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(De)construct for Circular Economy

(Des)construir para a Economia Circular

WP 3 – Material passports

Activity 3.1 – State-of-the-art

Final report

29th September 2021

Operador do Programa: REPÚBLICA PORTUGUESA – AMBIENTE E AÇÃO CLIMÁTICA

Promotor: cimbal – COMUNIDADE INTERMUNICIPAL DO BAIXO ALENTEJO

Parceiros: LNEG, NOVA School of Science & Technology, Politécnico de Portalegre, RESIALENTEJO E.I.M., Smart Waste Portugal, RDF Construções – Sociedade Imobiliária, Lda., cercibeja, IDN, ENVIROS, Centro Nacional Produtivo Consumo Durável

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Content

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1. Introduction

Providing 18 million direct jobs, the construction industry is very important to the European economy. It contributes to about 9% of the EU's GDP and creates new jobs and drives economic growth.[1]

In this large consumption sector, we need to apply circular economy and resource efficiency principles to buildings to reduce resource use in the future. This aspect is highly recognized and promoted by The European Commission in the European Green Deal, however the transition for a circular economy is not easy to implement, especially in a sector with a long-life cycle, and with a large and global value chain with several existing or potential dilemmas and challenges: structural resistance versus easy to disassemble, longevity versus flexibility, simple versus composite products, renovations versus new build, etc.[2]

There are several potential measures to implement in the building sector in order to promote the transition to a circular and sustainable economy. These are material efficiency measures which contribute to reducing material use, the substitution of high impact materials with lower impact materials and the recirculation of products or materials. As an example, the design of buildings so that their components can be disassembled and reused rather than wasted has an impressive potential for circularity. Up to 90% of the materials from a building designed to be disassembled can actually be reused.[3]

This disassembly and reuse of materials in buildings should be promoted since the beginning through the design of the building and the selection of materials, components and building solutions.

One important tool to promote this, are the material passports. These, by obtaining and processing systematized and optimized information, where materials are identified in a database, can be crucial in managing and providing information to stakeholders and facilitating decision making in order to innovate, create value and adopt measures to circularity and sustainability in construction.[4]

This report is organized as follows:

Chapter 2 (Building materials passports) is organized in 10 sections: Section 2.1 explains what is a materials passport. Section 2.2. elaborates on the usefulness of materials passports. In section 2.3, goals and benefits are presented. Section 2.4 presents the results of an inquiry performed with municipalities of the partner countries (31 in Portugal, 3 in Czech Republic, 1 in Norway and 3 in Romania), aiming at understanding current practices and knowledge about materials passports. In section 2.5, existing systems or schemes for material passports found in scientific and grey literature are presented. In section 2.6 the information from those schemes is systemized in order to provide an overview of how a passport can be organized, related data and other features. Section 2.7 presents a similar summary for Norwegian references, the only country in the partnership that could provide such information (in Czech Republic, Portugal and Romania it was not possible to find examples of passports). In section 2.8, a review of schemes, tools or indicator systems that may provide relevant information to be used in materials passport is performed and this is then summarized and

[1] https://ec.europa.eu/growth/sectors/construction_en
[2] Circular economy principles for buildings, 2020. European Commission. Retrieved from https://ec.europa.eu/docsroom/documents/39984
[3] https://ramboll.com/ingenuity/circular-economy-8-actions-to-cut-60-co2-in-the-buildings-sector
[4] M R Munaro, A C Fischer, N C Azevedo and S F Tavares, 2019. Proposal of a building material passport and its application feasibility to the wood frame constructive system in Brazil - IOP Conference Series Earth and Environmental Science, doi:10.1088/1755-1315/225/1/012018

systemized in a table that can be found in section 2.9. A similar input was provided by the Norwegian partner, that is presented in section 2.10.

The report is finalized with chapter 3. Conclusions.

2. Building Materials Passports

2.1. What is a building materials passport?

A building materials passport[5] is a digital document consisting of the compilation and display of materials that are included in a product or construction. It consists of a set of data describing defined characteristics of materials in products, which give them value for recovery, recycling and re-use. The core idea behind the concept is that a material passport will contribute to circular economy", promoting the use recovery, recycling and/or re-use of materials and components in a dedicated market. [6]

Material passports are a tool that addresses questions often not covered by other documents or certifications related to building products, especially concerning the potential of circularity of products. Material passports do not assess the data output and do not include an evaluation of data. Instead, they provide relevant information that can be used for several purposes at different stages of the life cycle of the building. The passports support also the assessment and certification by other parties and allow existing assessments and certifications to be entered into the passport as uploaded documents.

In brief, a building materials passport is a digital report containing circular economy relevant data that is collected and stored in a centralised database in the form of reports customised to the needs of diverse users. The scope of a materials passport can be focused on different levels and have different structures and ways or hierarchy levels to present the information. According to the needs of the users, a single passport can include the level of materials, components, products and systems that constitute a building (Figure 1).

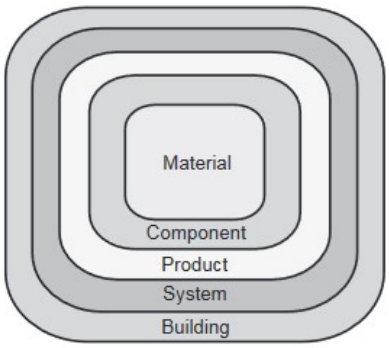

Figure1: Hierarchy levels covered in materials passports (Luscuere and Mulhall 2017) retrieved from Materials Passports - Best Practice - Innovative Solutions for a Transition to a Circular Economy in the Built Environment,

In terms of specific materials, the passport can define the topology and its value and potential for recovery. In terms of products and systems, it can define general characteristics that make them valuable for recovery such as their design for disassembly, but it can also describe specifics about a single product or system in its application.[7]

[5] Materials Passports - Best Practice - Innovative Solutions for a Transition to a Circular Economy in the Built Environment, Matthias Heinrich, Werner Lang – Technische Universität München, in association with BAMB, 2019
[6] https://en.wikipedia.org/wiki/Material_passport
[7] https://www.bamb2020.eu/topics/materials-passports/circular/

In order to have a global characterization of the system, non-material-related factors, such as energy performance and use, need to be addressed as well.[8]

2.2. What are passports for?

The building sector is responsible for around 40% of material resource use (by mass) and 40% of waste production (by volume)[9] (UNEP 2016) and the current trend is that this issues will further intensify in the future.

The majority of materials from buildings demolitions or renovations is either downcycled (e.g. used as road aggregate or backfilling) or ends up in landfills. Recycling material for use in new buildings or the reuse of building materials, components and systems rarely takes place.

Historically[10], building materials and products have generally been reused at a higher level to construct new buildings, however, due to the fast growth and demand of the construction sector and the increasing complexity of products and buildings, in the last 70 years this procedure has decreased. The current products and building solutions contain a large number of different types of materials that are attached to each other in different ways. These solutions provide relevant mechanical and physical properties but jeopardizes the reuse and recycling process in the end of useful life.

This constant search and development for innovative materials with higher properties and reduction of costs in most cases, leads to an information gap of material and product information. Often, the composition and properties of materials and products is unknown or not communicated to the relevant actors in the construction value chain. Therefore, standardised and transparent methods of data collection for materials and products within buildings throughout a building's life cycle are very much needed.

The information from materials passports must be purposeful and accessible to users and can be used for various assessments (e.g. building assessment and certification, material flow analysis, energy assessments and simulations etc.), reversible design protocols, product innovation and others.

