



Waterman Materials Passports Framework



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Waterman Materials Passports Framework

Introducing a Standardised Approach
to Materials Passports
in the Construction Industry

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This book presents the Waterman Materials Passports Framework, a standardised approach to Materials Passports in the construction industry, developed by Waterman in collaboration with CIRCuIT project partners (London cluster).

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Glossary

Material	A material refers to any substance, either raw or processed, that is utilised in the construction of buildings or other structures to form elements (see below for definition).
Component	A component refers to a part of a building or other structure that contributes to its structure, function, and/or decoration. It has specified geometry, the same function throughout its entire entity, and is assigned to one building element category (Level 3). The component is composed of either a single material that is applied to its entire entity or multiple materials that cannot be separated from each other and are applied to its entire entity.
Grouped component	A grouped component is an element that is comprised of multiple components and it can be traded by its manufacturer as a single unit, or it can be designed as such in a BIM model, or it is used for its intended purpose in this form.
Parent grouped component	A parent grouped component refers to an element that consists of other grouped component(s), which can be removed and replaced, as well as potentially other component(s).
Removable grouped component	A removable grouped component refers to a group component that is part of a parent grouped component, which can be removed and replaced.
Element	An element refers to a part of a building or other structure, which can be a component, grouped component, removable grouped component, or parent grouped component.
Building element category	Building element category refers to the buildings' elements' classification system, which has been defined in the NRM 1 (New Rules of Measurement), 3rd edition (Ref. 11). The building element categories are organised into three levels.
Buildings complex	A buildings complex refers to a group of buildings or structures that are inter-connected and designed to function together as a unified whole.

<p>Area</p>	<p>An area refers to a defined geographical region and/or administrative unit, that is defined by the government for the purpose of managing and delivering public services. These areas can be defined by geographical boundaries, such as the boundaries of a city or county, or by organisational divisions, such as council districts or parliamentary constituencies. Postcodes can also be used to define areas.</p>
<p>Product</p>	<p>A product is a tangible item that is traded by a manufacturer or supplier and is intended for use in the construction or renovation of buildings and other structures. A product has not yet been incorporated into a building but is available for purchase. Once it is used in the building process, it becomes an element.</p>
<p>Material Passports levels</p>	<p>Materials Passports levels refer to the hierarchical structure of Materials Passports, where higher levels of information result from aggregating data from lower levels.</p>
<p>Disassembly</p>	<p>Disassembly refers to the process of taking apart individual elements.</p>
<p>Separation</p>	<p>Separation refers to the process of taking apart the materials that compose an element.</p>
<p>Data carriers</p>	<p>Data carriers refer to physical media that serve as a link between the physical object and its digital passport, allowing stakeholders to access and update information throughout the building's life cycle.</p>
<p>BIM model</p>	<p>BIM model refers to a digital 3D computerised representation of the physical and functional characteristics of a building, that also allows for the storage and retrieval of various types of information.</p>

Executive Summary

The construction industry is known for being highly energy- and carbon-intensive and is among the largest consumers of raw materials worldwide. The reuse of materials has become increasingly significant in recent years and has been identified as a crucial strategy for addressing the climate emergency and achieving the Net Zero targets in the construction industry. However, the reuse of materials is still limited and challenging. This is mainly due to the uncertainty associated with the specifications and performance of used materials, including the lack of warranties for used/ refurbished construction products.

Materials Passports (MPs) aim to provide a solution to this problem by documenting the identity, specifications, and performance of materials throughout their lifecycle. However, they are currently not implemented due to their increased complexity, lack of a framework, and digital tools that allow for their production, visualisation and update. The scope of this document is to establish the initial stage towards a consistent and standardised framework for the production and lifecycle management of MPs for products, materials and elements in the built environment.

In Europe, new policies and regulations have been drawn up by the European Union under the European Green Deal (EGD). The Ecodesign for Sustainable Products Regulation (ESPR), which is currently in the proposal stage, includes the creation of a Digital Product Passport (DPP). DPP aims to form a key regulatory Element of the ESPR in order to enhance the traceability of products and their components. The DPP will allow to electronically register, process and share product-related information amongst supply chain businesses, authorities and consumers. According to the guidelines set by the Circular Economy Action Plan the textiles, construction products, electric vehicles and industrial batteries sectors are expected to be among the first to adopt DPP.

MPs can offer several benefits to the construction industry at different levels. At the materials level, MPs can provide a standardised format for recording material specifications and performance, as well as updating this information throughout their lifecycle, unlocking their reuse potential. Building-level MPs can provide an overview of a building's overall performance, automate various types of assessments, and support designing for disassembly, transforming buildings into banks of materials. MPs can serve as a comprehensive database for buildings, automating the conduction of different assessments and studies, such as embodied carbon assessments, circularity performance reports, resources efficiency reports, disassembly manuals, reuse and recycling catalogues, maintenance schedules, and facility management performance monitoring and assessment, among others. By collecting and compiling data from MPs of individual buildings and structures, a UK-specific Materials Stock Database can be created, which can support the creation of industry benchmarks and enable the implementation of urban mining and material exchange at the city level.

There are different levels of MPs that follow a "pyramid" structure, with the information at higher levels resulting from the aggregation of information from objects classified at lower levels. The identified levels of MPs include:

- **Product-level passport:** Provides information for a product that is provided by a manufacturer.
- **Material-level passport:** Records information for the materials that compose elements.
- **Component-level passport:** Documents information for a component.
- **Grouped component-level passport:** Captures information for a grouped component.

- **Elemental-level passport:** Contains statistics for the various building element categories of a building. An elemental-level passport results from the aggregation of data from the elements classified under the specific building element category.
- **Building-level passport:** Provides an overview of the recorded information for a specific building through the aggregation of data from the component- and grouped component-level passports.
- **Buildings complex/ Portfolio-level passport:** Shows an overview of the recorded information of the buildings and structures that belong to a complex through their building-level passports.
- **Area-level passport:** Provides an overview of the recorded information of the buildings and structures that belong to a specific area, based on their building-level passports.

The MPs record information for the entire lifecycle of materials and elements (Life Cycle Modules A-C). This document focuses on the information recorded for Life Cycle Module A (Manufacturing, Transport to Site, and Construction), which is categorised into design-related, manufacturing-related, and construction-related information. The design-related information includes details resulting from the building's design, such as classification, location in the building, geometry, types of connections with other elements, etc. The manufacturing-related information captures details about the element's manufacturer, certifications and datasheets, value, expected maintenance, circularity and carbon performance, composition overview, and performance overview. The construction-related information records information about the element's contractor and data carriers. The material-level passports contain material-related information, including material properties and specifications (e.g., type of material, manufacturer information, circularity and carbon information, certificates, etc.). It is proposed that it becomes mandatory for those elements composed of up to three materials to be accompanied by material-level passports. The rest of the elements shall only include the bill of materials.

It is intended that manufacturing-related and material-related information will be automatically derived from the product-level passports, which are produced by the manufacturers, and the design-related and construction-related information will be automatically derived from the as-built BIM model of a building. This would enable the automation of MP production for a building.

Different stakeholders are responsible for providing information for MPs at various stages of the materials' lifecycle. The manufacturing stage is documented by manufacturers (product-level passport), and the construction stage is documented by principal contractors. Facilities managers capture information for the use stage of a building, and deconstruction/strip-out contractors record information for the deconstruction of materials.

Producing MPs for a building can be a complex task due to the large amount of information that needs to be documented and managed, including the increased number of stakeholders that need to coordinate to provide the required information throughout a materials' and elements' lifecycle. Therefore, standardisation and clear communication of responsibilities are essential for the successful implementation of MPs.

The first critical step in MP production is defining the scope of work to identify the types of components and materials that will be recorded through MPs. When third parties are responsible for collecting the required information for MPs, it is critical to produce a specifications document to define what information needs to be provided, by whom, and when. Regular reviews by third parties are required during the process of collecting the required information as part of the quality assurance process. Once the required information is collected, the MPs model can be created using an MPs platform. When the process of importing all the information into the MPs platform is completed, the MPs ownership needs to be defined.

The MP's owner is responsible for updating the information in the MP throughout the building's and materials' lifecycle. Finally, the MP's model needs to be verified by a third party to ensure data validity and robustness.

MPs have tremendous potential to support efforts in tackling climate change. This document aims to take an initial step towards formulating a standardised framework. The next steps involve engaging with the industry and developing a Materials Passports Protocol in alignment with the DPP to ensure a standardised approach for the production and lifecycle management of MP's for products, buildings and infrastructure. Furthermore, it is important to develop examples and case studies that demonstrate the practical implementation of the framework. A case study for Edenica will be published soon, providing detailed information on how MP's have been and are being implemented on the scheme. Finally, a roadmap is proposed for introducing policy requirements for MP's, which can serve as a basis for discussions with policymakers and various industry stakeholders.

1. Introduction

1.1 Background

The construction industry exhibits a substantial reliance on energy and generates significant carbon emissions, thereby contributing to its reputation as one of the largest global consumers of raw materials. Within the European Union, the construction sector accounts for approximately 40% of CO₂ emissions (Ref. 1) and nearly a third of all waste (Ref. 2). Buildings are responsible for approximately 60% of total UK materials use (Ref. 3) and, based on the UK Statistics on Waste, construction, demolition and excavation waste was around three fifths (62%) of total UK waste in 2018 (Ref. 4). As the construction sector is one of the largest exploiters of resources, with half of them being non-renewable, it is imperative that solutions are adopted to reduce the use of primary resources. Therefore, the reuse of materials has been given significant importance in recent years and has been identified as one of the key solutions to tackling the climate emergency.

The reuse of materials allows for the elimination of environmental impacts associated with extracting and manufacturing raw materials, which are typically the highest contributors to a material's life cycle impact. In contrast, recycling still requires manufacturing processes, even though it results in carbon and energy savings in terms of extracting primary resources. Despite the increasing importance of material reuse across the industry, its implementation is still limited and challenging. One of the key reasons behind this is the uncertainty associated with the reuse of materials whose specifications are unknown, including the lack of warranties for used/ refurbished construction products.

Materials Passports (MPs) aim to provide a solution to this problem by documenting critical information for materials and elements throughout their life cycle to facilitate their reuse. Currently, there is no consistent approach or standardised framework to define the content, form, and production process of MPs.

1.2 Scope of the document

The purpose of this document is to present a MPs framework, which serves as a preliminary step towards establishing a comprehensive and standardised protocol for MPs in the construction industry. This document aims to provide clarity on the following:

1. Definition of MPs;
2. Scope and Benefits of MPs;
3. MPs Synergies;
4. Definitions of key terms;
5. Levels of MPs;
6. Content of MPs per Level;
7. MPs Data Structure;
8. MPs and BIM;
9. MPs Implementation Process; and
10. Next Steps.

A Materials Passports Protocol is critical to introducing a standardised approach to MPs across the construction industry. The scope of the Protocol is to establish a consistent and standardised framework for the production and life cycle management of MPs for products and buildings. This document provides an initial framework that will be updated and refined based on industry feedback and practical experience.

1.3 Key Author

Waterman Group is a multidisciplinary consultancy that provides sustainable solutions to meet the planning, engineering design, and project delivery needs of the property, infrastructure, environment, and energy markets. Waterman has a diverse portfolio of projects, including the regeneration of London's Canada Water, Liverpool's RIBA Sterling Award-winning Everyman Theatre, and the Edenica commercial development, as well as a variety of regional and national infrastructure and transport schemes.

Waterman's involvement with MPs can be summarised as follows:

- **Edenica:** Waterman pioneered the implementation of MPs in the UK construction industry through the Edenica project. Edenica is the first building in the City of London for which MPs are being produced. It is a new-build commercial office development for BauMont Real Estate Capital and YardNine, currently under construction at 100 Fetter Lane, London. Waterman was awarded 'Best Net Zero Project' in 2022 at the Association for Consultancy and Engineering Awards for its MPs initiative. A case study will be produced to provide insights on the implementation of MPs in the project.
- **MPs Framework:** Waterman is developing the MPs framework to introduce a standardised approach to creating MPs. This framework can be applied to any type or scale of construction, refurbishment or documentation of existing buildings, with the aim of kick-starting a thriving circular economy.
- **MPs in Infrastructure:** Waterman is developing a framework for the implementation of MPs in infrastructure projects.
 - **Technical Support for Circuland:** Waterman is providing technical advice to support the development of an online platform called Circuland. This platform will allow for the creation, viewing, and lifecycle management of digital MPs across building and city levels in accordance with the Waterman MPs Framework.

1.4 Technical Contributors: CIRCuIT project partners

Circular Construction in Regenerative Cities (CIRCuIT) is a project running from 2019-2023 with 31 ambitious partners across the built environment chain in Copenhagen, Hamburg, the Helsinki Region and Greater London. Funded by the European Commission's Horizon 2020 programme, CIRCuIT aims to bridge the gap between theory, practice and policy by delivering a series of demonstrations, case studies, events and other dissemination activities that showcase how circular construction approaches can be scaled and replicated across Europe.

BRE delivers innovative and rigorous products, services, standards and qualifications that are used around the world to make buildings better for people and for the environment. BRE is a partner of the CIRCuIT project and leads one of the work packages, which aims to help provide a consistent and comprehensive approach to data collection, analysis and management, fundamental for developing the concept of buildings

as Material banks (BAMB) at a city scale. Furthermore, enhanced data collection could facilitate the calculation of 'circularity indicators' and the interoperability of materials exchange portals - digital databases to optimise supply and demand.

CIRCuiT collaborates with government agencies and organisations to help achieve these built environment material data collection and management objectives. Their work includes collaborations with:

- Greater London Authority on embedding circular economy into built environment policy through the requirement of 'Circular Economy Statements' in the London Plan 2021;
- Participating in Orm's Material Passports group that focuses on gathering and organising data about materials contained within a building;
- Hosting material passport and circularity indicator events/activities with key built environment circularity experts to highlight how urban planners deliver performance evaluations in a circular built environment; and
- Waterman Group's Edenica project – a MPs pilot project in the City of London, designed as a storage bank where materials are held for future reuse.

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1.5 Key Regulations

In Europe, new policies and regulations have been drawn up by the European Union under the **European Green Deal** (EGD), which focuses on enabling Europe to reach net zero emissions by 2050.

Adopted in March 2020 under the EGD, the **Circular Economy Action Plan** (CEAP) announces initiatives throughout the entire lifecycle of products. It targets how products should be designed to promote circular economy processes, aiming to ensure waste is prevented, and the resources used are kept for as long as possible ([Ref. 5](#)). The goal of this initiative is to enhance sustainability and accessibility of products by increasing product traceability.

The **Ecodesign for Sustainable Products Regulation** (ESPR), which is currently in the proposal stage and falls under the broader CEAP, includes the creation of a **Digital Product Passport** (DPP) ([Ref. 6](#)). The document mentions: "The proposal includes the creation of a digital product passport to electronically register, process and share product-related information amongst supply chain businesses, authorities and consumers. This is expected to increase transparency, both for supply chain businesses and for the general public and increase efficiencies in terms of information transfer." ([Ref. 7](#)). Article 8 of the ESPR sets out the elements that need to be specified in the information requirements in relation to the DPP, for example the information to be included and who has access to what information. The DPP will form a key regulatory element of the ESPR by enhancing the traceability of products and their components.

