REINCARNATE

D2.3 Material upgrade and reinforcement

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Abstract

Currently, there is no widely agreed-upon set of terms and ideas related to the circular economy.

Keywords:

Circular Economy, Machine Learning,..

Revisions

Version	Submission date	Comments	Author
v0.1	7.11.2023		
v0.2			
...			
...			
...			

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Acronyms and definitions

Acronym	Meaning
XD	eXtreme Design
MOMo	Modular Ontology Modelling
...	...

Reincarnate project

The average lifespan of a building is 39 years — in Europe, it is only 25-30 years — and the main reason for demolition is obsolescence. This is why there is a large amount of construction and demolition waste (CDW) — representing approximately 25-30% of all waste in Europe —, in addition to that generated in current construction works.

The recycling rate for CDW is relatively high (above 75%). This activity generated $126.89 billion in 2019 — Europe contributed the largest share, almost two-fifths of the total global market — and is projected to reach $149.19 billion by 2027. Unfortunately, many of the most valuable materials in CDW cannot be meaningfully separated and end up in landfills. This helps to get an idea of the efficiency potential for climate neutrality that exists in construction.

Reincarnate aims at advancing circular economy practices within the European construction industry and enabling to significantly maximize the life cycle of buildings, construction products, and materials, reduce CDW by 80%, increase the reusability of buildings, construction products and materials and, as a result, lower the sector's emissions by 70%.

As a result of these actions, Reincarnate will significantly advance circular economy practices within the European construction industry. First, it will create a Circular Potential Information Management (CP-IM) platform and a set of innovations to use it. These solutions will draw upon emerging digital technologies, such as digital twin representation, artificial intelligence, and robotic automation.

Three empirically proven social science insights will allow fostering widespread adoption of reused high-quality construction products and materials, and business ecosystem development frameworks to combine actors within sustainable value chains. All innovations will be demonstrated on eleven selected real-world projects and value chains. Furthermore, business process guidelines and an e-learning platform will be developed to drive the dissemination and exploitation of the Reincarnate results.

Contents

List of Figures

List of Tables

Executive Summary (4p, Christoph, Sabine)

A concise overview of the report's goals, methodology, key findings, and conclusions.

1 Definitions and Interpretations

Construction Material: Refers to the raw substances or elements used in creating building structures, such as concrete, steel, wood, and composites. These materials are fundamental to the construction process, and their properties directly impact the overall quality, durability, and performance of the built environment.

Construction Component: Involves manufactured or fabricated elements that are part of a larger structure, like beams, columns, panels, or window units. These components are integral to the structural and functional aspects of buildings and infrastructure.

Building System: Refers to the comprehensive assembly of interconnected components that function together to provide essential services or perform specific functions within a building. This includes systems like HVAC (Heating, Ventilation, and Air Conditioning), electrical systems, plumbing, and structural frameworks. Building systems are designed to work in harmony to ensure the building's functionality, comfort, safety, and energy efficiency.

Data-Driven Method: A data-driven method refers to an approach that relies on data analysis to inform decision-making, predictions, or understanding of phenomena. In the context of construction materials and products, these methods often utilize statistical, machine learning, or AI algorithms to analyze data and draw insights about material conditions and durability.

Condition Assessment: Condition assessment in construction refers to the process of evaluating the state or health of a material, product, or system. It often involves the analysis of various indicators, such as physical properties, performance data, and degradation over time, to determine current conditions and predict future performance.

Durability: Durability in the context of building materials refers to the ability of a material or product to withstand environmental conditions and operational stresses over time without significant deterioration. It's a key factor in assessing the long-term performance and sustainability of construction materials.

Non-destructive testing: Non-Destructive Testing in construction is a range of techniques used to evaluate the properties, composition, and integrity of materials and structures without causing damage.

2 Introduction and Background (10-15p, Zia)

Combines the context, objectives, and a wide literature review relevant to construction material models, nondestructive testing, and digital workflows in building inspection.

The first draft of the Excel Table created, crossing materials, NDT methods, and data-driven methods, has now to be brought in the perspective of this dev

2.1 Concrete

2.2 Timber/Wood

2.3 Steel/Metal

2.4 Masonry/Bricks

3 Methodology and Data Integration (CP-IM workflow and ontology, max. 5p, Ben)

Details the CP-IM information, nondestructive testing methods, data collection, and techniques for integrating nondestructive field data with destructive material testing data.

- Role of ontologies in the data integration (use contents of NMR paper)

4 Analysis and Development of Material Models (data-driven methods for ndt-data, a machine learning model that works on ndt-data input and calculates (future) condition status, 10p Zia)

Focuses on analyzing chemical and mechanical properties, developing models for assessing material status and lifetime, and discussing challenges in data integration.

- Adaptive Sampling Approach (Zia's Paper)

5 Digital Workflow and Field Applications (focus on a specific case study here, 3per case study in total 9p, 3p CEMEX, 3p RAS, HKP???, Zia, Christoph, Sabine)

Describes the integration of non-destructive testing into the digital workflow and its application in the Building Inspection and Valuation methodology, including case studies.

- MFX, shows how such a case study is integrated in their software (who?)

- Cemex has to report their case study and we contribute with possible NDT solutions (Zia, Sabine)

RAS (Zia, Christoph)

6 Conclusions and Recommendations (4p, ALL)

Combines discussion of implications, suggestions for future research, and practical recommendations for industry practice.

References

Mechanism	Consequence on concrete	What is looked for?
Overloading	Damage cracking	• if distributed damage: crack density residual stiffness and strength
Restraining effects (temperature shrinkage)		• if localized cracking: location width depth
Freeze–thaw cycles	Scaling spalling delamination	• delaminating areas • depth of delamination
Fire	Strength decrease spalling	• depth reached by fire effects • residual strength at various depths
Abrasion–erosion	Material loss	• residual strength of surface layer
Carbonation	Increase in density depassivation of steel thus rebar corrosion	• carbonation depth • if corrosion: localization of active corrosion areas corrosion rate
Chloride attack	Rebar corrosion	• chloride content chloride profile • if corrosion: localization of active corrosion areas corrosion rate
Alkali–aggregate reaction	Internal expansion generalized cracking	• potential for future volume change
Sulfate attack		• residual stiffness and strength
Leaching	Cement paste dissolution increase in porosity	• residual strength porosity
Ammonium nitrate attack	Deterioration of the cement paste spalling rebar corrosion	• depth of the attack • if corrosion: localization of active corrosion areas corrosion rate

Table 1: Mechanisms of concrete deterioration and their evaluation

Indirect factors	Direct Factors	
	Exogenous factors (environmental influences)	**Endogenous factors (material-inherent resistance)**
Climate	Presence of species	Natural resistance
Air		
Temperature	Decay types	Wood species
Precipitation	Degradation mechanisms	Extractives Position in the log
Wind	Inoculum potential	
Relative humidity	Wood temperature	Juvenile/adult wood
Construction/design	Dynamics of conditions	Reaction wood
Dimension	Wood moisture content	Provenience
Shadow	Nutrients	Felling time
Distance to ground	Relationship between organisms	Storage
Orientation		Density
Roofing		Tylosis
		Improved resistance
		Type of wood preservative
		Retention of wood preservative
		Penetration/distribution of wood preservative
		Wood modification
		Hydrophobation
		Coatings
		Biological wood protection

Table 2: Factors influencing wood durability and preservation.