The development of material passports and making available the relevant information is capable of driving innovation by providing project orientation in the choice of materials and creating incentives for stakeholders to produce in a more sustainable way, and to communicate in a transparent manner the circular value of their products so that they can be reused. These must communicate the level of information related to a product in a living and dynamic document that can suit the stakeholders according to their needs[11].

At EU level, material passports will contribute to a number of high-profile policy initiatives including the strategy "A Europe fit for the digital age", the "European Green Deal" and its Renovation Wave, the new Circular Economy Action Plan and the forthcoming Strategy for a Sustainable Built Environment. They are also an important element to the implementation the EU strategy to trigger a Renovation Wave for Europe, which aims to break down long-standing barriers to energy and resource-efficient renovation, support fresh

[8] Materials Passports - Best Practice - Innovative Solutions for a Transition to a Circular Economy in the Built Environment, Matthias Heinrich, Werner Lang - Technische Universität München, in association with BAMB, 2019
[9] UNEP. (2016). The 10YFP Programme on Sustainable Building and Construction. UNEP
[10] Materials Passports - Best Practice - Innovative Solutions for a Transition to a Circular Economy in the Built Environment, Matthias Heinrich, Werner Lang - Technische Universität München, in association with BAMB, 2019
[11] M R Munaro, A C Fischer, N C Azevedo and S F Tavares, 2019. Proposal of a building material passport and its application feasibility to the wood frame constructive system in Brazil - IOP Conference Series Earth and Environmental Science, doi:10.1088/1755-1315/225/1/012018

investment over a sustained period starting from public and less efficient buildings, spur digitalisation and create employment and growth opportunities across the renovation supply chain[12].

The objective is to at least double the annual energy renovation rate of residential and non-residential buildings by 2030 and to foster deep energy renovations. Mobilising forces at all levels towards these goals will result in 35 million building units renovated by 2030. The increased rate and depth of renovation will have to be maintained also post-2030 in order to reach EU-wide climate neutrality by 2050[12].

2.3. Main goals and benefits of materials passports

Material passports, by providing relevant and diversified information about products and materials, have enormous application potential and can be used by various stakeholders and for various purposes. These include[13]:

- Keep or increase the value of materials, products and components over time (i.e. residual value)
- Create incentives for suppliers to produce healthy, sustainable and circular materials and building products
- Promote the development and use of more innovative, efficient materials and products with a greater potential for value in the future.
- Enable circular product design, material recovery and chain of possession partnerships
- Support material choices in reversible building design projects
- Reduce the eco-footprint
- Make it easier for developers, managers and renovators to choose healthy, sustainable and circular building materials
- Facilitate reversed logistics and reclaim products, materials and components
- Assessment of future material flows
- Management of supply and demand
- Assessment and forecast of potential secondary raw materials
- Systematic recovery and utilisation strategies can be identified and further developed
- Strategic positioning of plants (e.g. recycling, material traders etc) and supply chain management
- Link and make relevant data available for assessments on various hierarchy levels
- Reduce the costs by managing resources rather than managing waste
- Develop a sustainable life cycle management of materials, products and buildings
- Eliminate waste and reduce the use of virgin resources
- Improve the quality, value and security of material supply
- Provide a tool to move from a linear system to a circular one

Through the transparency and the relevance of the information recorded and made available, the passports not only operationalize circular potential but to put it into practice, they provide incentives for innovation in more than one way[13]:

[12] European Commission. (2020). Circular Economy Action Plan. #EUGreenDeal, 4. Retrieved from https://ec.europa.eu/environment/circular-economy/pdf/new_circular_economy_action_plan.pdf
[13] https://www.bamb2020.eu/topics/materials-passports/what/

- Guidance. The passport does not have a normative or a certificate purpose and having a passport does not necessarily make the product good for the Circular Economy. The need to collect and share information provides guidance throughout the life cycle of materials, products, systems and buildings
- Recognition. The development and availability of passports promote the differentiation from competitors through transparent communication of the characteristics of materials and products and their circularity potential
- Innovation and knowledge. This approach promotes companies to have a more active knowledge about their products and the materials that compose them. This knowledge also promotes innovation and the development of new and more efficient solutions for the entire life cycle.

- New business models. Passports promote new business models, both in terms of building construction and use. New solutions such as reversible products and systems, reuse, etc. promote new ways of use and ownership of buildings

2.4. Municipalities survey

Within the project, an extensive survey was performed in order to collect information needed for the project at several levels. The collaboration of the Alentejo Municipalities, the target group of the project and other Portuguese, Czech, Romanian and Norwegian municipalities, allowed the collection of relevant data to support the project development.

Regarding the topic addressed in this report, focused on the state-of-the-art in terms of material passports, within the activities of WP3 – Material passports, the questionnaire includes specific sections with relevant information about Material passports, Reuse of materials from in the construction sector and a section on the use of recycled materials or, materials with a percentage of recycled materials, within the construction sector.

2.4.1.Sample

The data available in this report considers the questionnaires filled in by 31 Municipalities, 25 in Portugal, 3 in Romania, 3 in Czech Republic and 1 in Norway.

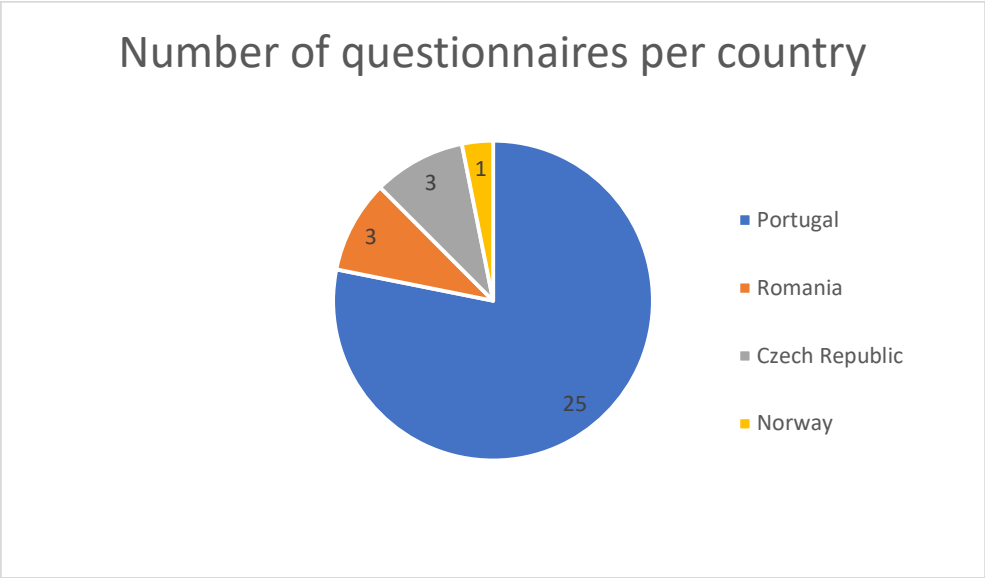

Figure 2: Questionnaires per country

2.4.2. Experience with material passports and availability of data to support the creation of passports

Regarding the experience with material passports, 100% of the municipalities indicated that they do not have any experience in the topic.

As for the data needed for the passports, six municipalities indicated that there is data available that can be used as inputs for the material passports.

2.4.3. Construction sector materials reuse

Within this topic, the aim was to understand actions and procedures carried out by the municipality or which are its responsibility regarding the reuse of construction materials.

From the 31 municipalities in the study, only 3 have the adoption of practices that promotes the reuse of construction materials regulated, 1 in Portugal and 2 in Romania. However, a higher number of municipalities (23) have mentioned that initiatives to recover building materials to be reused are implemented. The main materials and products reuse are sanitary ware, windows, doors, tiles, concrete, among others. But from these, only one municipality records the material and components. The other are reusing materials and component in a non-systematized way.