Based on the ESPR, the DPP shall meet the following conditions ([Ref. 7](#)).

- It should be connected through a data carrier to a unique product identifier.

- The data carrier should be physically present on the product, its packaging, or accompanying documentation.
- The data carrier and the unique product identifier should comply with the standard ISO/IEC 15459:2015.
- All information included in the product passport should be based on open standards, developed in an interoperable format, and should be machine-readable, structured, and\ searchable.
- The information included in the product passport should refer to the product model, batch, or item.
- Access to the information included in the product passport should be regulated in accordance with the essential requirements set out in ESPR.

Some of the general information categories detailed in the DPP include: the product description, unique identification code of the product type, product category, intended uses of the product, dimensions of the product, main materials or substances used, estimated average and minimum service lifetime, manufacturer's information, performance of the product, and environmental sustainability data (Ref. 8).

According to the guidelines set by the CEAP (Circular Economy Action Plan), the textile, construction product, electric vehicle, and industrial batteries sectors are expected to be among the first to adopt Digital Product Passports due to their potential for circularity, recyclability, and environmental impact.

As a result, stakeholders in these sectors are likely to be required to use Digital Product Passports in the near future.

2. What are Materials Passports?

2.1 Definitions

As a regular passport documents and certifies a person's identity, MPs enable materials and elements to be tracked and reused with ease (Figure 1). MPs record critical information about products, materials, and elements that can facilitate their reuse during the operation and end-of-life phases of buildings and other structures. In this way, the "used" materials turn into valuable resources instead of potential waste streams, and the buildings themselves are transformed into material storage banks.



Figure 1. Links between a person's passport and a material's passport.

Based on BAMB, MPs are “*electronic and interoperable data sets that collect characteristics of Materials and assemblies, enabling suppliers, designers and users to give them the highest possible value and guide all towards material loops. The availability and relevance of this data, in particular of the use history and re-use potential of a component, facilitates re-use, recycling and biodegradation of that component. Moreover, it is crucial for choosing components that can be re-used in the future. Accordingly, the development of MPs is seen as a mechanism to encourage innovative product design and the implementation of circular business models.*” (Ref. 9).

Additionally, based on BAMB, Material Banks are “*repositories or stockpiles of valuable Materials that might be recovered. If those Materials replace primary resources used during the construction, operation or refurbishment of buildings and their parts, the need for primary resource mining, for example of rare earth Elements, can be eliminated. This idea of urban mining implies effective material reuse and thus the realisation of material loops. Nevertheless, to enable and facilitate the harvesting of Materials or building parts, it is necessary to design them in a reversible way.*” (Ref. 10).

In this framework MPs are approached as digital datasets that document key as-built information for materials and elements throughout their life cycle to enable their future reuse and provide robust data and benchmarks for the materials stock across the industry.

2.2 Lifecycle Perspective

The MPs record information for the whole life cycle of materials and elements. This includes information on manufacturing, on-site construction, use, reuse(s) and end-of-life (Figure 2).

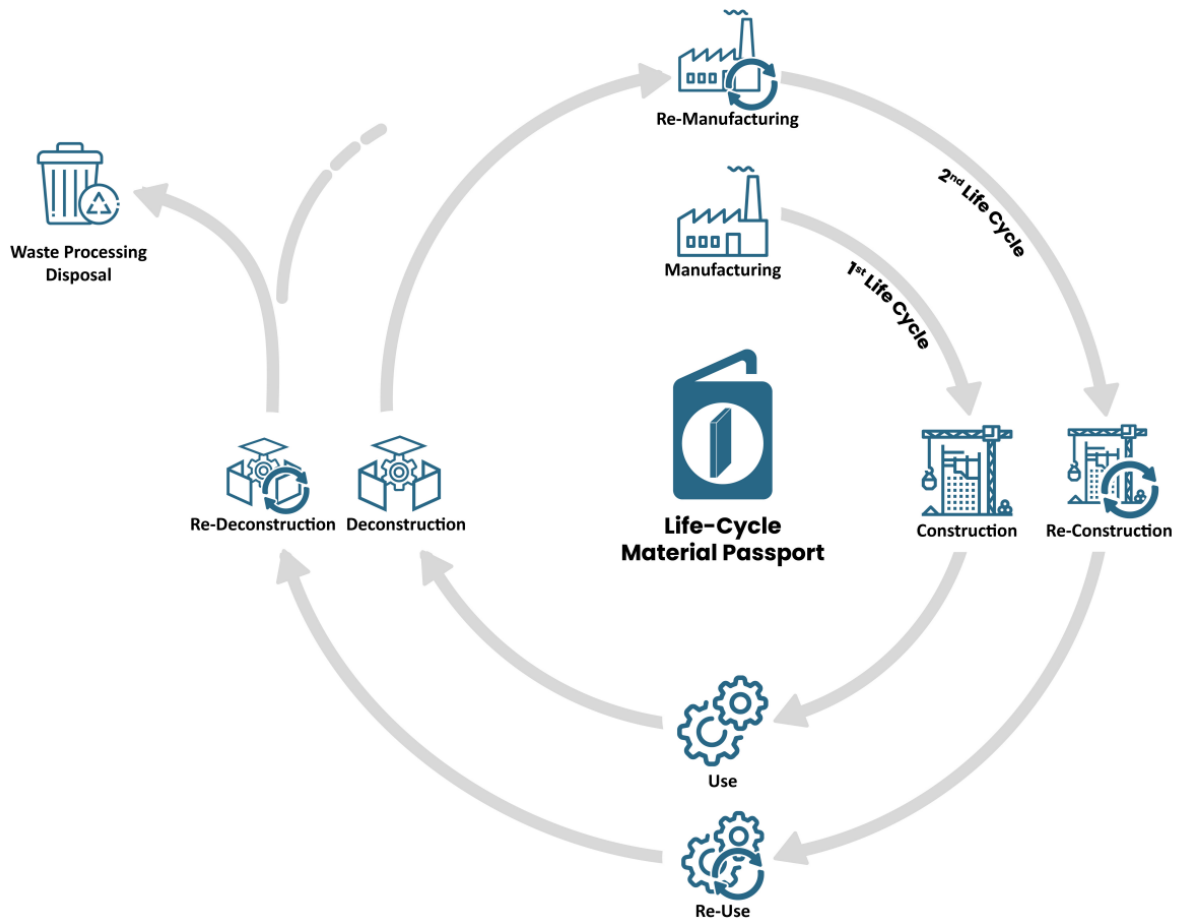


Figure 2. The Material Passport records information about the whole lifecycle of a material.

The life cycle of a built asset is structured into different lifecycle stages as defined by BS EN 15978:2011, which are further subcategorised into lifecycle modules. This standardised structure, used for Whole Lifecycle Assessments, has been adopted for organising information within MPs.

As depicted in Figure 3, the MPs record information for the following lifecycle stages during each material's life cycle.

- Product and Construction Stage (Life Cycle Modules A1-A5)
- In-Use Stage (Life Cycle Modules B1-B3)
- End-of-Life (Life Cycle Modules C1-C4)
- Beyond Life Cycle (Life Cycle Module D)



Figure 3. Life Cycle Modules for the products and building elements.

This document focuses on the information recorded for the first Lifecycle Stage (A). The information recorded for the Lifecycle Stages B-D will be defined in the Materials Passports Protocol.

3. Scope and Benefits of Materials Passports

MPs have multiple benefits for the construction industry on different levels. This section details the scope and benefits of MPs at materials, buildings as well as at city and country levels.

3.1 Materials

- **Standardised Documentation Format:** MPs establish a standardised format for digitally recording the specifications, properties, and performance of materials.
- **Benchmarks:** MPs support the development of benchmarks for key material types across key parameters such as recycled content, expected waste during the construction, lifespan, required maintenance, end of life scenarios.
- **Reuse:** MPs unlock the potential for material reuse. By providing transparency regarding the specifications and performance of used materials, MPs enable building designers and materials specifiers to confidently select reused materials, reducing waste and minimising the use of virgin resources. This helps maintain or even increase the value of materials over time.
- **Used Materials Warranties:** MPs can support the production of warranties for used materials by providing transparency, traceability, and documentation throughout the materials' life cycle.
 - **Life Cycle Documentation:** MPs document information across the life cycles of materials, encompassing details related to manufacturing, construction, maintenance, repair, reuse, end of the first life, and beyond the first life cycle.

3.2 Buildings

- **Building-Level Passport:** By creating MPs for a building's materials and elements, a building-level passport can be automatically generated using MPs software. This passport provides aggregated information on the building's material inventory, facilitating an understanding of the materials that are included in the building, such as their quantities, properties, and circularity performance in a standardised and simplified manner.
- **Automation of Assessments:** MPs can automate various types of assessments related to the building's materials, such as Carbon Assessments, Circularity Assessments, Material Intensity Assessments, Life Cycle Cost Assessments etc. MPs record information about materials' quantities, performance, and classification for different building elements, enabling software to calculate the building's performance against different indicators at different levels (whole building, building element categories, elements and materials). More details are provided in chapter 4.
- **Maintenance Schedule and Facilities Management:** MPs enable the automatic generation of maintenance schedules, indicating the expected maintenance and replacement time for different materials and elements in the building. Additionally, by comparing the actual maintenance with the expected schedule, critical information can be recorded to improve Facilities Management.
- **Material Banks:** MPs allow buildings to be considered as material banks, storing materials for

future reuse throughout their remaining lifespan and retaining the materials value.

- **Links to 3D Models:** MPs can be linked with Building Information Models (BIM) to combine the information captured by MPs with the accurate and detailed 3D representation of the building. This linkage facilitates efficient data sharing without making BIM models excessively large or difficult to maintain.
 - **Design for Disassembly:** MPs can facilitate designing for disassembly in the construction industry and support the implementation of reversible buildings. Reversible buildings are designed and constructed in a way that allows materials and elements to be disassembled. Data carriers, such as stickers with QR codes or NFC tags, can be used to link physical objects with digital datasets held as MPs. By providing access to disassembly manuals for each element, MPs simplify the process of disassembling a reversible building.

3.3 City and Country

- **UK Materials Stock Database:** By collecting and compiling data from MPs of individual buildings, a UK-specific Materials Stock Database can be created. The database provides insights into the types of materials present in the building stock, including their quantities, properties, circularity, and carbon performance. This data can be analysed and presented at various levels, such as councils, cities, countries, and across the UK, allowing for the generation of statistics and benchmarks. These statistics can support the evaluation of building performance in terms of circularity, carbon intensity, materials intensity, and building materials.
- **Urban Mining and Materials Exchange:** MPs support the implementation of the concept of "urban mining" by documenting the specifications of secondary materials (materials previously used in other buildings). This documentation facilitates materials exchanges at an urban level, creating a larger pool of reused materials and opening up new opportunities for the physical storage of reused materials.
- **Materials End-of-Life:** The documentation of materials' end-of-life through MPs at an urban level can generate statistics on different end-of-life routes (recycling, downcycling, thermal recovery, etc.) and recovery rates for key types of materials within different councils, countries, and the entire UK.
- **Net Zero Performance:** The aggregation of information from MPs plays a critical role in monitoring the construction industry's performance against Net Zero targets and other circular economy-related targets. It allows for recording statistics such as:
 - The area of buildings that have been retained, refurbished, or constructed as new structures.
 - Quantities and percentages of reused materials in buildings, including details about the type of material, classification, and location.
 - Quantities and percentages of disassembled elements, including details about the type of elements and materials.
 - Quantities and percentages of separable materials.
 - Overall statistics for the manufacturing locations of materials and elements (e.g., UK, Europe, USA, Asia).
 - Overall statistics on the types of materials used in constructed buildings.

- Actual as-built carbon emissions throughout the lifecycle of buildings, including insights into the contribution of different building element categories and materials.

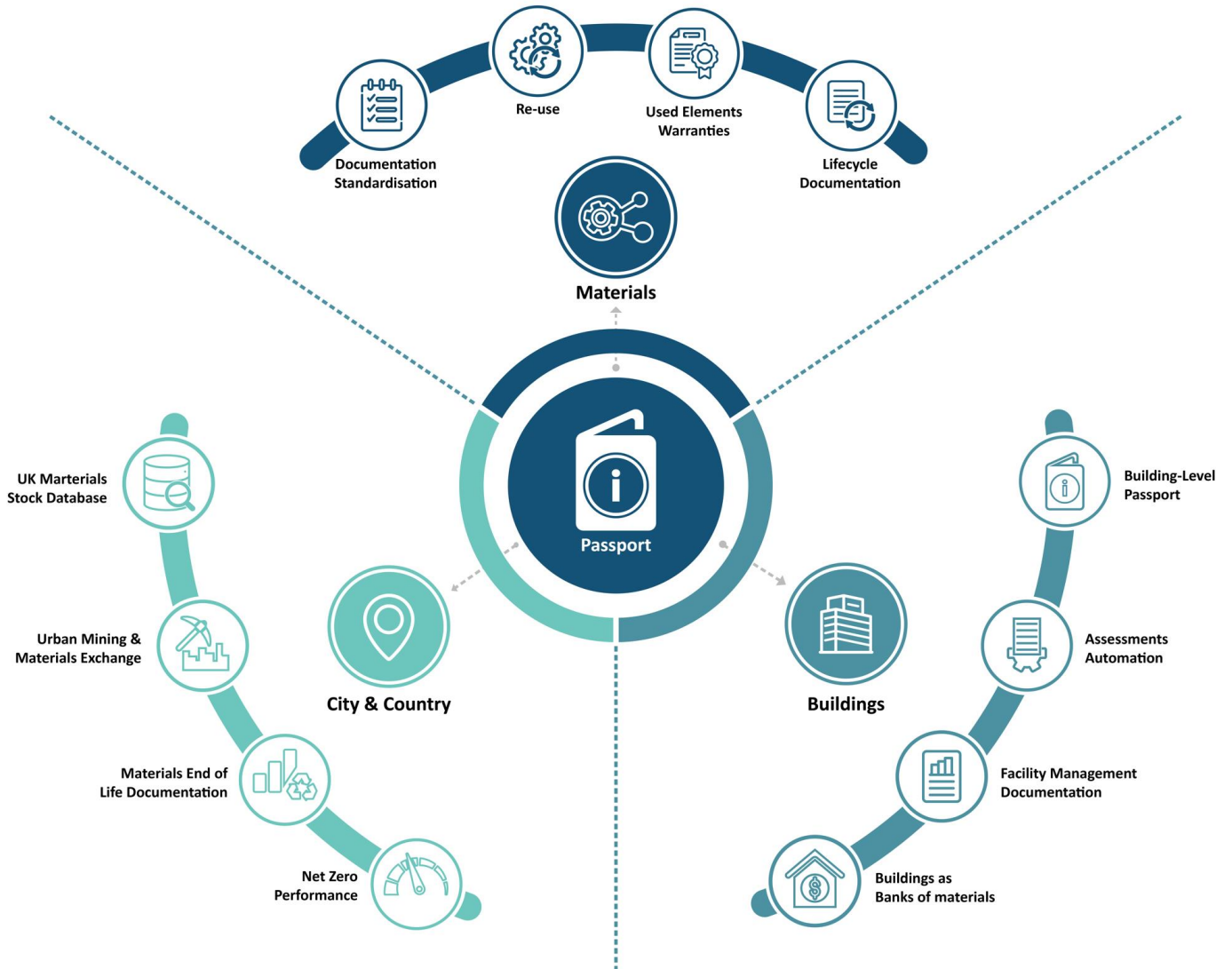


Figure 4. Overview of the scope and benefits of Materials Passports on different levels.

