce a Circular Construction mindset in the AECO industry include the following actions:

- Recycling of waste from Construction or other industries in the production of new components;
- Use alternative production techniques such as prefabrication;
- Design for deconstruction;
- Design for efficient building operation.

The Circular 2B project contributions to the implementation of Circular Construction include:

- Production of new components by incorporating waste and low carbon embodied materials;
- Development of modular construction solutions for buildings with high energy efficiency

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Selection of wastes

The characterisation of the wastes, either those already stored in the lab or those which will be included, for the first time, in the starting research, should be thoroughly and fully planned and ready to start as soon as the research is underway. This is a crucial aspect since the availability of this information is fundamental for the experimental work from the start of its development.

It will allow a more efficient integration and quick adjustment of the raw materials to the aims / objectives and the selected manufacturing procedures.

The availability of each type of waste should be guaranteed, as well as the stability of the properties of those wastes.

The characterisation of properties supports the definition of the wastes with the potential of being further used, a very significant aspect to consider when dealing with the application of relatively unknown materials to new applications.

Valorisation of wastes

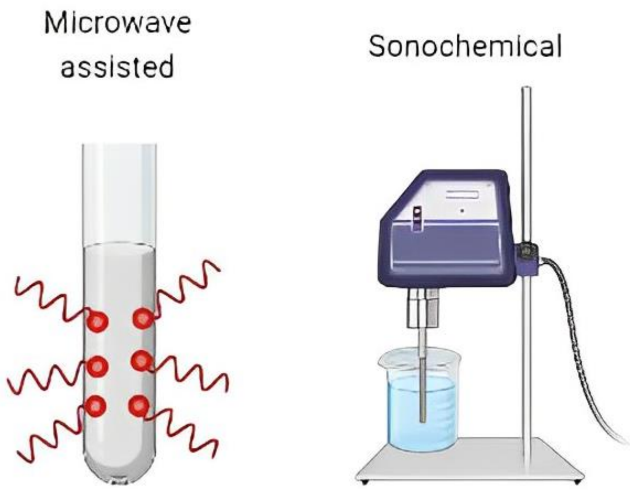
There are several advantages attributed to alkali-activated cementitious agents. One of the most outstanding is that they can be synthesised from precursors rich in aluminosilicates, which theoretically means that any raw material (or waste) that shows significant contents of aluminosilicates in its composition, if reactive to the attack of alkali agents, can be synthesized as a binder.

Therefore, a wide variety of industrial wastes, with a significant content of aluminosilicates, are potentially available as main precursors for developing alkali-activated binders.

As an alternative to standard concrete, the increasing development of alkali-activated materials (AAM) widens the range of opportunities to explore various types of foamed cement and concrete that meet the appropriate requirements for practical implementation in different applications, such as insulating materials in the envelope of buildings, wastewater treatment, dye absorbents, etc.

Green systhesis strategies

The green synthesis of nanoparticles relies not only on the choice of environmentally friendly chemical reagents but also on the fabrication procedures. Traditional approaches often require high energy inputs from external sources (e.g., baths, heating plates, or furnaces). Therefore, green chemistry aims to lower the impact related to chemical synthesis on human well-being and the environment. It is highly desirable to search for alternative and eco-friendly methodologies and move towards processes enabling higher reaction rates with lower temperatures. Paul T. Anastas and Jonh C. Warner developed the golden twelve principles of green chemistry to "reduce risk" and "minimize the environmental footprint".



1. Prevention: avoid waste rather than addressing or remedying it after it has been generated

2. Atom Economy: create synthetic techniques to improve the incorporation of all types of materials.

3. Less Hazardous Chemical Syntheses: develop strategies for utilising and generating substances with minimal to no adverse effects on human health and the environment.

4. Designing Safer Chemicals: design chemical products to fulfil their intended function while mitigating toxicity.

5. Safer Solvents and Auxiliaries: use of supporting reagents should be avoidable wherever possible and harmless when used.

6. Design for Energy Efficiency.

7. Use of Renewable Feedstock.

8. Reduce Derivatives.

Twelve Principles

9. Catalysis: selective as possible are superior to stoichiometric reagents.

10. Design for Degradation: products should be proposed so that at the end of their service life they turn harmless degradation products and do not continue in the environment.

11. Real-time Analysis for Pollution Prevention: Control the creation of dangerous compounds.

12. Inherently Safer Chemistry for Accident Prevention: Chemicals should be chosen to minimize possible accidents.

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Modular construction

Modular construction is an alternative approach to new buildings, in view of the more traditional techniques that are still commonly used in the South of Europe. This region was used to on-site based construction, incorporating mostly concrete and masonry components. The search for more efficient techniques, that are less work intensive and reduce waste, is gaining traction in the AECO industry, leading to a sustained growth of modular construction.

Modular Construction is a solid ally to Circular Construction as it relies in prefabrication, using mostly low weight components. The optimization of manufacturing techniques reduces waste and allows the incorporation of modules that can be reused. It is also more adaptable to the design for disassembly, with standardized components often relying on mechanical connections.