2.4.4. Use of recycled materials or materials incorporating recycled components in the construction sector

In what regards the use of recycled materials or materials incorporating recycled components, regarding the actions and procedures carried out by the municipality or that are your responsibility, only 1 municipality from Romania have practices that promote the use of this type of construction materials regulated with a specific regulation that provides for the possibility of reusing certain CDW functions if they are not contaminated with hazardous chemicals.

The concept is not regulated in almost all municipalities, however, some (11 municipalities) are promoting the use of this type of materials in the construction sector. These are including in their specifications some specific indications in this regard.

Like in the previous topic, only one municipality has records of these materials or components.

2.4.5.Survey conclusions

As conclusion, the municipalities are demonstrating interest in the reuse and recycling of materials and components in their projects and in promoting it to society, however, their experience in the topic is very low, not systematized and with a case-by-case approach. At the same time, they do not have any experience with material passports.

2.5. Overview of main references – material passports

2.5.1.BAMB - Buildings as material banks[14]

The BAMB project, consist out of a consortium of 16 companies, research institutes and universities started in September 2015 and progressed for 3 and a half years as an innovation action within the EU funded Horizon 2020 program.

The project, aiming for the prevention of construction and demolition waste, the reduction of virgin resource consumption and the development towards a circular economy is one of the most important references in material passports has developing and integrating tools to enable the shift: Materials Passports and Reversible Building Design – supported by new business models, policy propositions and management and decision-making models.

By creating circular solutions like Materials Passport, Reversible Building Design, Circular Building Assessment, new business models and providing proposals for policies and standards. This will lead to less waste from the building sector.

The BAM project include a Materials Passports Platform which is a software and linked database to create MP. The platform compiles structured and unstructured data of buildings and building materials. The platform enables multiple stakeholders to fulfil two major purposes:

1. generate BMP
2. provide and see data during all the product and building usage phases.

2.5.2.MADASTER[15]

MADASTER is based on a register system for materials and products. In this online platform buildings are registered including the materials and products that are used. Documenting, registering and archiving materials in buildings and construction objects makes re-use easier, encourages smart design and eliminates waste. By doing so, every building becomes a material bank. The owners and/or managers of real estate or infrastructure always have up-to-date information on the financial and circular value, toxicity, dismantlability and reuse potential of applied materials, products and elements.

[14] www.bamb2020.eu
[15] https://madaster.com/platform/

MADASTER automatically generates a secure web-based passport of a registered building or construction object. The passport contains information about the quality, origin and location of materials and products and provides insight into the material, circular and financial (residual) value of a building.

2.5.3.The CIRCULAR BUILDINGS project[16]

This project, which began in May 2020, aimed at developing decision support tools to promote increased reuse of materials and a reduction in the production of waste in the construction sector. It was developed Portugal by the Smart Waste Portugal Association, in collaboration with 3drivers - Engineering, Innovation and Environment, the Faculty of Engineering of the University of Porto (FEUP) and the Portuguese Technological Platform for Construction (PTPC), and financed by the EEA Grants.

The tools facilitate the definition of building materials passports and the calculation of circularity and material, water and energy efficiency indicators. A tool to assess the environmental and economic benefits associated with circularity in buildings was also developed.

The project results included:

- Guide to Creating Passports for Building Materials
- Good practice guide for promoting circularity in DAP
- Good practice guide for calculating building efficiency indicators
- Calculation tool for environmental and economic impacts associated with the reuse of materials and construction products and waste treatment

This project provides a good example of a materials passport through an Excel based template, freely available under request (figure 3).

[16] https://construcaocircular.pt/edificios

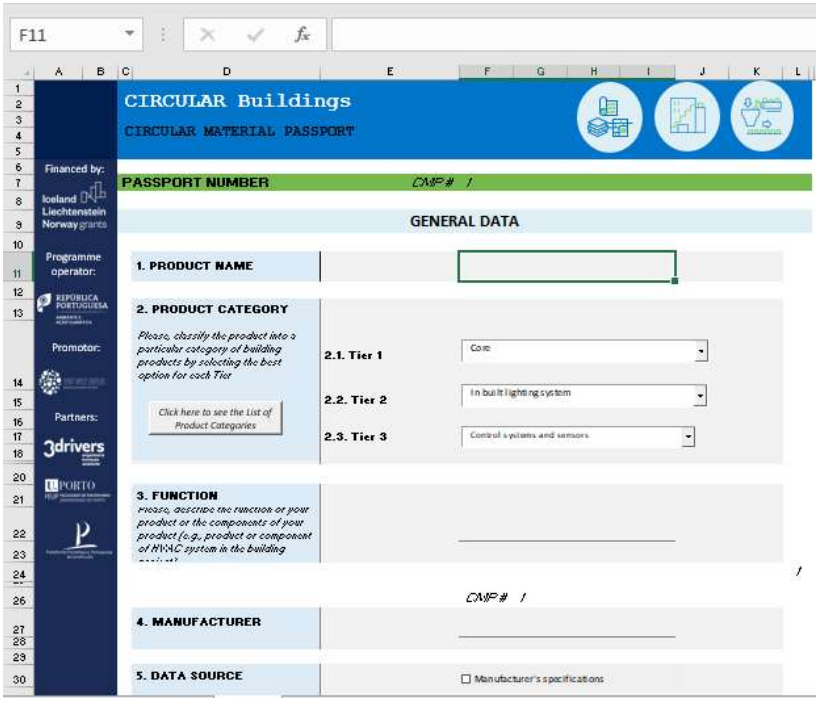

Figure 3: An excerpt of the Circular Material Passport developed within the CIRCULAR BUILDINGS project

2.5.4. Material passport - Working together towards a circular Economy - Publication - Alliander[17]

Alliander is a Dutch group composed by several companies related to energy networks.

Within its activities and mission towards sustainability and circular economy, the company created a methodology and tool to develop material passports in order to identify and register the materials and their characteristics in term of properties and circularity.

The tool was developed with the aim of asking suppliers to complete a raw materials passport for all the primary assets, such as installations, cables and pipes. The passport provides insight into the raw materials and materials the product consists of, how many recycled materials it contains and to what extent the product or material can be recycled or reused at the end of its life.

2.5.5. Fundamental Characteristics and Concept of Material Passports[18]

This article explores the characteristics of material passports. The goal of the research s the definition of the fundamental characteristics of material passports and their role in the current economy. She considers that a clear definition and characterization are lacking and it's necessary due to the innovative matter of material passports.

In the article, she aims to answer her central research question. “What are the fundamental characteristics which define the concept of material passports?”.

[17] https://www.alliander.com/en/
[18] https://epea.com/en/services/buildings

Based on the literature review, a standardized model for Material Passports is presented in the article.

2.5.6.EPEA - Cradle to Cradle Buildings – Material passports[19]

EPEA (Environmental Protection Encouragement Agency) was founded by Michael Braungart, in order to not only point out environmental problems but also to motivate companies to act and develop solutions together. The agency has as a goal to establish the Cradle to Cradle® design framework for a circular economy in all industry sectors. This allows supporting companies to move onto the right path and become part of the change: from the molecular to the modular level, from chemicals to cities.

Within its activities, the Agency has services at Industry products levels, Cities and infrastructure, Business transformation and Buildings.