4. Materials Passports Synergies

MPs can be used as a one-stop database that can automate the completion of different assessments and studies for a building or other structures. These include::

- **Embodied Carbon Assessment:** MPs track the information needed for calculating the embodied carbon footprint of a building throughout its lifecycle. This includes details about the types and quantities of materials used, manufacturing location, carbon factors, maintenance rates and expected lifespan. This information allows for automated carbon assessment to be carried out for a building throughout its life cycle. The embodied carbon performance can be calculated and recorded on the different levels of MPs (component, elemental, building, complex). Additionally, MPs can play a critical role in recording the actual embodied carbon of a building during its use stage. This can support claims for Net Zero Construction Building status throughout its whole life cycle.
- **Circularity Performance Report:** MPs record data related to the circularity performance of materials and elements, including information about recycled content, end-of-life, take-back schemes, material separability, and design-related circularity information such as disassembly ability, types of connections, and access to these. By compiling this data, Circularity Performance reports can be automatically generated to show how the building and its elements perform against key circularity indicators.
- **Materials Resource Efficiency:** By gathering data from MPs at an area-level, benchmarks can be created for the material intensity of different types of buildings and building element categories. These benchmarks can be used to automatically assess materials' resource efficiency for the entire building and different building element categories.
- **Disassembly Manual:** MPs can play a crucial role in the production of disassembly manuals for buildings. They document critical information about which elements can be disassembled, types of connections, and accessibility. This information can be combined with detailed disassembly instructions for different elements, which can be linked to physical objects through data carriers such as QR codes or NFC tags. Scanning these data carriers provides access to disassembly instructions, including text, drawings, or 3D representations, enabling clear depiction of the disassembly process and visualisation of hidden elements.
- **Reuse and Recycling Catalogue:** MPs can automate the generation of a reuse and recycling catalogue for buildings. They document information about elements that can be disassembled and reused, including expected end-of-life scenarios for materials. This information allows for the production of key statistics on reuse and recycling for the entire building and different building element categories. It also helps identify element and material categories that can be reused, along with average expected recycling/diversion from landfill values for key types of materials.
- **Maintenance Schedule:** MPs can automate the production of maintenance schedules for buildings. They record data about the expected lifespan of elements and the required maintenance. This information is used to create a maintenance schedule that details expected tasks for maintenance and replacement of different elements, timescales for the required works during the use stage of the building, and the expected remaining life of materials and elements. The maintenance schedule informs decisions about potential refurbishments of the building.

- Facility Management (FM) Performance (Estimated vs Actual):** MPs record data throughout the lifecycle of materials and elements, enabling the comparison of actual maintenance information with the estimated data provided by manufacturers during the building's life cycle stage A. This comparison helps identify inefficiencies and improve FM performance, which is crucial for achieving Net Zero during the use stage of a building. Additionally, the information documented in MPs can provide required input for the Digital Building Logbook, recording major events and changes over a building's lifecycle, such as ownership changes, maintenance, refurbishment, and other interventions.
- End-of-Life Report:** MPs document information about the expected and actual end-of-life of materials. At a building's end-of-life or refurbishment stage, an end-of-life report can be automated to indicate the actual end-of-life of the materials used in the building and compare it to the expected lifespan.

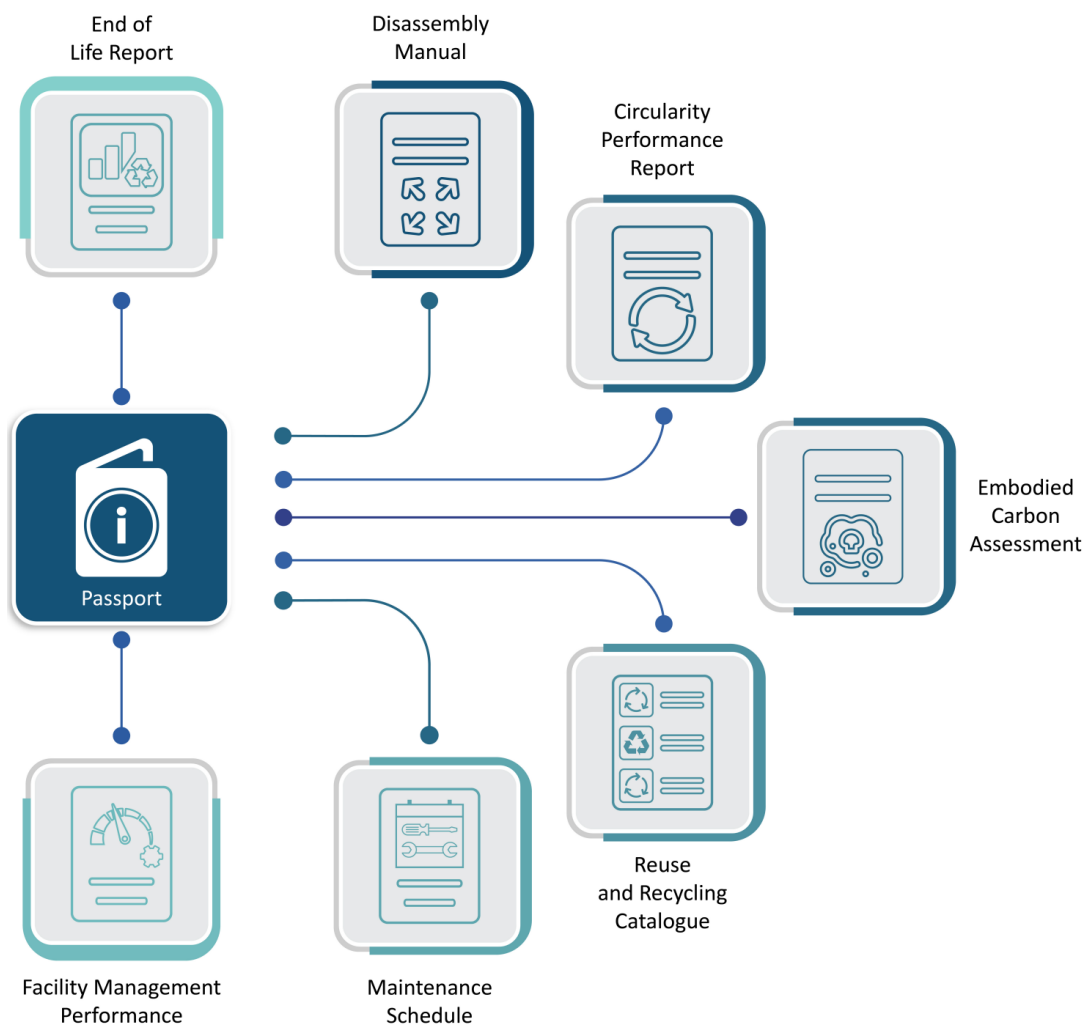


Figure 5. Illustrative overview of Materials Passports Synergies.

5. Definitions of Key Terms in this Document

5.1 Definitions for Buildings

5.1.1 Material

Materials refer to substances, either raw or processed, that are utilised to construct elements in the built environment. For the purposes of this document, materials are classified into three types, to support the development of MPs for each type. The identified types are as follows:

- **Material type I (Ingredients):** Materials are used as ingredients to construct elements. The materials Type I (Ingredients) have properties, carbon and circularity performance (for declared unit) but do not have dimensions. Examples of materials type I (Ingredients) are concrete mix, paint, mortar, adhesives etc.
- **Material type II (Modular):** Modular materials are modules that are assembled or connected to each other in order to construct elements. Materials type II (Modular) have properties, carbon and circularity performance (for declared unit) and specified dimensions for each module. Examples of modular materials are bricks, tiles, timber boards etc.
 - **Material type III (Sub-components):** Materials with specified dimensions that at least one dimension needs to be adjusted before the material is placed in the building (i.e., through cutting); Examples of materials type III (Sub-components) materials are rolls of insulations, insulation boards, gypsum boards etc. and/or more than one pieces of the material are required to construct an element.

5.1.2 Component

For the purposes of this document, a component is defined as a part of the building that meets the following criteria:

- It contributes to the structure, function, and/or decoration of the building.
- It serves the same function throughout its entirety.
- It is assigned to a specific building element category.
- It has a specified geometry.
- It is composed of either a single material (as defined in the previous section) applied to its entire entity or multiple materials that are inseparable from each other (e.g., reinforced concrete) and are applied to its entire entity.

The exact definition of components may vary depending on the building element category (Level 3) ([Appendix A](#)) to which they are assigned. The definition of components for each building element category will be specified in the Materials Passports Protocol. [Table 1](#) provides examples of components for these building element categories, including the substructure, frame, upper floors, and roof.

The geometry of a component is determined by its design and construction. The intention is to automatically derive geometric information from the building's BIM models. Therefore, the geometrical definition of a component relies on how it is designed within the BIM model. Further guidance on this matter will be provided in the Materials Passports Protocol.

Table 1. Examples of Components for structural Elements.

Building Element Categories			Component
Level 1	Level 2	Level 3	
1. Substructure	1.1 Substructure	1.1.1 Standard Foundation	Each Pile
			Each Pile Cap
			Each Retaining Wall
		1.1.3 Lowest Floor Construction	Each section of the Lowest Floor Slab
2. Superstructure	2.1. Frame	2.1.1 Steel Frame	Each Steel Column
			Each Steel beam
	2.2. Upper Floors	2.2.1 Floors	Each piece of precast slab
			Whole floor slab topping per floor
	2.3 Roof	2.3.1 Roof Structure	Each piece of precast slab

5.1.3 Grouped Component

For the purposes of this document, a grouped component refers to an element that is comprised of multiple components (as defined in the previous section) due to one or more of the following reasons:

- It is traded by its manufacturer in this combined form (e.g., a desk composed of metal legs and a timber surface).
- It fulfils its intended function as a grouped component (e.g., an aluminium-framed window consisting of different components such as glass, aluminium frame, gasket, etc., that collectively form a window).
- Furthermore, the definition of a grouped component is related to how elements are designed in BIM models. More detailed exploration of this aspect will be provided as part of the Materials Passports Protocol.

5.1.4 Removable Grouped Component

For the purposes of this document, a removable grouped component refers to an element that is comprised of multiple components and is used as an interchangeable and removable part of a parent grouped component.

A removable grouped component possesses the following characteristics:

- It is a grouped component.
- It serves as an interchangeable part of a parent grouped component, allowing for replacement or interchangeability with another element that fulfils the same function.
- It is a removable part of a parent grouped component, meaning it can be easily disassembled and removed without causing damage to the parent grouped component.
- Its expected lifespan may differ from that of the parent grouped component.
- It may be manufactured by a different manufacturer than the parent grouped component.

5.1.5 Parent Grouped Component

For the purposes of this document, a parent grouped component refers to an element that consists of one or more removable grouped component(s) as well as potentially other component(s).

5.1.6 Element

For the purposes of this document, an element refers to a part of a building or other structure, which can be a component, grouped component, removable grouped component, or parent grouped component.

5.2 Definitions for Products

5.2.1 Product

A product is a tangible item that is manufactured or supplied and is intended for use in the construction or renovation of buildings and other structures. It has not yet been incorporated into a building but is available for purchase. Once it is utilised in the building process, it transitions into an element.

5.2.2 Product Types

A product is a tangible item that is manufactured or supplied and is intended for use in the construction or renovation of buildings and other structures. It has not yet been incorporated into a building but is available for purchase. Once it is utilised in the building process, it transitions into an element.

- **Product type 1: Material type I (Ingredients):** Products of materials that, after they are sold, will be used as ingredients to construct components. Examples of product type 1 include a 25kg bag of concrete mix, a 5L paint tin, a 25kg bag of cem mortar, etc.
- **Product type 2: Material type II (Modular):** Products of modular materials that, after they are sold, will be assembled or connected to each other in order to construct components. Examples of product type 2 include a pack of bricks, a pack of tiles, one timber board, etc.
- **Product type 3: Material type III (Sub-components):** Products of materials that have specified dimensions that after they are sold and used in a building:
 - at least one of the dimensions needs to be adjusted before the material is placed in the building; and/or
 - more than one pieces of the material are required to construct a component.

Examples of product type 3 are a 15m rolls of insulation, a pack with 10 insulation boards, a pack with 5 gypsum boards etc.
- **Product type 4: Components:** Products that can be directly used in a building as a component. Examples of product type 4 include a steel beam, a precast wall panel etc.
- **Product type 5: Grouped components:** Products that can be directly used in a building or other structure as a grouped component. Examples of product type 5 are prefabricated elements such as windows, doors, unitised facades and systems such as HVAC etc. Products type 5 can be classified into two categories:
 - **Product type 5: Removable grouped components:** Products type 5 that are used as an interchangeable and removable part of product type 5-parent grouped component. Examples of removable grouped components are a window that is part of a unitised façade, a door (composed of different components such as frame, glass panel, handle and hinges) in an aluminium framed glass partition wall etc.

- **Product type 5: Parent Grouped Components:** Product type 5: parent grouped component refers to a product type 5 that consists of one or more product type 5-Removable grouped component(s) as well as potentially other product(s) type 4.

■ 5.2.3 Product Element

For the purposes of this document, a product element refers to a part of a product type 5 which can either be a product type 4 or a product type 5: removable grouped component.