Circular 2B pursued a strategy of valorisation by using specific wastes on the fabrication of the core material that is applied on prefabricated panels eligible for modular construction.
The replacement of all the components is still a challenge as some adhesives, for instance, should incorporate a lower amount of raw materials.

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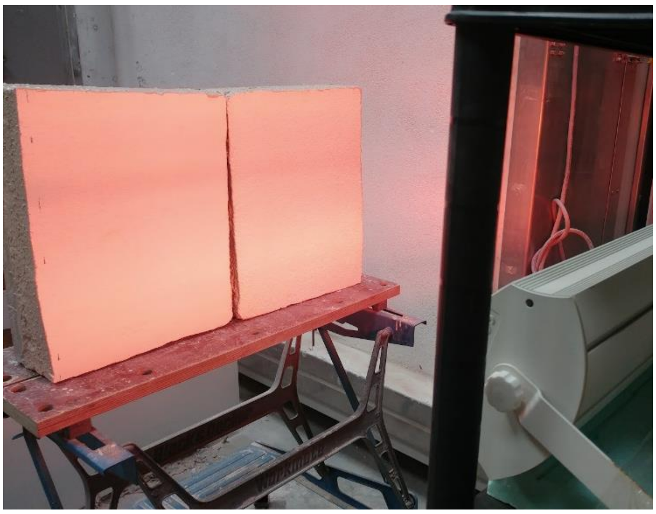
Durability

Durability is the ability of a building or part of a building to perform its function for a certain period of time under in service conditions (durability is not an intrinsic property of a particular construction item, but rather a characteristic that depends on the conditions to which it is subject in service).

The Design for Durability is adamant for Circular Construction, owing to its capacity to increase the service life of the building and its components. It has the ability to reduce property costs and facilitate maintenance and repair.

The ISO 15686 standard provides a structure for service life planning, including service life estimation, that enables a proper life cycle analysis.



The development of new products, including the ones that stem from waste valorisation, must include durability assessment.

Only an adequate set of accelerated ageing tests can supply the means for a proper service life estimation. The definition of those tests must be adapted to the climatic conditions to which the buildings will be exposed.

Life Cycle Assessment

Life Cycle Assessment (LCA) is a technique to evaluate the environmental impacts that covers all stages of the life of a product from “cradle to grave” (ie, from the extraction of the raw material to its disposal or recycling, including materials processing, manufacturing, transport, use, repair and/or maintenance). This assessment will often be performed “from cradle to gate” or “from cradle to cradle”.

LCA allows the compilation of energy and material inputs, along with the associated emissions. This allows to determine the resulting impacts and enables a more informed decision during the selection of materials and components for the building fabric.

The availability of detailed information, such as the contents of the Environmental Product Declaration (EPD) is fundamental for the systematisation of LCA.

The detailed description of the building construction is a key point for the determination of the whole building LCA. Together with the base components characterisation by EPDs, the detailed information on transportation and assembly process is of high relevance. Again, modular construction will more easily provide a proper estimation of this data.

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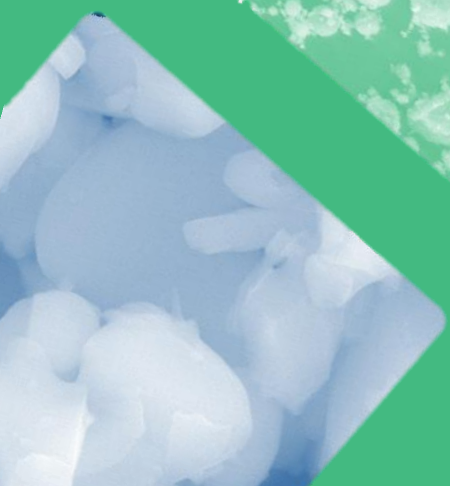

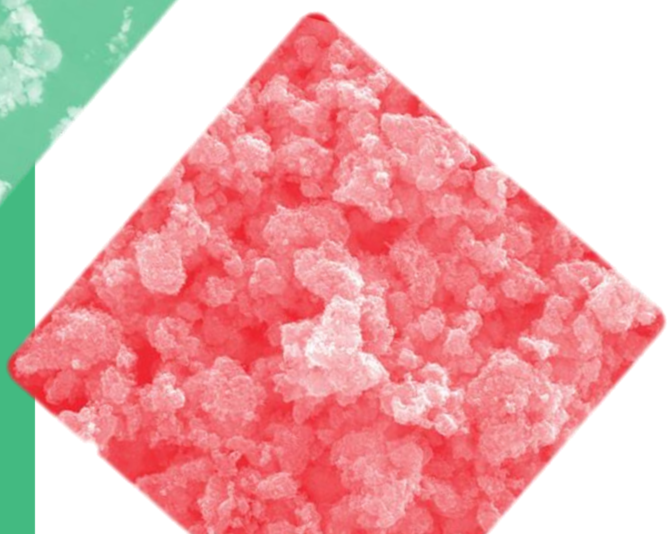

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