On what concerns buildings, EPEA support the implementation of the Cradle to Cradle® design framework for buildings and developed the Building Circularity Passport®" which serves as a planning and documentation tool, for enabling the circulation of a building in collaboration with architects, all planning disciplines as well as the construction firms. For completed construction projects, the Building Circularity Passport® additionally provides detailed information on which of the used materials can be easily separated, as well as on the chemical composition of the products used in the building. It is also possible to determine the monetary value of the structures used in the buildings. This information on the building provides you with considerable benefit for financing, through aspects of risk assessment, value determination as well as the operation of the building[22].

[19] https://epea.com/en/services/buildings

2.6. Summary of main references - Material passports

Reference	Structure	Required data	Sources of data	Usability	Platform	Pros and cons	Remarks
BAMB - Buildings as material banks	Identifier - General information of the product Value for user – information about reuse features of the product. It includes also documents such as EPD, material safety datasheets, technical datasheet Installation – Basic information on installation and maintenance of the product Residues – information about residues related to the product Potential – Information on product potential next use. • Reuses as it is, re-installable for same use • Extracted and reused in other buildings • Extracted and refurbished • Design for recycling • Designed for composting Material Health – information on the scenarios of the product and if has an assessment or certification	• Physical properties • Chemical properties • Biological properties • Material Health • Unique product and system identifiers • Design and production • Transport and logistics • Construction - identifying material and product locations within buildings • Use and operate phase • Disassemble and reversibility • Reuse and recycling	The platform includes feature to support the link to different sources of data. It includes an API to transfer data between systems efficiently. One example: SundaHus Material Data system (SHMD) contains a significant amount of data that is relevant for MP Specific data uploaded by stakeholders		Materials passport platform (MPP)-The software and linked database developed by BAMB for the creation of MP. This IT solution enables multiple stakeholders to generate and view MP		

MADASTER	The Madaster passport has the following structure:
	• General information
	• Source files
	• Building materials
	  ○ site
	  ○ structure
	  ○ skin
	  ○ services
	  ○ space plan
	  ○ stuff
		Madaster uses the "Shearing Layers" model (onion layers model) [Duffy, Brand, 1994] to organize the materials and products buildings consist of. Based on this model, a structure to classify the building is	Madaster primarily uses IFC (2x3) building files to calculate the material quantities. To do this, you must include the "base quantities" of the objects in the export.
			As a secondary source of information, a Microsoft Excel file (based on a Madaster Excel template) can be imported containing geometric
				The passport compiles the information that is registered in the Madaster platform structured in a simple and clear way.	Online platform developed by MADASTER	Con:
						• From the example available, is not clear the distinction of different materials from the same type. For example, It displays the
							The information registered in the MADASTER Platform is used by other material passports

Reference	Structure	Required data	Sources of data	Usability	Platform	Pros and cons	Remarks
	○ unknown ○ introduction • Building products ○ site ○ structure ○ skin ○ services ○ space plan ○ stuff ○ unknown ○ madaster circularity indicator (ci) • Circularity ○ circularity indicator (ci) ○ circularity construction phase ○ circularity use phase ○ circularity end- of-life phase • Additional information The results are displayed in values for stone, glass, wood, plastic, metal and unknown. The Madaster Circularity Indicator assesses the uploaded sources files and gives the building a score between 0 and 100%. A building is assessed on three phases: input in the construction process, the utility during the use phase and the destination of the materials at the end-of-life phase. A building with a high score is constructed with reused and recycled materials, has a higher than average utility and can be disassembled after use for easy reuse and recycling. A fully circular building has a score of 100%.	proposed. In this model each layer has a distinctive functional cycle.	information about the building, information on the building parts and/or components, materials. Circularity Indicator is based on the Material Circularity Indicator that has been developed by the Ellen MacArthur Foundation			information about wood, but do not specify which type of wood is.	
Circular Material Passport developed within the CIRCULAR BUILDINGS project	Passport number (automatic field) **General data** **Product context: use and location**	**General data** 1. Product name 2. Product category	**General data** 1. User	Clear and user-friendly tool, but with some bugs that need	Excel	Pros: • User-friendliness	

Reference	Structure	Required data	Sources of data	Usability	Platform	Pros and cons	Remarks
	Building identification (address and type of building/infrastructure, to be inserted by the user)	3. Function 4. Manufacturer 5. Data sources **<u>Use and location</u>** 6. Building identification 7. Installation date 8. Location 9. Expected service lifespan 10. Maintenance 11. Expected end-of-life **<u>Circularity potential</u>** 12. Design for disassembly (type of connection, subtype of connection, type of connection accessibility, type of crossings, type of form (12.1-12.4) 12.5 Score for disassembly potential	2. List of categories following the Level(s) framework, 3 tiers) 3. User 4. User 5. E.g., manufacturer's specifications **<u>Use and location</u>** 6. User 7. User 8. User 9. Inserted by the user or reference value provided by the tool, according to tier 3 10. User 11. Installation date + expected lifespan **<u>Circularity potential</u>** 12. Drop down lists 12.5 Automatic rating (0-1) with a comment on the damage associated to the possibility to recover the product 13. User 14. User, at product or component level, in weight	to be solved (e.g.		• Three circularity criteria: design for disassembly, types of material inputs and waste scenarios) • The design for dismantling aspect is very detailed, although difficult to be filled on by a layperson • Graphically attractive • Light excel file • Complemented by guidelines that provide detailed information on how the tool was built including references Cons: • It does not provide any clues on how to increase the circularity potential	

Reference	Structure	Required data	Sources of data	Usability	Platform	Pros and cons	Remarks
		13. Disassembly instructions 14. Quantity 15. Material composition 16. Material input sources 17. Waste scenarios (including a graph and a table, both automatically generated)	15. User fills in percentage for a list of predefined materials, with the possibility of adding more 16. User fills in % oy types of sources of the whole product or components, provided by the tool (reused/recycled/biomass /virgin 17. Drop down list, at product or component level (reuse, recycling, energy recovery, backfilling, landfill)			• Some important information is missing, such as the presence of hazardous materials • It does not allow for filling in and combining multiple products – one has to fill in one excel file per product • The graph with the waste scenarios does not give a visual indication of a circularity hierarchy	
ALLIANDER tool	The tool is developed in excel and consists in 4 spreadsheets. • Introduction • Legend • Material passport data • Material list In the Material passport Spreadsheet, the user has to select the material from the list available, insert the weight the percentage of recycled and recyclable material and select if	Definition of the materials, weights, % of recycled and recyclable material	The data is inserted by the user and the calculation is done by the tool based on the information included	Simple and intuitive use of the tool	Excel	Pros: • Very simple and intuitive to use. Cons: • The circularity aspects are related to recyclability only. The tool does not	

Reference	Structure	Required data	Sources of data	Usability	Platform	Pros and cons	Remarks
	it is recycled or downcycled. The scenarios are included in the tool. As results, the tool provides: •The circularity score of the material based on the percentages of recycled and recyclable attributed to the material. •The amount of circular material (g) •The amount of recycled material (g) •The amount of recyclable material (g)					include other aspect related to reuse, lifetime, etc.	
Fundamental Characteristics and Concept of Material Passports	The proposed structure aims to contain all the basic information that should be present in any version of Material Passports The main template includes three pages. Page 01- • name of the document • name of the product • name of the company/organization offering the product Page 02 The second page aims to reinforce the knowledge about the document type and the purpose of such document. • Importance of a circular economy. • Definition of material passports • Purpose of material passports Page 03 separate sections for each important characteristic product type and description • Product composition • Product location • Product recycling potential • Disassembly instructions & disposal. In addition to these basic sections, each passport can contain additional information, however, none of the sections mentioned	Technical and quantified information related to the section mentioned.	N.A	N.A	N.A	N.A	The information available is a proposal for the structure of material passports based on the research under development on the topic.