6. Levels of Materials Passports

There are different levels of MPs that follow a "pyramid" structure. This pyramid adheres to the hierarchy of material flow systems, meaning that the information at higher levels is a result of aggregating information from the lower levels (Ref. 12). The identified levels of MPs are:

- Product-level passport
- Material-level passport
- Component-level passport
- Grouped component-level passport
- Elemental-level passport
- Building-level passport
- Buildings complex/ Portfolio-level passport
- Area-level (i.e., Council, UK countries, UK) passport

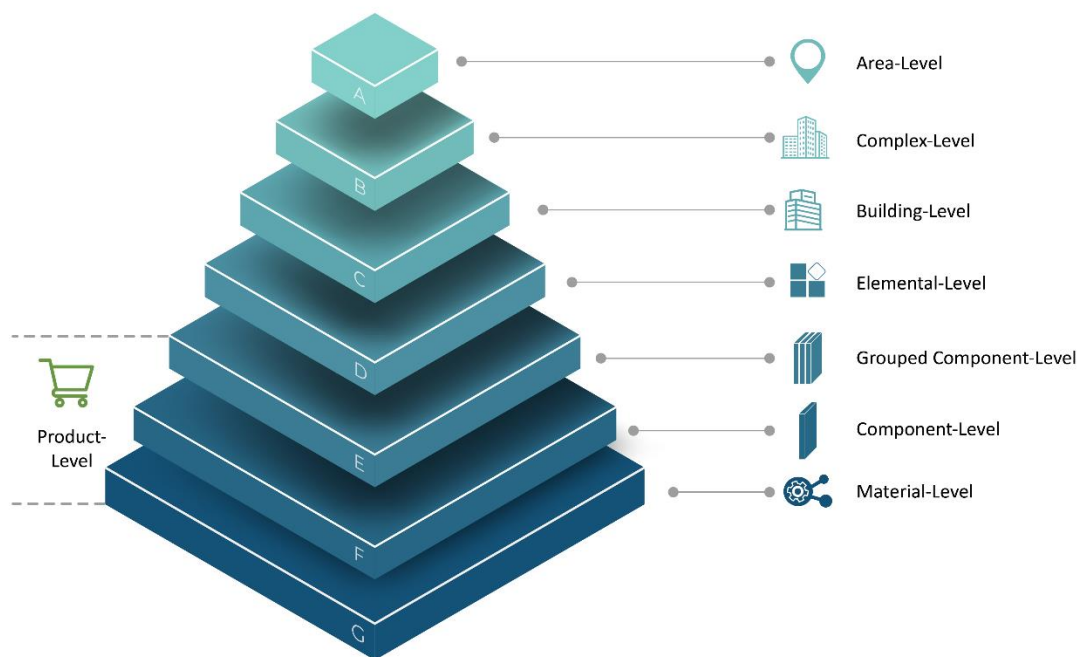


Figure 6. Materials Passports Pyramid.

Figure 6 illustrates the MPs Pyramid, displaying the various levels of MPs related to the materials used in the Buildings Stock. Product-level passports are not included in the MPs Pyramid since products represent potential materials, components and grouped components that are available for sale but have not yet been used or incorporated into a building or other structure. Therefore, they are not accounted for in the buildings stock. Depending on the type of product (definitions provided in section 5.2.2), product-level passports may align with the material-, component-, and grouped component-level. **Figure 7** showcases the MPs Spectrum, demonstrating the inverse relationship between the level of information granularity in MPs and the data aggregation for the UK Stock Database.



Figure 7. Links between UK Stock data aggregation and Materials Passports levels.

The following section describes the different levels of MPs:

- Product-Level Passport:** A product-level passport contains information about a product that is traded by a manufacturer. This passport is applicable to products that have not yet been used or placed in a building but are available for sale. When a product is used in constructing a building, it transforms into an element. The product-level passport includes details such as the product's description, price, manufacturer information, carbon and circularity performance, certificates, and information about the materials used to compose it. For more information about the content and structure of product-level passports, refer to chapter 7.7.
- Material-Level Passport:** A material-level passport provides information about a specific material that constitutes an element. Material-level passports accompany component-level and grouped component-level passports and document the properties and specifications of the material, including the type of material, manufacturer information, circularity, carbon information, and certificates. Chapter 7.1 provides further details on the content and structure of material-level passports.
- Component-Level Passport:** A component-level passport records information about a specific component that is used in a building or forms part of a grouped component. The component-level passport always includes material-level passport(s) for the material(s) that make up the component. The information recorded in a component-level passport is categorised as design-related, manufacturing-related, and construction-related. Material-related information is documented through the material-level passport(s) of the materials comprising the component. For more information about the content and structure of component-level passports, refer to chapter 7.2.
- Grouped component-level passport:** A grouped component-level passport provides information about an element that is composed of other components and/or grouped components. The grouped component-level passport contains the same type of information as component-level passports, more specifically design-related, manufacturing-related, and construction-related details. Chapter 7.3 elaborates on the content and structure of grouped component-level passports.

- **Elemental-Level Passport:** An elemental-level passport provides an overview of the recorded information for components classified under a specific building element category. These categories are based on the NRM 1 (New Rules of Measurement), 3rd edition in the UK, ensuring consistency and interoperability between Bills of Quantities (BoQs), cost plans, and carbon assessments (Ref. 11).

The information recorded in the elemental-level passports is derived from aggregating data from component-level and grouped component-level passports of the elements classified under a specific building element category. An elemental-level passport documents essential statistics for this category in a specific building, such as the overall recorded mass of materials, the total number of components, the types of materials used, the mass per type of materials, the percentage by mass of recycled content, the mass of reused materials and materials that can be disassembled. Additionally, it includes graphs that illustrate the performance of this category in relation to key indicators. For more details about the content of elemental-level passports, please refer to the chapter 7.4.

- **Building-Level Passport:** A building-level passport provides a comprehensive overview of the recorded information for a specific building. The data contained in a building-level passport is obtained through the aggregation of information from component-level and grouped component-level passports associated with that building. A building-level passport documents essential statistics for the building, such as the overall recorded mass of materials, types of materials, recycled content, reused elements, elements that can be disassembled and reused, including manufacturing location. It also includes graphs that illustrate the overall performance of the building based on key indicators. For further details regarding the content of building-level passports, please refer to chapter 7.5.
- **Buildings Complex/ Portfolio-Level Passport:** A buildings complex-level passport offers an overview of the recorded information for the buildings within a complex, utilising their respective building-level passports. It documents key statistics for the complex, similarly with the building-level passport and it includes graphs that illustrate the overall performance of the complex based on key indicators.
- **Area-Level Passport:** An area-level passport provides an overview of the recorded information for all the buildings (for which MPs have been produced) located within a specific area, utilising their building-level passports. It documents key statistics for the designated area, and it includes graphs that indicate the overall performance of the area based on key indicators such as the overall mass of materials that can be reused or disassembled. For further details regarding the content of area-level passports, please refer to chapter 7.6.

Figure 8 illustrates that the initial three levels of passports for a building (material-, component-, and grouped component-level) are derived from the input provided by the MPs generator. Hence, these levels of MPs contain the raw data for the materials and components. The remaining levels of MPs (elemental-, building-, complex-, and area-level) can be automatically generated using software by aggregating data from the previous levels of MPs. These levels present overall statistics and graphs to provide an overview.

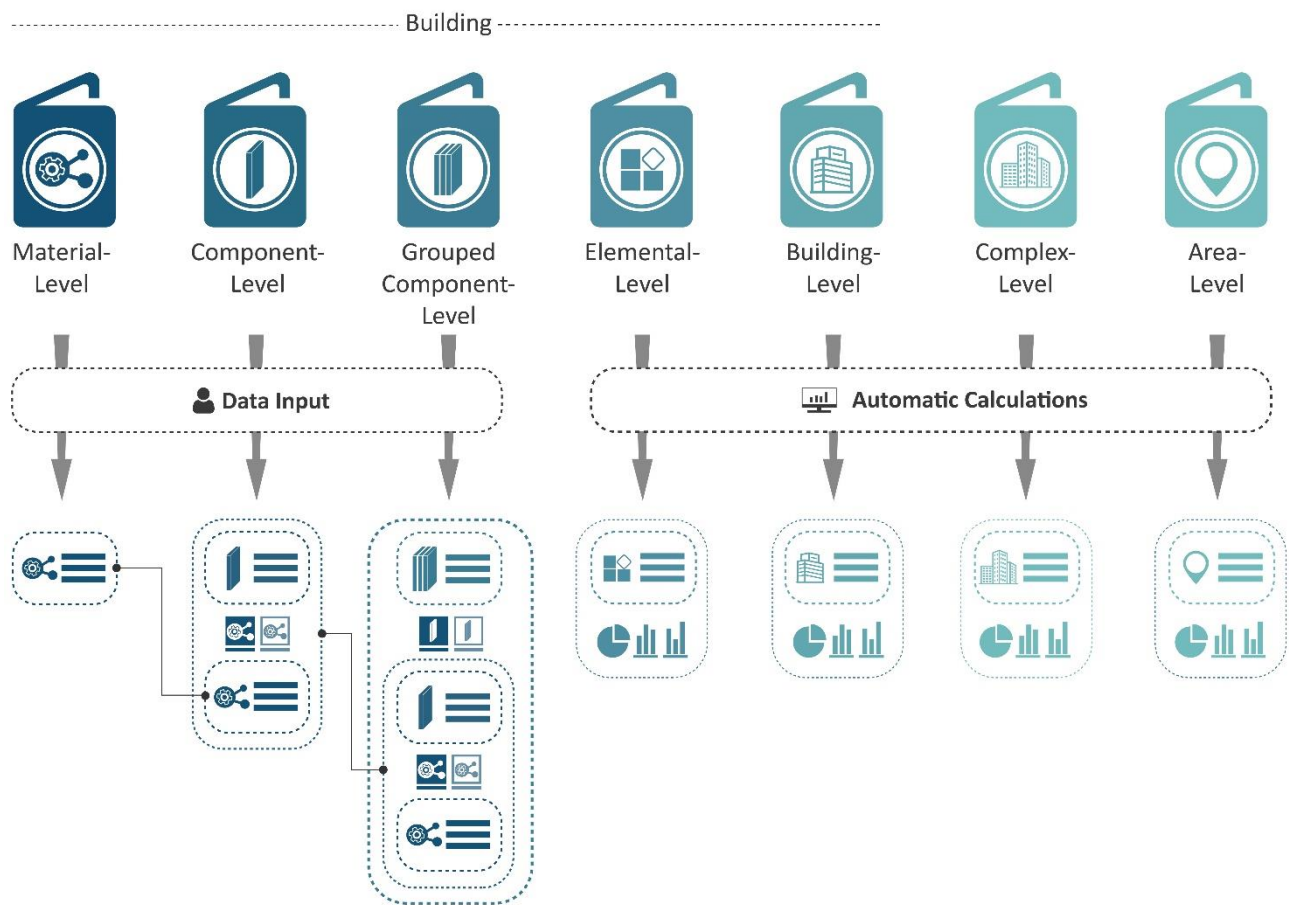


Figure 8. Overview of the relationships between the different levels of Materials Passports.

Figure 9 provides an example of the various levels of MPs for the Edenica project, where Waterman have been at the forefront of implementing MPs in the City of London. The image demonstrates the connections between different MPs levels, which are as follows:

- Material-level passports for glass material and aluminium material.
- Component-level passports for glass components and aluminium mullions.
- Grouped component-level passports for the aluminium-framed window and the unitised façade.
- Elemental-level passports for the external walls and superstructure.
- Building-level passport for the Edenica building.
- Area-level passports for the City of London.

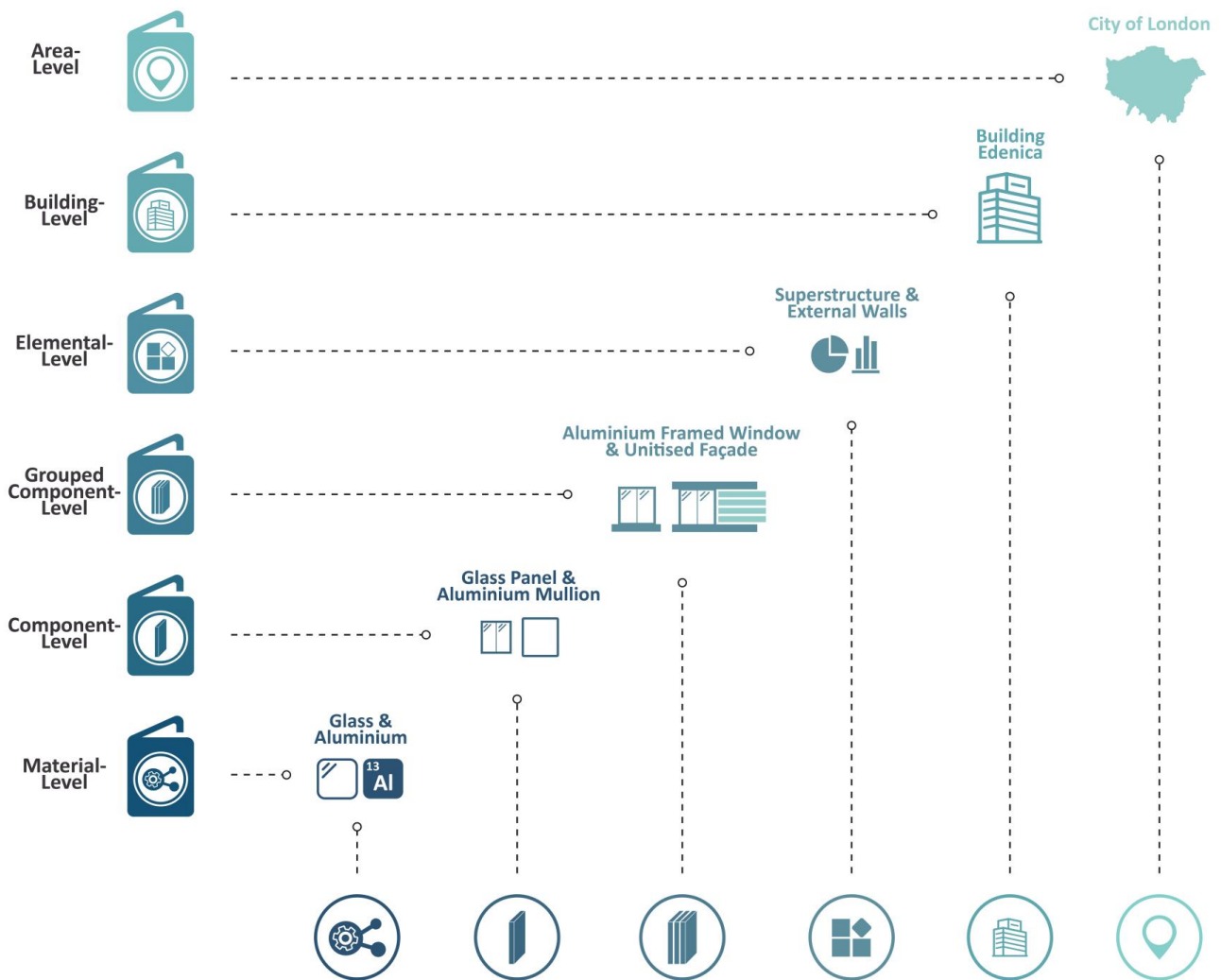


Figure 9. Example of different Materials Passports levels.

7. Content of Materials Passports

7.1 Material-Level Passport

A material-level passport captures information about a particular material that constitutes a component or grouped component. Material-level passports offer the highest level of granularity in this framework and are always included alongside component- and grouped component-level passports. These MPs document various categories of information about the material, including its type, manufacturer, certifications, geometry (where applicable), circularity, carbon performance, and material properties. **Figure 10** provides an overview of the information categories recorded within the material-level passport.