Reference	Structure	Required data	Sources of data	Usability	Platform	Pros and cons	Remarks
	could be removed. The characteristics selected aimed to have the proper level of universality, so that they can be applicable in any situations.						
EPEA - Cradle to Cradle Buildings – Material passports	According to the example provided in the EPA website, the structure used includes the following information: • Information about the cradle2cradle concept • Madaster ZI-Score • Performance overview (presented in charts %) • Indication of SDGs related to the passport • General information about the boundaries of the passport • Passport status (pre-screening, Pre-check, AS- Design, AS Built • Material Health – data and chats • Embodied Carbon Footprint – data and chats • Material Sourcing • Material recovery (potential) • Dismountability, Separability • Authorship information, disclaimer and other information	In the assessment the information is structured in: – Interior walls – Interior floor slabs – Exterior walls – Roof areas and ceiling – Floors above exterior air – Foundations and basement elements – Exterior windows and doors – Other elements	Building Material Scout Madaster	The passport is presented as a report with all the information	PDF report	Good communication element. User friendly with all information in charts	The information is based on the example available in the webpage.

2.7. Overview of material passports in Norway

Reference	Structure	Required data	Sources of data	Usability	Platform	Pros and cons	Remarks
Co-builder solutions including: 1. Product Data Sheet (PDS) 2. Product Circularity Data Sheet (PCDS)	PDS: 1.Manufacturer data 2.Performance data 3.Electrical data 4.O&M data 5.Environmental data 6.Geometric data 7.Features data 1.Product and company identification 2.Composition/Information on product constituents 3.Design for better use 4.Design for disassembly 5.Design for re-use From 03.2021 The Product Circularity Data Sheet (PCDS) developed in LU was incorporated in into Cobuilder solution what will unleash the circular potential of the Cobuilder PDS as material passport.	PCDS 1. Product Identifiers 2. Manufacturer Identification 3. Production Site Information 4. PCDS issuance and revision Section 2. 1. Chemical substance threshold 2. Product composition disclosure 3. Chemical composition 4. Hazard statements 5. Pre-consumer recycled content 6. Post-consumer recycled content 7. Sourcing statements Section 3 (descriptive statements) 1. Design for maintenance and repair 2. Design for safe operation 3. Design for actively positive impacts Section 4 (descriptive statements) 1. Demounting 2. Disassembling 3. Dismantling Section 5	1. Harmonised standards 2. European Assessment Documents 3. Standards: EN, ISO, National standards 4. Industry recognised requirements (COBIe, BREEM-NOR) 5. User-specific requirements/information PCDS – declaration of the manufacturers and compliance with CE	Internatio-nal player	www.nobb.no	Pros: 1. Coherency with relevant standards (**EN ISO 23387**) **EN ISO 23386** – standardisation work done by CEN/TC 442 Workgroup 4, align with Smart CE marking initiative; 2. Based on a **Common European technical language** in a Data Dictionary based on EN ISO 12006-3; 3. Through intricate mapping to the **common sharing format IFC**, all data digitised through Cobuilder DTs can be attributed directly to COBie and hence to different BIM 'Models 4. Available internationally for non-Norwegian customers Cons 1. The number of available data templated might be overwhelming for not advanced users	One of two leading platforms in Norway

Reference	Structure	Required data	Sources of data	Usability	Platform	Pros and cons	Remarks
		Circularity scenarios					
ECOProduct, available at NOBB.no	1. Substances hazardous to health and the environment 2. Indoor climate 3. Global warming (GWP) 4. Use of resources 5. Energy 6. Sustainability for recycling	Substances hazardous to health and the environment 1. Assessment of Norwegian priority list, 2. REACH covered substances Indoor climate. Assessment of levels of 1. TVOC 2. Formaldehyde 3. Ammonia 4. Carcinogens 5. Odour GWP Use of resources Assessment of % of total mass of 1. Secondary 2. Renewable 3. Use Certified tropical timber 4. Use of material from the EU critical resources list Energy 1. Use of renewable secondary fuels 2. Renewable primary energy used as energy carrier 3. Use of non renewable secondary fuels 4. Non renewable primary energy as the energy carrier Sustainability	EDP, BREEM NOR ad. 1 EDPs, relevant standards, BREEM NOR, if there is a laboratory test it will be decisive (especially if the results is very low emitting) ad.2 Third party verified EDPS ad. 3 Physical parameters declared, conversion factors, database of Byggtjeneste, declaration ad.4 EPDs prepared in accordance with EN 15804: 2019 this information is mandatory, but for EPDs prepared in accordance with EN 15804: 2012, it will be possible to submit a self-declaration based on table 11 there if this information is missing.	ad. 1 EDPs, relevant standards, BREEM NOR,	www.nobb.no	Pros 1. The interface is simpler (shopping list type of impression) Cons 1. Solution addressing only Norwegian market, available only in Norwegian	ECOproduct is a collaboration between Grønn Byggallianse and Byggtjeneste where Grønn Byggallianse owns the method that ECOproduct uses, and Byggtjeneste operates the database and performs the assessments.

Reference	Structure	Required data	Sources of data	Usability	Platform	Pros and cons	Remarks
		Reuse 1. Material recycling 2. Energy utilisation 3. Landfill disposal (HW) 4. Landfill disposal (NHW) 5. Landfill of radioactive waste					

2.8. Overview of main references – Relevant information for material passports

2.8.1. LEVEL(S) - European framework for sustainable buildings[20]

Level(s) is a European approach to assess and report on the sustainability performance of buildings, throughout the full life cycle of buildings.

Using existing standards, the Level(s) framework with its indicators provides a common language for building sustainability, which can be used directly on building projects and portfolios, or as a basis for other initiatives, policies, schemes and actions, to include life cycle thinking and circularity.

It tracks performance across the various stages of a building project, to give a complete picture throughout the full lifecycle.

Within the Level(s) framework, each indicator is designed to link the individual building's impact with sustainability priorities at the European level. This allows Level(s) users to focus on a manageable number of essential concepts and indicators that contribute to achieving EU and national environmental policy goals.

2.8.2. EEB feedback to the Inception Impact Assessment for the revision of the Energy Performance of Buildings Directive 2010/31/EU[21]

The European Environmental Bureau published a position document concerning the revision of the Energy Performance Buildings Directive (EPBD) 2010/31/EU, in which it states the need of considering the whole life cycle of the building and its products and materials, rather than the operation phase only. It states that "A low percentage of deep and light renovations, not including embodied carbon emissions and not considering the Whole Lifecycle Carbon (WLC) of buildings, hinders the achievement of the zero-energy building stock in the EU" (EPBD, 2021, p.1). Therefore, it calls for a revision of the Directive that "addresses both operational energy use and embodied impacts that tackle carbon embodied emissions in both buildings and construction materials, ensuring a whole life cycle approach" (EPBD, 2021, p.2).

There are of course implications from this perspective to the information that could be included in a materials passport embracing a similar life cycle perspective, which is crucial in a circular economy.

The document states that a "Whole Lifecycle Carbon Approach" to energy efficiency and circularity strategies could be supported by Level(s) (see 2.8.1), based on EN 15978. It also refers to environmental product declarations as part of the data collection schemes (see DAP Habitat System, section 2.8.4).