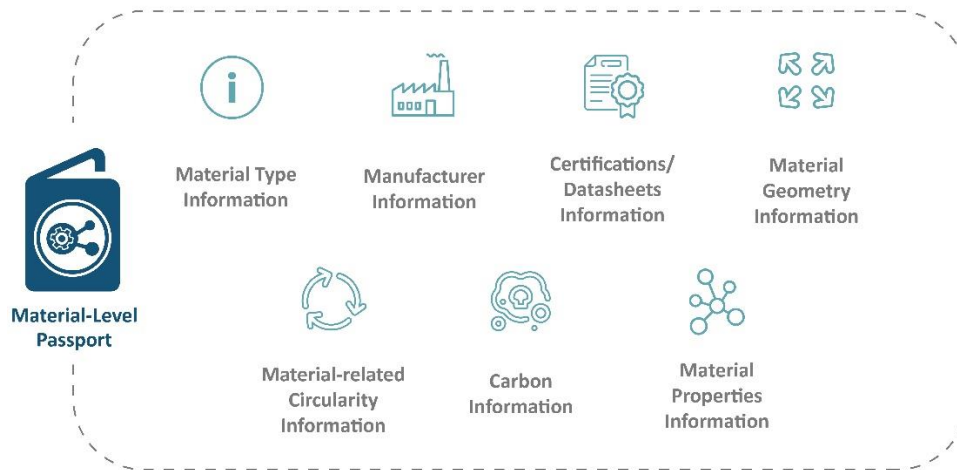


Figure 10. Overview of the information categories that are recorded within the material-level passport.

The following section describes the information provided in each information category:

- Material Type Information:** Documentation of the material photo, product registration number, material type and contribution to the overall mass to the component or grouped component. More information for each information field can be seen below:
 - Material Photo:** Photo that demonstrates what the material looks like.
 - Product Registration Number:** Number that links the material with a specific product (type 1-3, as defined in the section 5.2.2). This number should be the Global Trade Item Number (GTIN) standard from the GS1 organisation. It is a unique identification code assigned by GS1 to products and packaging, to enable worldwide identification and tracking of products.
 - Material Type:** Specification of the material type 1 and 2 based on the classification system Uniclass2015 January 2023 release (**Ref. 15**).
- Material's Manufacturer Information:** Manufacturer's logo, name, address, website, contact email and manufacturing location.
- Material's Certifications/ Datasheets information:** Information for certification and datasheets that document the material's properties and specifications. For each certification/ datasheet the following information should be provided: name, type (from pre-defined list), description that explains what information is documented in the certification/ datasheet and expiration

date (where applicable).

- Material's Geometry Information:** Information about the material's density and geometry. As detailed in the section 5.1.1, there are three identified types of materials (ingredients, modular, sub-components). Depending on the material type, different information is required to be documented for the material's geometry. The table below provides more clarity on the recorded information for each category.

Table 2. Overview of the required information for the material geometry for the different types of materials.

	Material Categories		
	Category I (Ingredients)	Category II (Modular)	Category III (Sub-Components)
Density	YES	YES	YES
Length	N/A	YES	YES
Width		Dimensions of the Module	only standardised dimensions
Height			

- Material-related Circularity Information:** Information about the material's expected lifespan, recycled content, take-back scheme, reuse potential, separability and end-of-life management. More information for each information field can be seen below:
 - Expected Lifespan:** The anticipated lifespan of the material, as specified by the manufacturer, in years.
 - Recycled Content:** The percentage, by mass, of the material that is composed of recycled content.
 - Take-back Scheme:** Indicates whether the manufacturer has a take-back scheme in place for the material.
 - Reuse Potential:** Indicates whether the material can be reused.
 - Separability:** If a component or grouped component consists of multiple materials, this field documents whether the material can be separated from the others without causing damage.
 - End-of-Life Management:** Provides information on the percentage, by mass, of the material that is estimated to be recycled, downcycled, used for energy recovery, and sent to landfill. Further details on downcycling and energy recovery are explained in the subsequent sections.
 - Downcycling:** Downcycling refers to the process of turning a material into something of lesser quality, functionality, or value (compared to the original material), which cannot be used for its original purpose. This is in contrast to recycling, which involves turning a material into something that can be used again for its original purpose or a similar one. Downcycling is often used when it is not possible to recycle a material in a way that maintains its original quality. For example, a used aluminium mullion may be recycled and used to make a new aluminium mullion, but a plastic bottle may be downcycled into a lower-quality plastic product, such as a park bench or a plastic lumber deck.
 - Energy Recovery:** Energy recovery from waste refers to the process of capturing

the energy content of waste materials for the purpose of generating electricity or heat. This can be done through various methods, including the incineration of solid waste to generate steam, the fermentation of organic waste to produce biogas, and the anaerobic digestion of biomass to create methane. Energy recovery from waste can help to reduce our reliance on fossil fuels and mitigate the negative environmental impacts of waste disposal. However, it is important to ensure that energy recovery facilities are designed, operated, and regulated in a way that minimises any negative environmental or public health impacts.

- **Material's Carbon Information:** Documentation of the carbon datasheet type, declared unit, manufacturing carbon (A1-A3), sequestered carbon, use stage carbon (B1-B3) and end-of-life carbon (C1-C4).
- **Material's Properties Information:** Information about the material's health and documentation of material's optical, structural, thermal, acoustic and fire resistance properties. Different types of properties need to be documented for various elements and materials. Therefore, this section requires further development to identify the properties that must be reported based on the type of material and building element category. This task will be carried out as part of the Materials Passports Protocol.

It is recommended that certain information in the material-level passport is mandatory, while the remaining information is optional but strongly encouraged. [Appendix B](#) provides a detailed description of the information documented in a material-level passport.



7.2 Component-Level Passport

A component-level passport captures information about a specific component that is utilised in a building or structure or forms a grouped component. Component-level passports should be accompanied by a material-level passport(s). In cases where a component is made up of multiple materials (e.g., a concrete slab with both reinforcement and concrete mix), multiple material-level passports are required. It is recommended that material-level passports be mandatory for elements composed of up to three materials. For elements comprising more than three materials, a bill of materials can be generated to illustrate the mass percentage contribution of each material, as it is acknowledged that gathering information for more complex elements can be challenging. Additional guidance on this matter will be provided in the Materials Passports Protocol.

A component-level passport encompasses design-related, manufacturing-related, and construction-related information. The table below presents an overview of the information categories recorded within a component-level passport.

[Figure 11](#) and [Table 3](#) show the structure and content of the component-level passport.

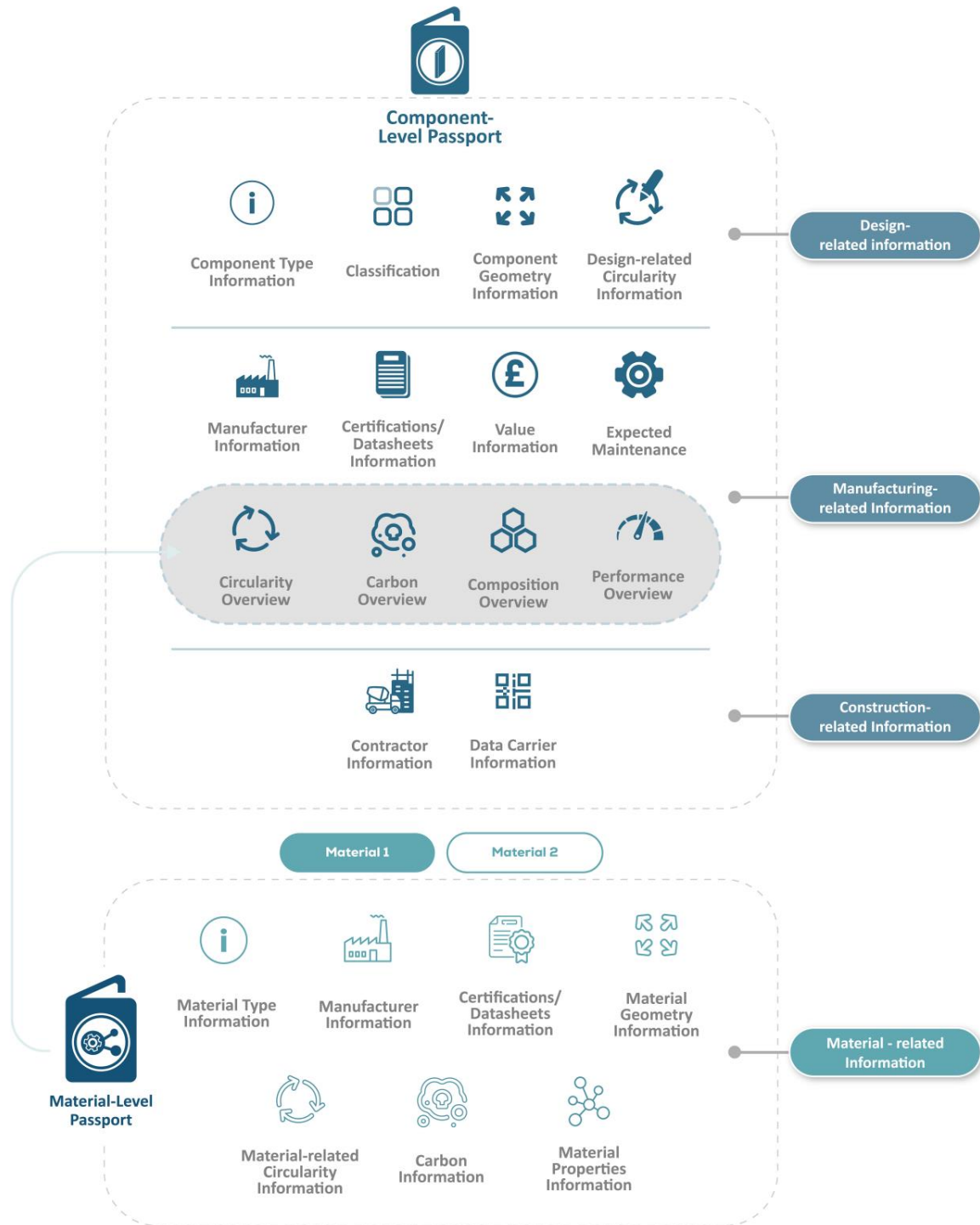


Figure 11. Illustration of the structure of a component-level passport and the information categories that are recorded in it.

Table 3. Overview of the information categories that are recorded in the component-level passport.

Information Categories	
Design-related	<ul style="list-style-type: none"> • Component type Information • Classification • Geometry Information • Design-related Circularity Information
Manufacturing-related	<ul style="list-style-type: none"> • Manufacturer Information • Certifications/ Datasheets Information • Value Information • Expected Maintenance Information
	<ul style="list-style-type: none"> • Circularity Overview • Carbon Overview • Composition Overview • Performance Overview
Construction-related	<ul style="list-style-type: none"> • Contractor Information • Data Carrier Information

7.2.1 Design-Related Information

The design-related section in the component-level passport documents information about the component's type, classification, geometry, and design-related circularity information.

- **Component type information:** This information category includes the component's unique ID, photo/visualisation, and type. There are four identified types of components, which are detailed below:
 - **New Component:** This category encompasses components added to either new or existing buildings that are composed of new material(s). The purpose of a new component's passport is to document information related to the component and its materials, capturing its performance, establishing benchmarks, and facilitating its future reuse.
 - **Reused Component:** This category includes components added to either new or existing buildings that have previously been used in other buildings/structures. The purpose of a reused component's passport is the same as that of a new component, while also capturing the benefits of reuse. If a Material Passport (MP) was not created for the initial use of the component, there may be challenges in collecting the required information for the component-level passport and material-level passport of the reused component. Consequently, a more limited amount of information is necessary for the component-level passport of reused components ([Appendix E](#)). However, if a component-level passport was produced for a component during its initial use, when it is reused, all the required information should be provided for its second life.
 - **Existing Component:** This category comprises components that already exist in a building. The purpose of an existing component's passport is to document the available information for the specific component and its materials, creating benchmarks for the building or identifying elements that can be reused. Similar to the reused component's passport,

limited information is expected to be available for the component. Therefore, a more limited amount of information is required for existing components ([Appendix E](#)).

- **To be Demolished:** This category includes components that currently exist in a building and are intended to be demolished or removed. The purpose of this type of component-level passport is to record information for components that will be demolished and facilitate their potential reuse. These passports can be used alongside pre-redevelopment and pre-demolition audits, aiding in the identification of reuse opportunities for existing components that are no longer needed (resulting in potential carbon savings that can be used for offset schemes), including estimates of recycling materials per material type.
- **Classification Information:** This documents the building level on which the component is based and the building element category to which the component is assigned. The building element categories are defined in the NRM 1 (New Rules of Measurement), 3rd edition UK ([Appendix A](#)).
- **Geometry Information:** Recording of the component's mass, volume, and overall length, width and height.
- **Design-related Circularity:** This information category records if the component can be disassembled from its adjacent components without damaging them, how it is connected with its adjacent elements, and information about the accessibility to the connections. The intention is that in the future, this section will be linked to the buildings' digital Disassembly Guides.
 - **Types of Connections:** The following types of connections have been identified:
 - **Welded connections:** These are created by heating two metal surfaces until they melt and fuse together.
 - **Mechanical connections:** These are created by using bolts, screws, nuts, or other mechanical fasteners to join two components together.
 - **Adhesive connections:** These are created by using a strong adhesive, such as epoxy or construction adhesive, to bond two components together.
 - **Connections Accessibility:** Five options have been identified to document the accessibility to the connections as follows:
 - Directly accessible connection
 - Hidden Connection
 - Layer(s) to be removed – no damage
 - Layer(s) to be removed – damage
 - Not accessible connection

7.2.2 Manufacturing-Related Information

The manufacturing-related section in the component-level passport records information for the component's manufacturer, certifications, and datasheets (where applicable), value, and expected maintenance. The information in the manufacturing-related section should be derived from the product-level passports. The section below describes what information is recorded in each information category:

- **Manufacturer Information:** Manufacturer's logo, name, address, website, contact email, and manufacturing location.
- **Component's Certifications/Datasheets information:** Information for certifications and

datasheets that document the component's properties, specifications, and performance. For each certification/datasheet, the following information should be provided: name, type (from a pre-defined list), description that explains what information is documented in the certification/datasheet, and expiration date (where applicable).

- **Value Information:** Value, priced unit, and years of warranty.
- **Expected Maintenance Information:** Expected percentage of the mass of the component that is expected to be replaced annually and maintenance guidance.

Additionally, the manufacturing-related section of the component-level passports includes the following information, which can be automatically derived (through MPs software) from the material-level passport(s) that accompany the component-level passport:

- **Circularity Overview:** Information about the component's expected lifespan, recycled content, take-back scheme, reuse potential, separability, and end-of-life management.
- **Carbon Overview:** Documentation of the carbon datasheet type, declared unit, manufacturing carbon (A1-A3), sequestered carbon, use stage carbon (B1-B3), and end-of-life carbon (C1-C4).
- **Composition Overview:** An overview of the materials that form the component and their percentage by mass contribution to the component's mass.
- **Performance Overview:** An overview of the functional performance of the component. The functional performance depends on the building element category and the material(s) that compose the component. Therefore, this section needs further development to identify the functional performance that is required to be reported per building element category (Level 3). This task will be undertaken as part of the Materials Passports Protocol.

The below overview of information is important for components that are formed from more than one material. If a component is composed of only one material the below information will be the same as in the material-level passport.

7.2.3 Construction-Related Information

The construction-related section in the component-level passport records information for the Contractor and Data Carriers.

- **Contractor Information:** The Contractor is the company responsible for the construction of the component on-site (or off-site, if the component is pre-fabricated). The information to be recorded includes the Contractor's name, address, website, and contact email.
- **Data Carriers:** The component-level passport provides a digital twin for the real-life component, which is directly linked to the physical object through the use of data carriers. Data carriers are physical media that serve as a link between the physical object and its digital passport, allowing stakeholders to access and update information throughout the building's life cycle.

Various types of data carriers can be used to identify and track components, including:

- **RFID tags:** These tags use radio frequency identification (RFID) technology to store and transmit data wirelessly. RFID tags can be attached to components and read by RFID scanners or RFID-enabled devices such as smartphones or tablets.
- **NFC tags:** These tags use near field communication (NFC) technology to communicate with compatible devices, such as smartphones and tablets. NFC tags can be attached to components and read by bringing an NFC-enabled device close to the tag.

- **QR codes:** These are two-dimensional barcodes that can be scanned with a smartphone or other device to access information about the component. QR codes can be attached to components and linked to a website or other online resource with more detailed information.
- **Smart labels:** These labels contain a small electronic device, such as an RFID chip or NFC tag that can store and transmit data. Smart labels can be attached to components and read by compatible devices.

Appendix C provides a detailed description of the information documented in a component-level passport.



7.3 Grouped Component-Level Passport

A grouped component-level passport provides information for an element that is composed of other components. The grouped component-level passports document the same type of information as the component-level passports, which includes design-related, manufacturing-related, and construction-related information (**Table 3**).

There are two methods for documenting grouped components: the simplified method and the detailed method.

- **Simplified method:** In the simplified method, the grouped component-level passport records information for the overall grouped component and the material(s) that form it. It does not include information about the individual components that compose the grouped component. Therefore, the grouped component-level passport is only accompanied by material-level passports.
- **Detailed method:** In the detailed method, the grouped component-level passport records information for the overall grouped component as well as all the components that compose it. In this case, the grouped component-level passport is accompanied by both component-level passports and material-level passports.

Figure 12 illustrates the structure and content of the grouped component-level passports using both the simplified and detailed documentation methods.

Appendix D provides an overview of relationships between the material-level, component-level and grouped component level passport.

Similar to component-level passports, if a grouped component is made up of multiple materials, multiple material-level passports are required. It is recommended that material-level passports be mandatory for elements composed of up to three materials. For grouped components comprising more than three materials, a bill of materials can be generated to illustrate the mass percentage contribution of each material, as it is acknowledged that gathering information for more complex elements can be challenging. Additional guidance on this matter will be provided in the Materials Passports Protocol.

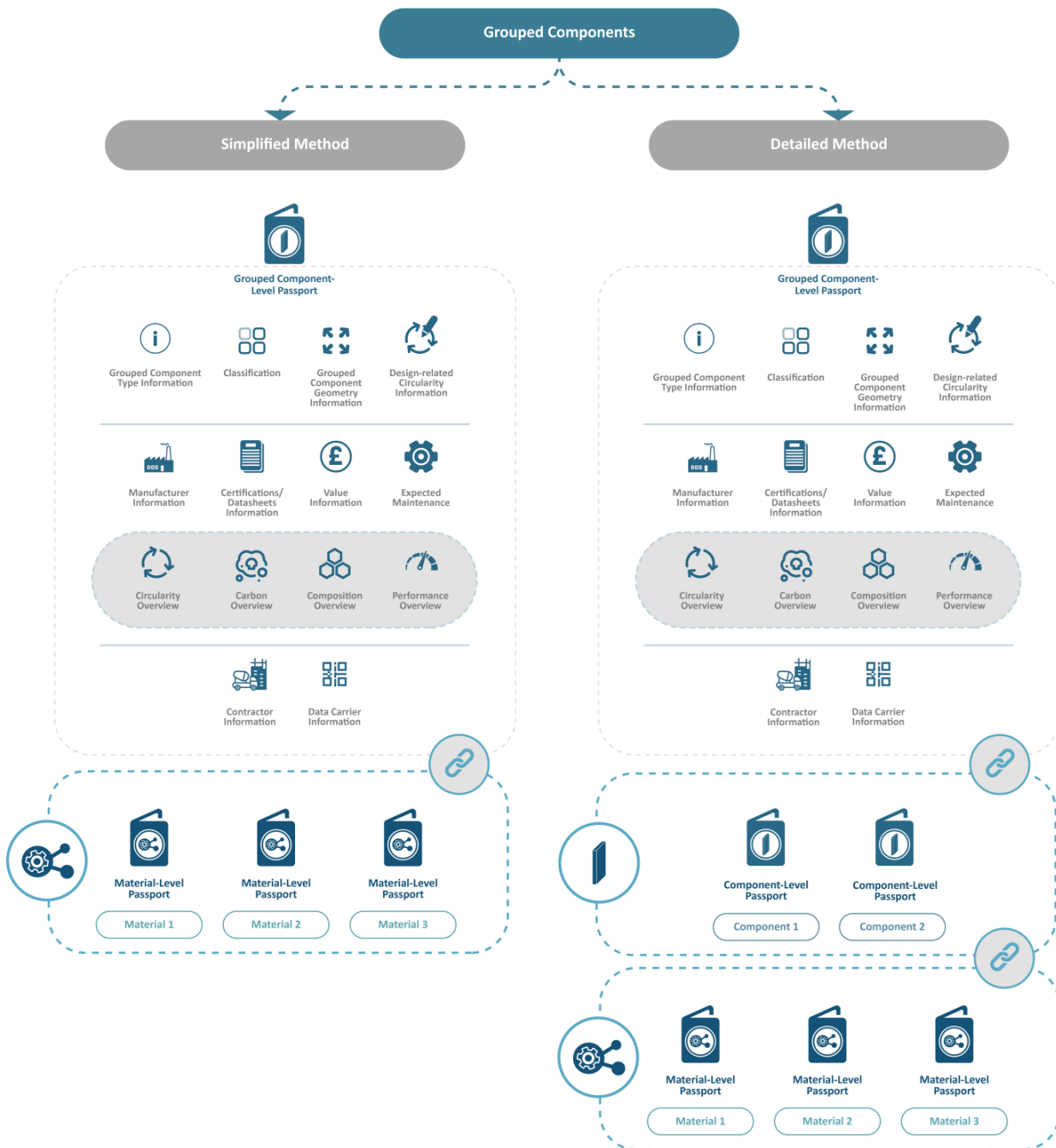


Figure 12. Overview of the structure and content of grouped component-level passports.

Additionally, it is possible for a grouped component to be composed of other grouped components. This occurs when a parent grouped component, as defined in section 5.1.5, is made up of removable grouped components, as defined in section 5.1.4, that can be removed and replaced.

A parent grouped component-level passport has the same content and structure as a regular grouped component-level passport. The only difference is that it is also accompanied by the grouped component-level passports of the removable grouped components. Figure 13 illustrates the structure and content of the parent grouped component-level passports using both the simplified and detailed documentation methods.

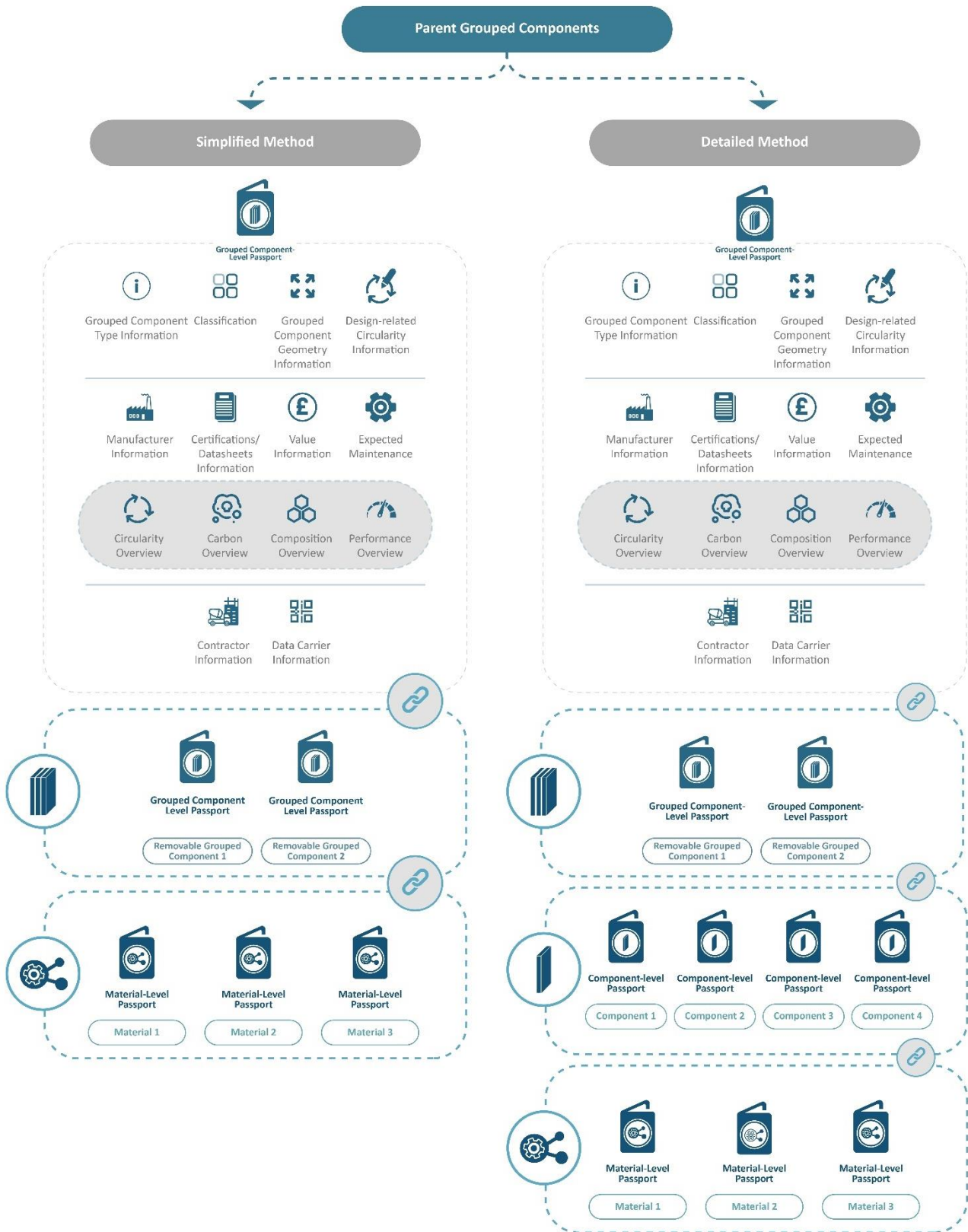


Figure 13. Overview of the structure and content of the parent grouped component-level passports.

7.4 Elemental-Level Passport

Elemental-level passports contain important information related to the different building element categories within a building. These passports provide a comprehensive overview of the recorded information for elements belonging to a specific building element category.

The building element categories (BEC) are based on the NRM 1 (New Rules of Measurement), 3rd edition UK, which ensures consistency and interoperability between Bill of Quantities (BoQs)/cost plans and carbon assessments (Ref. 11). These categories align with the Building Elements Classification System used by the Greater London Authority (GLA) for Carbon Assessments and Circular Economy Statements (Ref. 14, Ref. 15), the UK Green Building Council (UKGBC) for Net Zero Reporting Templates, and the Built Environment Carbon Database (BECD). A complete list of the building element categories can be found in Appendix A.

The information recorded in elemental-level passports is obtained by compiling data from material-level, component-level, and grouped component-level passports of the elements assigned to the specific building element category. As shown in Figure 14, the component-level and grouped component-level passports are filtered based on their building element category, and automatic calculations are performed using software to generate the elemental-level passports. Elemental-level passports are created for both building element categories Level 1 and Level 2.

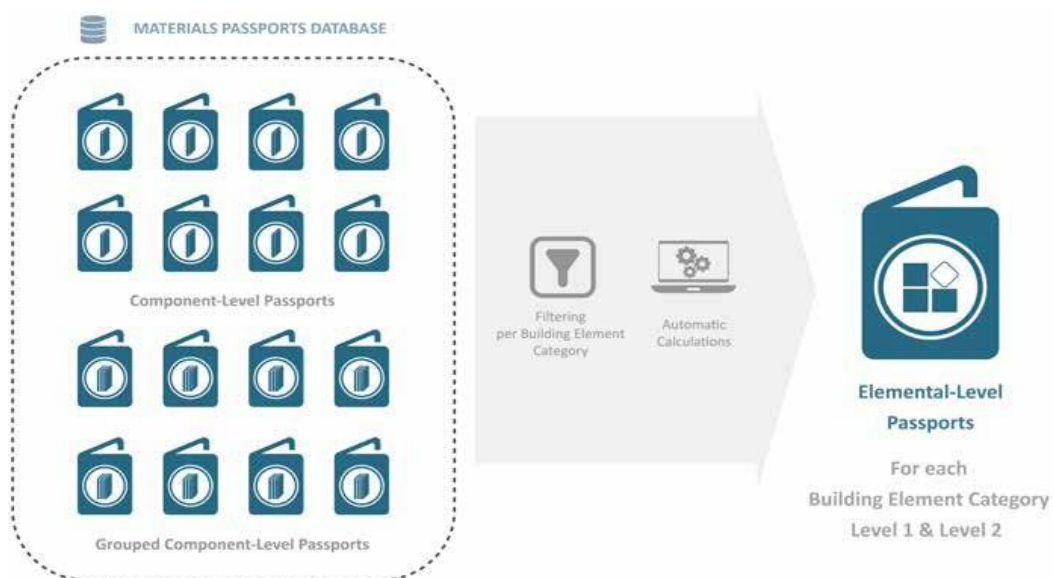


Figure 14. Links between component- and grouped component-level passports and elemental-level passports.

The Elemental-Level Information captures the following details for each building element category Level 1 and Level 2:

- **Elements Type Information:** Statistics for the types of elements (new, reused, existing, to be demolished) that are assigned to each building element category.
- **Mass information:** Overall mass of recorded elements (in tonnes) and materials intensity (in kg/m² GIA) per building element category and percentage of documented mass of a building element category to its overall mass.
- **Design-related Circularity Information:** Statistics for the elements that can be disassembled,

- types of connections and accessibility to the connections per building element category.
- **Manufacturers and Contractors Information:** Number of manufacturers and contractors, including statistics for manufacturing location per building element category.
- **Value Information:** Statistics for the elements' value per building element category.
- **Material-related Circularity Information:** Statistics for the materials that can be reused, that are supported by take-back scheme, including average percentages by mass of recycled content and end-of-life management (recycling, downcycling, landfill) per building element category.
- **Carbon Overview:** Overall embodied carbon (tonnesCO₂eq) and embodied carbon intensity kgCO₂eq/m² GIA) per building element category.
- **Composition Overview:** Number of materials, components and grouped components per building element category.
- **Data Carriers:** Statistics for the elements that have data carriers and types of data carriers per building element category.