2.8.3. A Framework for Circular Buildings[22]

This report provides a general framework for circular buildings and proposes concrete strategies and indicators for possible inclusion in BREEAM New Construction and Refurbishment & Fit-Out (NC &RFO). The aim of the report is twofold: to provide stakeholders from government, business and academia with a basic framework to approach circularity in buildings, and to accelerate the transition to a circular built environment by

[20] https://ec.europa.eu/environment/levels_en

[21] European Environmental Bureau, 2021. EEB feedback to the Inception Impact Assessment for the revision of the Energy Performance of Buildings Directive 2010/31/EU. 26th March. Retrieved from https://eeb.org/library/revision-of-the-eu-energy-performance-of-buildings-directive-eeb-feedback/.

[22] Bamberger, M., Blok, M., Faes , K., Hoek,. J., Kubbinga, B., Noort, E., Reek, D., Roemers G., (2018). A framework for circular buildings – Indicators for possible inclusion in BREEAM. Dutch Green Building Society (DGBC), Metabolic, SGS Search and Circle Economy

suggesting strategies and indicators for integrations into leading global standards for sustainable buildings like BREEAM.

The definitions used in the framework are aligned with the Transition Agenda for circular construction in the Netherlands. The proposed strategies further build on the strategies presented in the recently published Roadmap for Circular Land Tendering as well as on a range of existing frameworks and tools. The suggested indicators are either adaptations of existing indicators in BREEAM RFO and NC, or entirely new indicators. The final list of suggested indicators was created with input from external experts.

The main topics addressed in the report are a Strategy framework for creating circular Buildings, a Gap-analysis of BREEAM and Circular indicators for possible inclusion in BREEAM.

In annex it also includes a Strategy framework for circular buildings & potential indicators for BREEAM and a detailed description of six building strategies and suggested indicators.

2.8.4. DAP Habitat System[23]

The DAP Habitat System is a Portuguese registration program of Type III Environmental Product Declarations (EPD) for products from the habitat field. The Habitat field includes all the products and services involved in buildings and construction works. The programme is aligned with ISO 14025 and EN 15804. This EPD programme allows any organisation or entity from any country to request the development of the PCR and registration of EPDs. The development and the communication of EPDs make environmental performance of products/services tangible through documents verified by an independent third party (https://daphabitat.pt/en_US/daphabitat/o-sistema/).

The Portuguese System includes a series of Product Category Rules based on the European Standard EN 15804+1. There is a general document (PCR_Basic Model, that serves as the foundation for the specific PCR's and is also applicable to any construction product and service not included in the list of the specific PCR's), and specific PCR's, for the following products:

- Floor coverings
- Wall coverings
- Thermal insulation
- Sanitary ware
- Masonry

According to the generic PCR document, EPD's shall include the results of a life cycle assessment, covering at least the product stage or the "cradle to gate" stage (i.e., raw materials processing, transportation and product manufacturing). The remaining life cycle stages are optional. Thus, in an EPD within the DAP Habitat system (as it is with all EPD Systems for construction products following the European standard), it is clear that the embodied impacts of a product or material are reported (for the categories contemplated in the standard). The waste production that is reintroduced in the production process, replacing raw materials, is included within the system boundaries. Data on reuse, recovery and recycling potential is optional (with a dedicated information module).

[23] http://www.centrohabitat.net/pt/page/sistema-daphabitat

2.8.5. The Portuguese "More Sustainable Buildings" Support Programme (Programa de Apoio Edifícios Mais Sustentáveis)[24]

In the context of the Portuguese Energy and Climate Programme 2030 and the Plan of Recovery and resilience of Portugal (approved in 2021), the 2nd phase of the "More Sustainable Buildings" Programme (Programa de Apoio Edifícios Mais Sustentáveis or PAE+S) funds refurbishment measures that improve the energy efficiency of buildings. This enhances the achievement of multiple objectives, namely, improving thermal comfort levels, reducing the country's bill and energy dependence, reducing greenhouse gas emissions, improving energy efficiency, indoor air quality, the health benefit, the promotion of labour productivity, the reduction of energy poverty, the extension of the useful life of buildings and the increase of their resilience. Energy and environmental renovation also promotes improvements in other dimensions of building performance such as resource efficiency.

The PAE+S Programme supports six typologies of interventions in residential buildings:

1. Replacement of non-efficient windows with efficient windows, with an energy class equal to "A+";
2. Application or replacement of thermal insulation on roofs, walls or floors, using natural-based materials (eco-materials) or those incorporating recycled materials, as well as the replacement of entrance doors;
3. Ambient heating and/or cooling and domestic hot water (DHW) systems that use renewable energy, of energy class "A+" or higher;
4. Installation of photovoltaic panels and other equipment for the production of renewable energy for self-consumption with or without storage;
5. Interventions aimed at water efficiency by replacing water use devices in the home with more efficient ones, by installing solutions that allow the monitoring and intelligent control of water consumption or by installing rainwater harvesting systems ;
6. Interventions for the incorporation of bioclimatic architecture solutions, involving the installation or adaptation of fixed elements of the building, namely shading, greenhouses and green roofs or facades, favoring natural-based solutions.

Given the wide scope of the programme (over 17,000 applications are expected until the end of November 2021) and the existence of very objective criteria to assess the eligibility of the applications, based on good practice, these can contribute to the definition of elements of the passport, such as the energy labelling of windows, or the recycled content of insulation materials, for example. Indeed, companies and building/house/flat owners are becoming more and more familiar with this type of tools and evidences and therefore they should be addressed in the setting up of a material passport model for the Baixo Alentejo region.

2.8.6. Circulytics[25]

Circulytis is a circularity measurement tool for companies which supports a company's transition towards the circular economy by assessing products and material flows and revealing the extent to which a company has achieved circularity across its entire operations through the use of a set of indicators of two types, enablers and outcomes. Circulytics:

[24] https://www.fundoambiental.pt/apoios-prr/paes-2021.aspx
[25] https://www.ellenmacarthurfoundation.org/resources/apply/circulytics-measuring-circularity

- Measures a company's entire circularity, not just products and material flows.
- Supports decision making and strategic development for circular economy adoption.
- Demonstrates strengths and highlights the areas for improvement.
- Provides optional transparency to investors and customers about a company's circular economy adoption.
- Delivers unprecedented clarity about circular economy performance, opening up new opportunities to generate brand value with key stakeholders.

Circulytics, developed by the Ellen MacArthur foundation with 13 partners, is aligned with other circular economy related initiatives to improve the efficiency of the method and tool.

2.9. Summary of main references – Relevant information for material passports

Reference	Focus	Data and general information for material passports	Source
LEVEL(S)	Level(s) is an assessment and reporting tool for sustainability performance of buildings, firmly based on circularity. Level(s) uses core sustainability indicators, tested with and by the building sector, to measure carbon, materials, water, health and comfort, climate change impacts. It takes into account lifecycle costs and value assessments.	Level(s) is divided into three areas, each with its own subject matter and desired outcomes: • Resource use and environmental performance during a building's lifecycle • Health and comfort • Cost, value, and risk Each of the three areas has its own set of indicators dealing with a building's environmental, social, and economic long-term sustainability. Resource use and environmental performance: 1. Greenhouse gas emissions along a buildings life cycle 1.1 Use stage energy performance (kWh/m2/yr) 1.2 Life cycle Global Warming Potential (CO2 eq./m2/yr) 2. Resource efficient and circular material life cycles 2.1 Bill of quantities, materials and lifespans 2.2 Construction and demolition waste 2.3 Design for adaptability and renovation 2.4 Design for deconstruction 3. Efficient use of water resources 3.1 Use stage water consumption (m3/occupant/yr) Health and comfort 4. Healthy and comfortable spaces 4.1 Indoor air quality 4.2 Time out of thermal comfort range 4.3 Lighting 4.4 Acoustics Cost, value and risk 5. Adaption and resilience to climate change 5.1 Life cycle tools: scenarios for projected future climatic conditions 5.2 Increased risk of extreme weather 5.3 Increased risk of flooding 6. Optimised life cycle cost and value 6.1 Life cycle costs (€/m²/yr)	https://ec.europa.eu/environment/levels_en

Reference	Focus	Data and general information for material passports	Source
		6.2 Value creation and risk factors	
EEB feedback to the Inception Impact Assessment for the revision of the Energy Performance of Buildings Directive	Need of a comprehensive and deep review of the EPBD to address the decarbonisation of buildings beyond the energy performance target, including other lifecycle impacts in order to achieve the EU environmental objectives by 2030 and by 2050.	1. Data from Environmental Product Declarations 2. Reuse potential of construction materials 3. Reused construction materials 4. Recyclability of construction materials 5. Recycled content of construction materials 6. Bio-based insulation materials 7. Circular insulation materials 8. Carbon footprint of construction products (own interpretation of more generic data in the document)	European Environmental Bureau, 2021. EEB feedback to the Inception Impact Assessment for the revision of the Energy Performance of Buildings Directive 2010/31/EU. 26th March. Retrieved from https://eeb.org/library/revision-of-the-eu-energy-performance-of-buildings-directive-eeb-feedback/.

DAP Habitat System	This document is part of the official documentation and the work of the DAP Habitat System, establishing the general rules for the elaboration of the Life Cycle Assessment studies according to the EN 15804:2021+A1:2013 standard, for construction products and systems.	For the life cycle stages included in the EPD (at minimum the product stage = raw material supply, transport and manufacturing or "cradle to gate" LCA's):
		
		• Name and address of the manufacturer(s)
		• Identification of the product
		• Visual representation of the product
		• Description of the product (main component(s) and/or materials)
		• Main technical characteristics of the product
		• Description of the product's application
		• Reference service life
		• Placing on the market/Rules of application in the market/Technical rules of the product
		• Quality control
		• Special delivery conditions
		• Components and substances to declare
		• Declared unit or functional unit
		• System boundaries
		• Parameters describing environmental impacts
		  • Global warming potential (kg CO2 equiv.)
		  • Depletion potential of the stratospheric ozone layers (kg CFC 11 equiv.)
		  • Acidification potential of soil and water (kg SO2 equiv.)
		  • Eutrophication potential (kg PO4(3-) equiv.)
		  • Formation potential of tropospheric ozone (kg C2H4 equiv.)
			Plataforma para a Construção Sustentável, 2020. Product Category Rules (PCR) – Basic Module. Construction Products and Services according to the EN 15804:20121 + A1:2013. Version 1. Edition November 2020. 33 p.

Reference	Focus	Data and general information for material passports	Source
		• Abiotic depletion potential for non-fossil fuel resources (kg Sb equivalent) • Abiotic depletion potential for fossil resources (MJ, PCI) • Parameters describing resource use • Primary energy • Secondary materials and fuels and use of water • Other environmental information • Hazardous waste for disposal • Disposal of non-hazardous waste • Disposal of radioactive waste • Reuse components • Recycling materials • Materials for energy recovery • Exported energy • Additional info on release of dangerous substances during the use stage	
PAE+S	Programme financing refurbishment measures that improve the energy efficiency of buildings	Windows: • Energy class of the window (according to the energy label) Thermal insulation material: • FSC certification (in the case of wood) • Ecolabel • % of natural materials (in mass) • % of recycled materials (in mass) Doors: • Thermal transmission coefficient (W/(m2.K))	Ambiente e Ação Climática, Gabinete do Ministro, 2021. Regulamento de atribuição de incentivos da 2ª Fase do Programa de Apoio a Edifícios Mais Sustentáveis. Despacho 6070A/2021. Retrieved from https://dre.pt/web/guest/pesquisa/-/search/165564281/details/maximized.
Framework for Circular Buildings	This report provides a general framework for circular buildings and proposes concrete strategies and indicators for possible inclusion in BREEAM New Construction and Refurbishment & Fit-Out (NC & RFO). The aim of the report is twofold: to provide stakeholders from	The objectives of this project are twofold, which can inspire the (Des)Construir project: **1- The report provides a basic strategy indicator framework for a circular building.** **It provides** a source of inspiration for elaborating strategies and programmes that aim at making the built environment more circular. • Identify desired impacts and key strategies, building on the strategies identified in the Roadmap Circular Land Tendering • Take inspiration from existing strategy and indicator frameworks (including BREEAM, other standards amongst which LEED, DGNB, Cradle-to-Cradle	Ben Kubbinga, Max Bamberger, Edwin van Noort, Dirk van den Reek, Merlijn Blok, Gerard Roemers, Justin Hoek, Kees Faes, 2018. A FRAMEWORK FOR CIRCULAR BUILDINGS indicators for possible inclusion in BREEAM, Circle Economy, DGBC, Metabolic and SGS Search

Reference	Focus	Data and general information for material passports	Source
	government, business and academia with a basic framework to approach circularity in buildings, and to accelerate the transition to a circular built environment by suggesting strategies and indicators for integrations into leading global standards for sustainable buildings like BREEAM.	**2- To suggest circular strategies and indicators for possible inclusion in BREEAM** The key objective of this report is to propose strategies and indicators for possible inclusion in the international BREEAM New Construction (NC) and Refurbishment and Fit-Out (RFO), as well as the Dutch versions of these standards. The following approach was taken to reach this objective: • Perform a gap-analysis of BREEAM based on the strategy framework, to answer the question which indicators are fully covered, which ones are only partially covered and which are not yet addressed by BREEAM. • Identify - with the support of experts in the field - and describe key indicators that have the highest potential of improving the circularity of a building. **Remark**. BREEAM is a sustainability assessment method for master planning projects, infrastructure and buildings. It recognises and reflects the value in higher performing assets across the built environment lifecycle, from new construction to in-use and refurbishment.	
Circular economy principles for buildings	This publication aims to inform and support actors along the construction value chain, this document provides principles for circular design of buildings. Behind these principles lie a vast amount of knowledge and information. The document is aligned with the launch of Level(s), a voluntary reporting framework to improve the sustainability of buildings	Use harmonised materials passports and building passports. Existing Environmental Product Declarations and national tools - to help the manufacturer to understand how the product is used/applied - should be developed and used. This will support the choices to be made during the use of the building, end-of-life, and recovery. - Know for what purpose the product has been designed (e.g., repair, reuse, remanufacturing, reconfiguration?); - Know how the product is implemented/installed in, and connected to, the building and other construction products and systems; - Keep available information about the technical characteristics of materials and products and promote traceability of the changes and uses of the product during its life cycle	https://www.steelconstruct.com/wp-content/uploads/Final-Circular-Economy-Principles-for-buildings-design.pdf
Circulytics	Circulytics is a comprehensive tool available for measuring the circular economy performance of companies, informing their decision	On the website, the users have access to a complete set of resources to support the knowledge and implementation of Circulytics in companies. From the indicators available in the tool, two themes are especially relevant to support the development of material passports: **Theme 6. Products and Materials:**	https://www.ellenmacarthurfoundation.org/resources/apply/circulytics-measuring-circularity