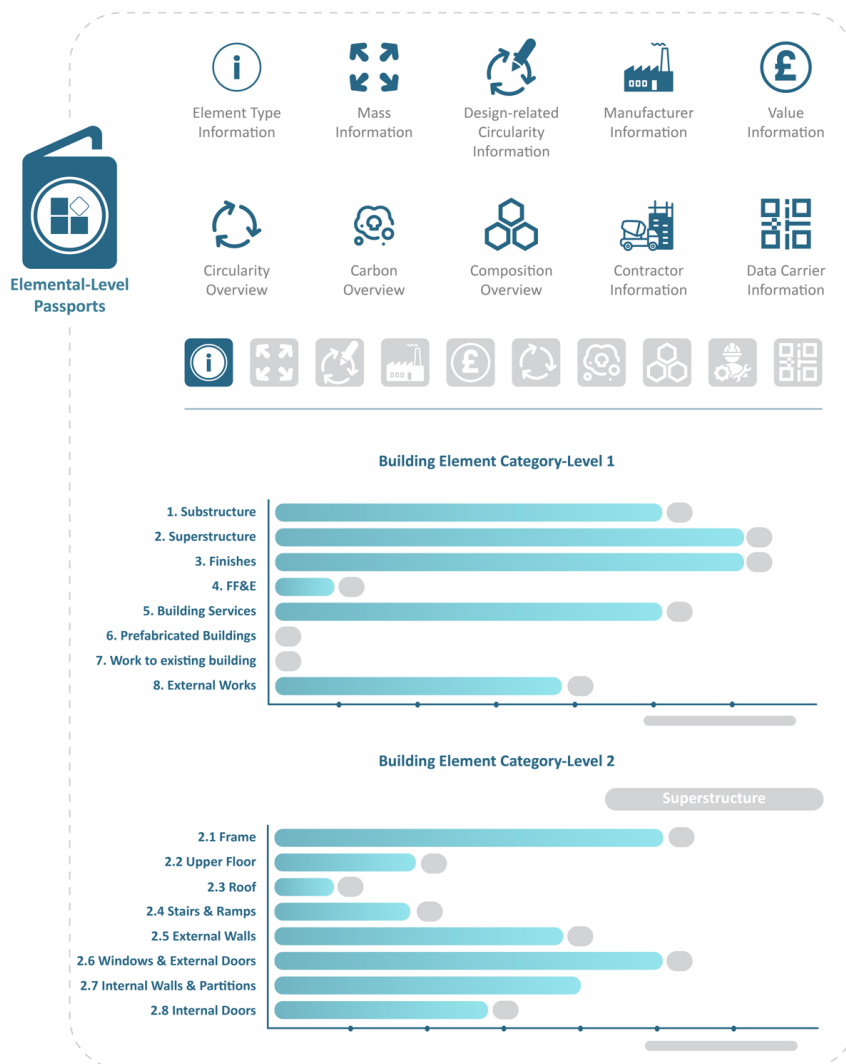


Figure 15. Overview of the information that is included in the elemental-level passports.

Figure 15 visualises the information categories for which statistics are recorded within the elemental-level passports, including illustration of the communication of the information for the building element

categories Level 1 and Level 2. **Figure 16** shows examples of different graphs that can be included in the elemental-level passport for building element categories Level 1. **Appendix F** provides additional information on the data that is collected in the elemental-level passport.

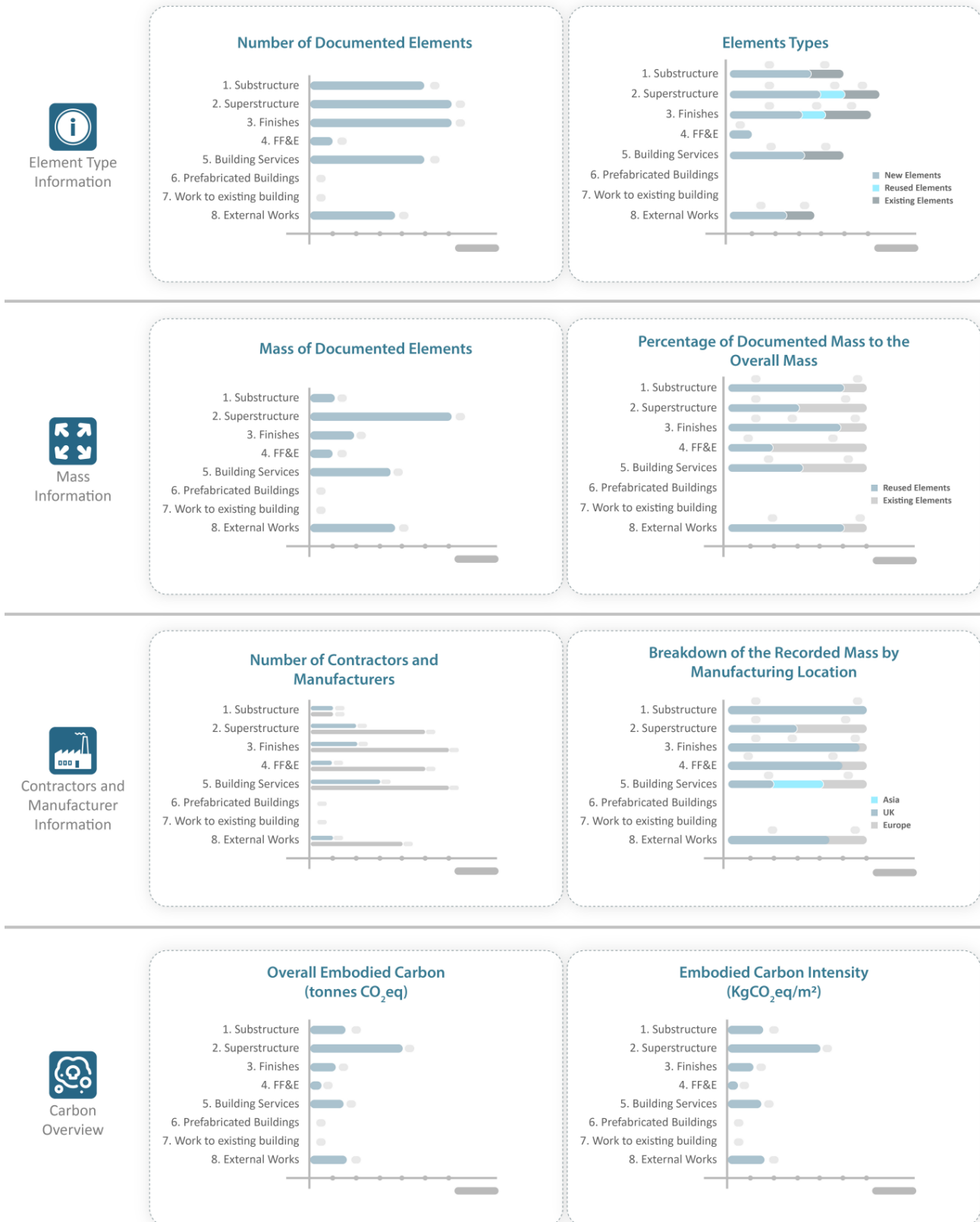


Figure 16. Overview of different graphs that can be provided in the elemental-level passport for building element categories Level 1.

7.5 Building-Level Passport

A building-level passport provides a comprehensive overview of the recorded information for a specific building. The information documented in the building-level passports is derived from aggregating data from material-level, component-level, and grouped component-level passports. **Figure 17** provides an illustration of the information included in the building-level passport.

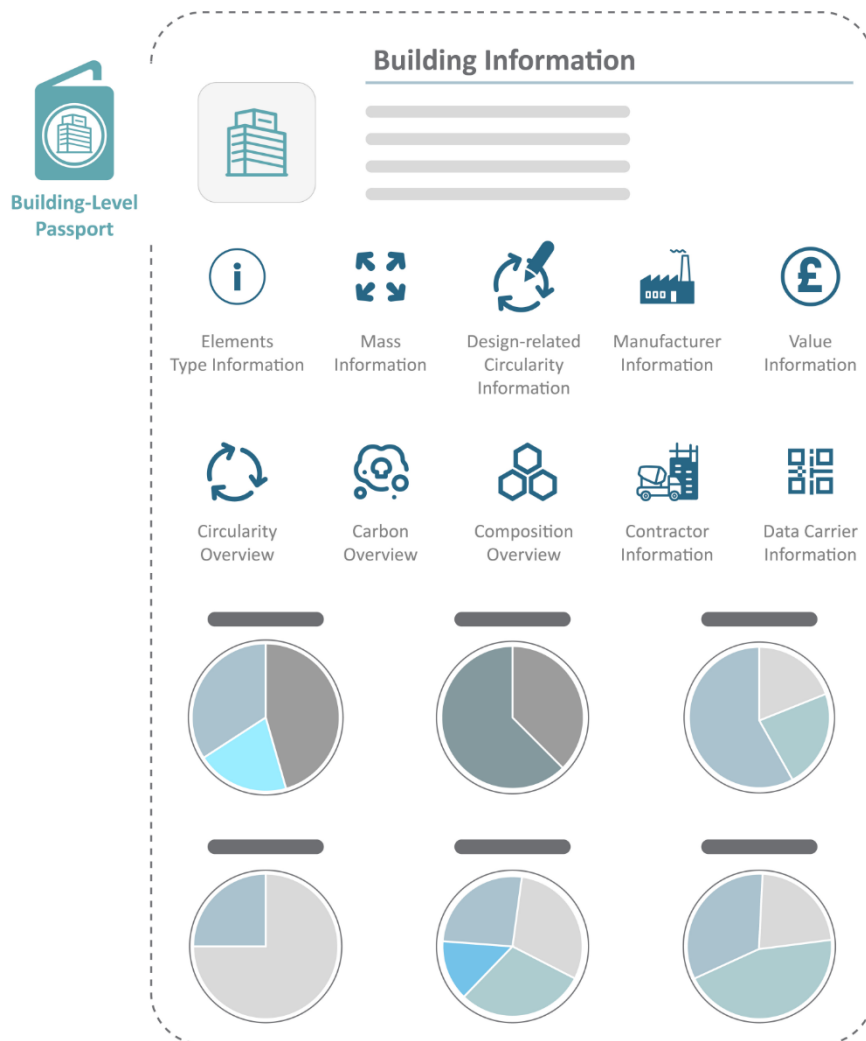


Figure 17. Overview of the information that is included in the building-level passport.

The building-level passport includes the following information:

- **General Building Information:** This includes the building name, use (e.g., commercial, residential, retail), project type (e.g., new building, refurbishment, extension), in-scope areas (e.g., whole building, specific floors, specific areas within the building), and address.
- **Elements Type Information:** Statistics pertaining to the types of elements (new, reused, existing, to be demolished) recorded in the building.
- **Mass Information:** This includes the overall mass of recorded elements, materials intensity (kg/m² GIA), and the percentage of documented mass compared to the building's overall mass.
- **Design-related Circularity Information:** Statistics related to elements that can be disassembled, types of connections and accessibility to the connections.

- **Manufacturers and Contractors Information:** Number of manufacturers and contractors involved, including statistics regarding manufacturing locations.
- **Value Information:** Statistics related to the value of elements, including value for elements that can be reused.
- **Material-related Circularity Information:** Statistics related to materials that can be reused and are supported by take-back schemes, including average percentages by mass of recycled content and end-of-life management options (recycling, downcycling, landfill).
- **Carbon Overview:** Overall embodied carbon and embodied carbon intensity.
- **Composition Overview:** Number of materials, components, and grouped components present.
- **Data Carriers:** Statistics regarding the elements that have data carriers and the types of data carriers used.

The complex/ portfolio -Level passports contain exactly the same information fields as the building-level passports.



7.6 Area-Level Passport

An area-level passport provides an overview of the recorded information for a specific geographical area, based on the MPs produced for buildings located within that area. The information documented in the area-level passports is derived from aggregating data from the building-level passports of the buildings within the specified area. The area-level passport includes the following information:

- **Area Information:** This includes the area name, type (Council, City, Region, Country, etc.), documentation year, and population.
- **Buildings Overview Information:** Overall statistics for the buildings that have been documented through MPs, such as the number of buildings, their use (commercial, residential, retail, etc.), and project types (new building, refurbishment, extension, etc.).
- **Elements Type Information:** Statistics for the types of documented elements (new, reused, existing, to be demolished).
- **Mass Information:** The overall mass of recorded elements and the percentage of documented mass compared to the total mass of the buildings. Statistics for materials intensity for different building typologies.
- **Design-related Circularity Information:** Statistics related to elements that can be disassembled, including information about the types of connections and their accessibility.
- **Manufacturers Information:** Statistics regarding manufacturing locations.
- **Material-related Circularity Information:** Statistics related to materials that can be reused and are supported by take-back schemes, including average percentages by mass of recycled content and end-of-life management options (recycling, downcycling, landfill).
- **Carbon Overview:** Overall embodied carbon and embodied carbon intensity for different building typologies.
- **Composition Overview:** Statistics related to the different types of materials used.

Figure 18 provides an illustration of the information included in the area-level passport.

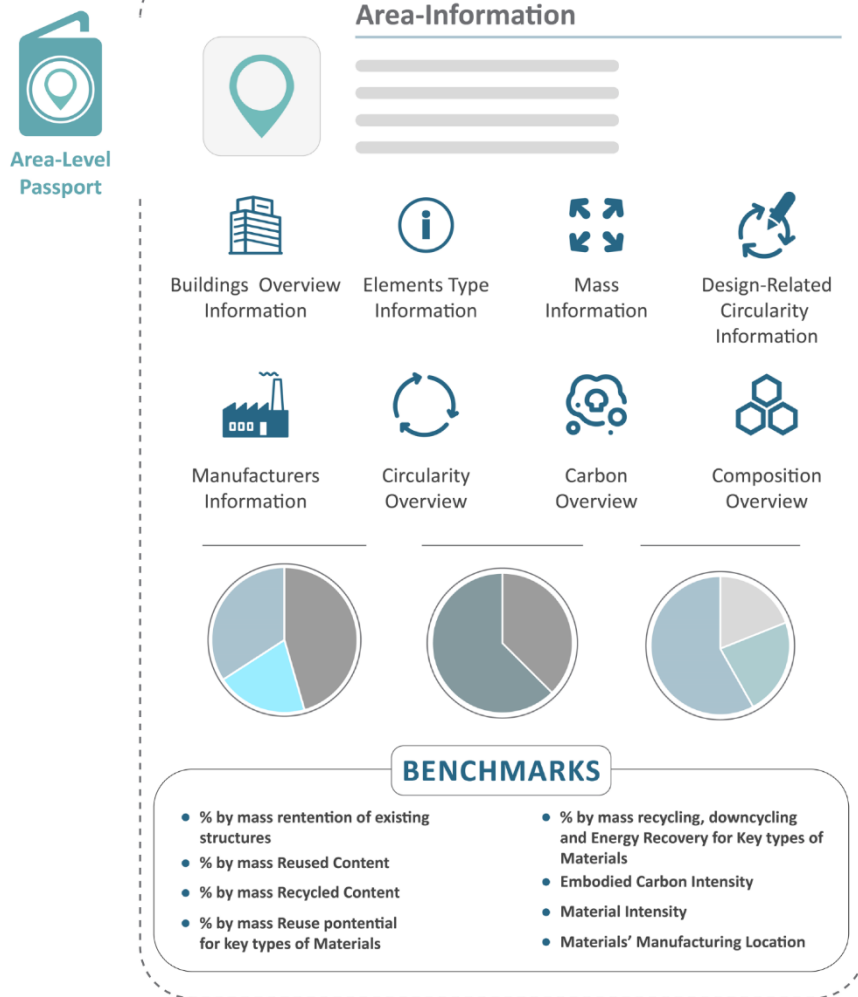


Figure 18. Overview of the information that is included in the Area-Level Passport.