Reference	Focus	Data and general information for material passports	Source
	making and guiding their circular economy strategies. Circulytics measures the circular economy performance of a company's entire operations, using a comprehensive set of indicators. It measures this in two main ways: Enablers and Outcomes. CATEGORY 1: ENABLERS - The critical aspects to enable company-wide transformation • STRATEGY AND PLANNING • PEOPLE AND SKILLS - • OPERATIONS • INNOVATION • EXTERNAL ENGAGEMENT- CATEGORY 2: OUTCOMES - Measuring how circular a company is today • PRODUCTS AND MATERIALS • SERVICES • PLANT, PROPERTY, AND EQUIPMENT ASSETS • WATER • ENERGY • FINANCE	6a. Part 1. Please provide the total annual mass of inflow products and materials suitable for the technical cycle 6a. Part 2. Please provide the total annual mass of inflow products and materials suitable for the biological cycle 6a. Part 3. Please provide the total annual mass of outflow products and materials suitable for the technical cycle 6a. Part 4. Please provide the total annual mass of outflow products and materials suitable for the biological cycle 6b. For products and materials suitable for the technical cycle, what % (by mass) of your inflow (physical material that comes into your manufacturing processes) 6c. For products and materials suitable for the biological cycle, what % (by mass) of your inflow 6d. What % (by mass) of your total outflow of products and materials suitable for the technical cycle is waste or by-products that go to landfill or incineration and are therefore not recirculated? 6e. What % (by mass) of your total outflow of products and materials suitable for the biological cycle, is waste or by-products that go to landfill or incineration and are therefore not recirculated? 6f. Part 1. What % (by mass) of your physical products are designed along circular economy principles? Select all that apply and input % (by mass) in the fields below. 6f. Part 2. For products that do not meet the requirements of circular product design in either of the two categories above, what % of your physical products (by mass) are designed to enable your customers to improve their product's circular economy performance? 6f. Part 3. Do your material outflows (all products, by-products, waste and materials used in processes) contain any substances from the Cradle-to-Cradle Certified Products Program, DRAFT v4 Restricted Substances List (RSL) in quantities above the maximum allowable concentration (ppm) defined in the list? 6g. What % (by mass) of your products and materials suitable for the technical cycle are recirculated in practice in the following ways (only counting the first cycle of recirculation after initial use) 6h. For products that are recirculated through reuse, how many average uses do your products have before reaching end of use? **Theme 8. Plant, Property, and Equipment (PPE) Assets**	

Reference	Focus	Data and general information for material passports	Source
		8a. Which plant, property, and equipment (PPE) assets do your company own and/or lease? 8b. What amount of plant, property, and equipment (PPE) assets does your company own and/or lease? 8c. What % (by units: #items or m2 for buildings) of your plant, property, and equipment (PPE) assets are procured with the following circular procurement approaches? 8d. What % (by units: #items or m2 for buildings) of your plant, property, and equipment (PPE) assets have policies or agreements in place to enable recirculation in practice at their end-of-use in the following ways?	

2.10. Overview of references from Norway – Relevant information for material passports

Reference	Focus	Data for the material passports	Source
Product Circularity Data Sheet (PCDS) v3.2s		Outline of the Product Circularity Datasheet	
Analysis of material streams in construction waste in Norway. [26]	Overview of the streams of construction demolition waste in Norway	Assessment of the state of the art and potential for reuse of construction waste in Norway	https://www.sintef.no/en/publications/publication/?pubid=1376798
EcoProduct Methodology Description [27]	Description of the methodology and structure for one two relevant material passports in Norway	Description of the methodology and structure for one two relevant material passports in Norway	https://byggalliansen.no/wp-content/uploads/2018/11/Metodebeskrivelse-ECOproduct-versjon-5.0-1.pdf
Analysis of barriers and opportunities for reusing of construction materials and technical installation in Norway [28]	Barrier, opportunities and recommendation to increase demand for reusing of CDW	Describing the status for reuse of construction materials. Used materials have to fulfil the same requirements as new product (with some exemptions by the Norwegian Road Authorities reusing the concrete)	http://www.byggemiljo.no/wp-content/uploads/2018/10/NHP-Barrierer-for-ombruk-v4.pdf

[26] A. Rønning, C.. Engelsen, A. Brekke, *Materialstrømsanalyse - byggavfall. Betong, gips og vindusglass*, SINTEF 2016.
[27] K. Th. Bramslev, *ECOproduct. Metodebeskrivelse vs 5.0*, 2020 r.
[28] A.S. Nordby, *NHP-nettverket Utredning av barrierer og muligheter for ombruk av byggematerialer og tekniske installasjoner i bygg*, (2018), http://www.byggemiljo.no/wp-content/uploads/2018/10/NHP-Barrierer-for-ombruk-v4.pdf.

3. Conclusions

The majority of materials from buildings demolitions or renovations is either downcycled (e.g. used as road aggregate or backfilling), ends up in landfills or is simply littered. Recycling material for use in new buildings or the reuse of building materials, components and systems rarely takes place. This is one of the reasons of the significant environmental impacts of the building sector and the EU is tackling this huge problem with a number of policies, namely the "European Green Deal" and its "Renovation Wave for Europe", the new "Circular Economy Action Plan" and the forthcoming "Strategy for a Sustainable Built Environment".

It is acknowledged that a valuable instrument to support these policies is a building materials passport. Building materials passports are sets of data describing defined characteristics of materials and components in products and systems that give them value for present use, recovery, and reuse. They are digital reports containing circular economy relevant data that is collected and stored in a centralised database in the form of reports customised to the needs of diverse users.

The situation analysis reported in this document combined literature review (review of publications, existing projects and initiatives which are not directly concerned with material passports, but nevertheless relevant) and field work (through a survey aiming at 31 municipalities from the partner countries). The ultimate aim of this report is to provide the basis for the definition of a materials passport model to be applied in the *Baixo Alentejo* region.

The main conclusions of this study are:

- Despite the variety of related projects, examples of material passports applied in practice are not available with the exception of the one from the Circular Buildings Project; nevertheless, descriptions of contents of passports were identified, namely those provided by the Norwegian partner IDF
- Passports can be established at different levels: individual products, structures, shearing layers and buildings as a whole; a promising approach seems to be adopting the product level and then combine the passports of products to the desired scale of work
- Passports include data that is directly related to circularity and environment (e.g. recycled content, recycling potential, reuse potential, design for maintenance and repair, etc.) and other data (quantities, technical properties, composition, hazardousness, site data, manufacturer data, etc.)
- As for circularity data, some passports models have their own indicators, whereas others make use of Circularity Assessment Tools, such as Circulytics (Ellen MacArthur Foundation); in the case of the former, it is not always evident how those indicators are calculated
- There are many instruments that can be used to provide relevant circularity and other environmental data for a relatively easy creation of a building materials passport: ecolabels, environmental product declarations, sustainable building certification schemes, energy labelling, etc.; since these instruments are very rare, especially when it comes to old buildings, it is expected that for many years it will be difficult to have a complete data set to characterize the products and the buildings from a circularity point of view
- The interviews showed that in the studied municipalities there is an interest in this type of tool, but a very limited knowledge or experience about it; interviewees recognize material passports' potential to avoid CDW, extract value from products and materials resulting from demolitions and

refurbishments and operationalize a circular construction, but have no experience with this instrument

In view of these results, it is clear that the implementation of materials passports in the Baixo Alentejo region needs to be:

- Sensible (in terms of priority buildings, products and features)
- Established in very close dialogue with all stakeholders (collective learning)
- User-friendly and compatible with platforms that are used in the municipalities and construction companies (eventually, the integration with Building Information Modelling)
- Very well communicated (in order to be understood as an advantage rather than a burden)
- Composed of data that is required in the licencing procedures of the municipalities
- Complementary to the pre-demolition audits guide that is being developed in Work Package 4.

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