Area-Level Passports play a significant role in creating benchmarks for key indicators in different geographical regions. They facilitate communication and comparison of circularity and carbon performance among different councils, cities, countries, etc., and support the monitoring process of actual performance against Net Zero targets for the built environment. Key benchmarks that can be generated from the Area-Level Passports include:

- Percentage, by mass retention, of existing structures
- Percentage, by mass, of reused content
- Percentage, by mass, of recycled content
- Percentage, by mass, of reuse potential for key types of materials
- Percentage, by mass, of recycling, downcycling, and energy recovery for key types of materials
- Embodied carbon intensity (overall building, per building element category)
- Material intensity (overall building, per building element category, specific type of material per building element category)
- Materials' manufacturing location.

7.7 Product-Level Passport

A product-level passport provides information for a specific product that is traded by a manufacturer. The product-level passport serves as a valuable tool for capturing essential information about products, enabling effective comparison and analysis for various purposes, including sustainable building practices and material selection. The purpose of the product-level passport is to:

- Provide a standardised format for reporting the specifications, properties, and composition of products.
- Facilitate the direct and easy comparison of different products based on their properties, technical performance, cost, manufacturing location, carbon footprint, and circularity performance.
- Streamline the process of generating MPs for buildings.

As described in section 5.2.2, there are five types of products: **Product type 1:** Material type I – Ingredients, **Product type 2:** Material type II – Modular, **Product type 3:** Material type III - Sub-component, **Product type 4:** Component, and **Product type 5:** Grouped component. The first three product types pertain to products that will be utilised as materials (as defined in section 7.1). Therefore, the product-level passports for these product types correspond to the material-level passports of buildings. On the other hand, product-level passports for product types 4 and 5 correspond to the component-level passports and grouped component-level passports, respectively. **Figure 19** provides a visual representation of the connections between the different types of product-level passports and the levels of building MPs.

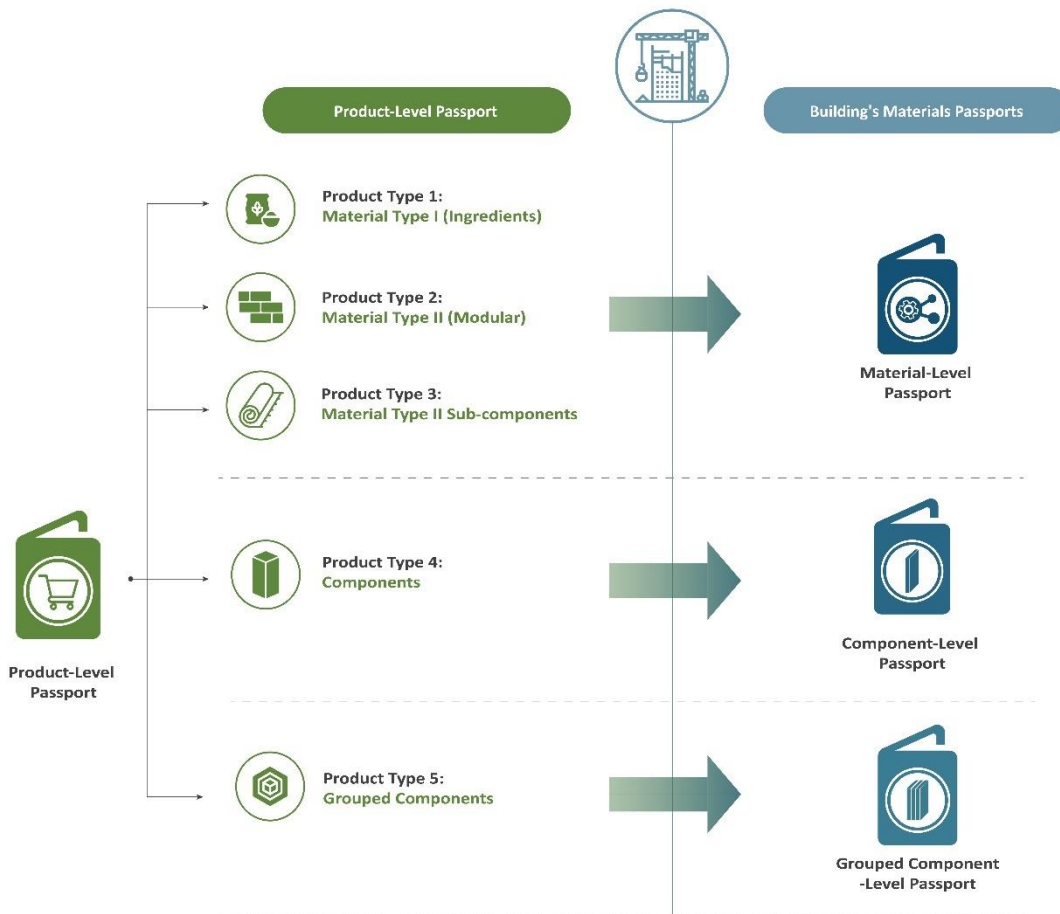


Figure 19. Links between the Product-Level Passports and the Buildings' Materials Passports.

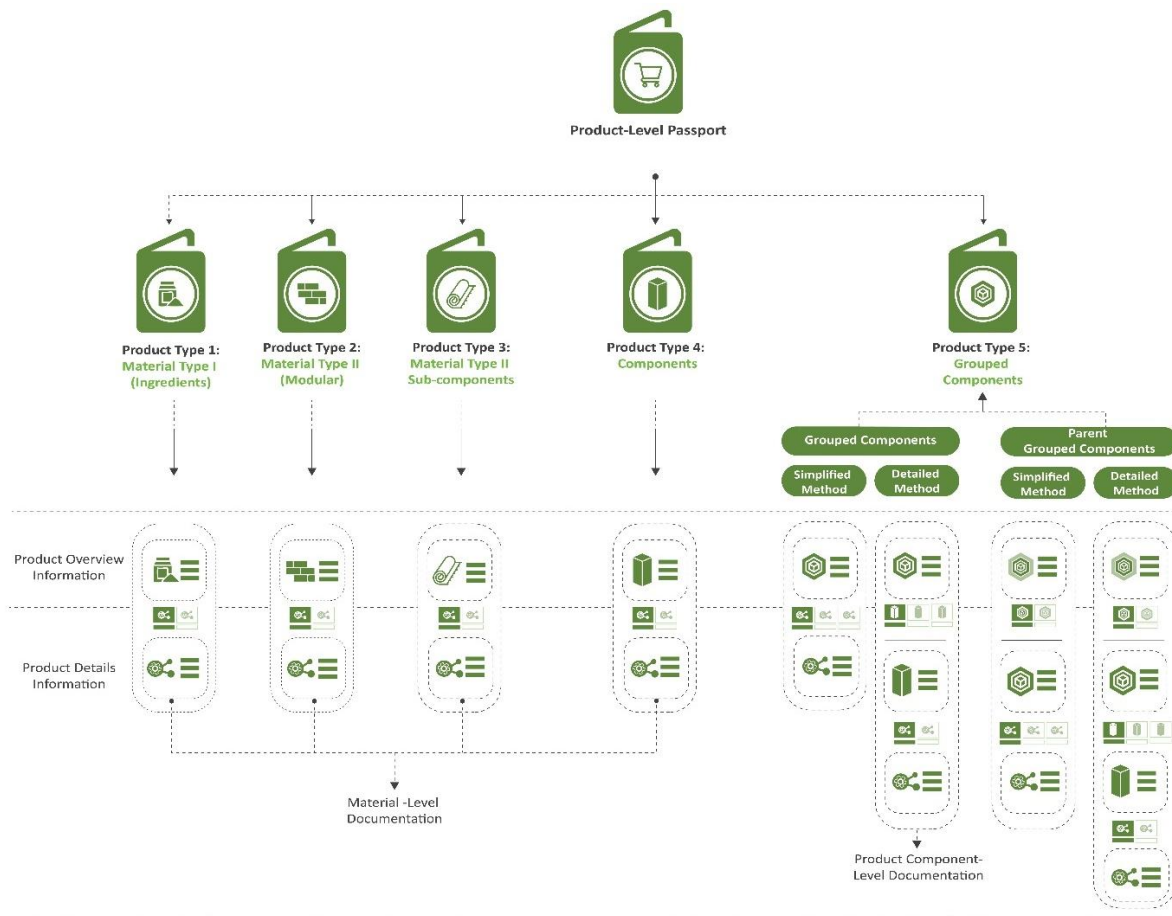


Figure 20. Overview of the structure of the product level passports for the different product types.

Product-level passports consist of two sections: "**Product Overview Information**" and "**Product Details Information**". The former maintains the same content and structure for all product types, providing a comprehensive overview of key information about the product. This includes the product's name, registration number, categorisation, manufacturer, certificates, price, expected maintenance, overall carbon and circularity performance, and a description of its overall composition.

The "Product Details Information" varies depending on the product type. The "Product Details Information" for product types 1-4 includes the documentation of the materials that constitute them. These product types can comprise multiple materials. For example:

- **Product type 1:** A concrete mix is composed of cement, aggregates, and additives.
- **Product type 2:** A floor laminate can be composed of a printed paper saturated with melamine resin, high-density fibreboard, and melamine resin-impregnated paper.
- **Product type 3:** A gypsum board is composed of gypsum, paper, and additives.
- **Product type 4:** A steel beam is composed of structural steel and intumescent paint.

Product type 5 is more complex as it consists of multiple product elements. Consequently, the "Product Details Information" section for product type 5 can either include documentation solely for the materials that form it (simplified method) or the documentation of the product elements that compose it (detailed method). Product type 5 can be composed of other product types 4 and/or other product types 5 (as detailed in section 5.2.2). Additional information is provided in section 7.7.2.

Table 4 shows an overview of the product composition for each product type.

Table 4. Overview of the product composition for each product type.

	Product Composition		
	Product Removable Grouped Component	Product Component	Material
Product type 1: Material Type I- Ingredients	N/A		YES (Potentially more than one)
Product type 2: Material Type II- Modular			
Product type 3: Material Type III-Sub-Component			
Product type 4: Component			
Product type 5: Grouped Component	Potentially	YES (more than one)	

It is recommended that material-level passports are mandatory for products composed of up to three materials. For products comprising more than three materials, a bill of materials can be generated to illustrate the mass percentage contribution of each material.

7.7.1 Product Overview Information

The "Product Overview Information" is the initial section of the product-level passports and maintains the same structure and content for all product types. It encompasses the following information categories and fields:

- **Product's General Information:** Product name, Registration number, product type category (chosen from a predefined list based on the potential use of the product), and product type (as defined in Section 5.2.2). This number should be the Global Trade Item Number (GTIN) standard from the GS1 organisation. It is a unique identification code assigned by GS1 to products and packaging, to enable worldwide identification and tracking of products.
- **Product's Geometry:** Product's mass, volume, length, width, and height (applicable only for product types 4 and 5).
- **Product's Manufacturer Information:** Manufacturer's logo, name, address, website, contact email, and manufacturing location.
- **Product's Certifications/ Datasheets:** Information regarding certifications and datasheets that document the product's properties and specifications. For each certification/datasheet, the following details should be provided: name, type (chosen from a predefined list), description explaining the information documented in the certification/datasheet, and expiration date (if applicable).
- **Product's Price:** Product's price, unit that has been costed, and guarantee information.
- **Product's Expected Maintenance Information:** Expected lifespan of the product, expected percentage of the product's mass to be replaced annually, and maintenance guidance.
- **Product's Packaging Circularity Performance:** Recycled content of the packaging material and recycling rate at the end-of-life.

Additionally, the "Product Overview Information" section of the product-level passports includes the following information, some of which can be automatically derived through a MPs software by aggregating data from the "Product Details Information" section:

- **Product's Circularity Overview:** Information about the product's overall recycled content, presence of a take-back scheme, reuse potential, materials' separability (if applicable), and end-of-life management.
- **Product's Carbon Overview:** Documentation of the carbon datasheet type, declared unit, manufacturing carbon (A1-A3), sequestered carbon, use stage carbon (B1-B3), and end-of-life carbon (C1-C4).
- **Product's Composition Overview:** Overview of the number of materials and product elements that compose the product, as well as the bill of materials. This information should be automatically calculated through data aggregation provided in the "Product Details Information" section.
- **Product's Performance Overview:** Overview of the functional performance of the product, which is dependent on the product type category and potentially the material(s) that compose the product. This section will be further developed as part of the Materials Passports Protocol.

For more details about the information categories and fields recorded in the "Product Overview Information," please refer to [Appendix 0](#).

7.7.2 Product Details Information

The structure and content of the "Product Details Information" varies depending on the product type.

Product Types 1-4

The "Product Details Information" section for product types 1-4 comprises the material documentation information, corresponding with the Material-Level Passport. Product types 1-4 can be composed of multiple materials, in which case documentation should be provided for each material. The material documentation section in the product-level passports includes the same information categories as the Material-Level Passports, which are detailed in chapter 7.1. These categories include material type, manufacturer information, certifications/datasheets information, material geometry information, material-related circularity information, carbon information, and material's properties. Further details can be found in chapter 7.1. In cases where a product consists of only one material, certain information fields in the material documentation section and the "Product Overview Information" section have identical content. Therefore, these fields can be recorded only once. [Figure 21](#) illustrates the structure and content of the product-level passports for product types 1-4. The example shown in the illustration is a product type 1 consisting of one material. The greyed-out icons indicate the information categories that can be automatically populated from the material documentation section. [Table 5](#) provides a list of the information fields from both sections that coincide when a product is composed of a single material.

The product-level passport for product type 2 documents the exact same information as product type 1, with the only differentiation being the inclusion of material geometry information. As explained in Chapter 7.1 for product type 1, only the Material's density needs to be recorded. For product type 2, both density and the module's dimensions should be recorded. For product type 3, density and standardised dimensions of the sub-component are recorded. The product-level passport for product type 4 includes the same information as product types 1-3, with the additional inclusion of product geometry information.

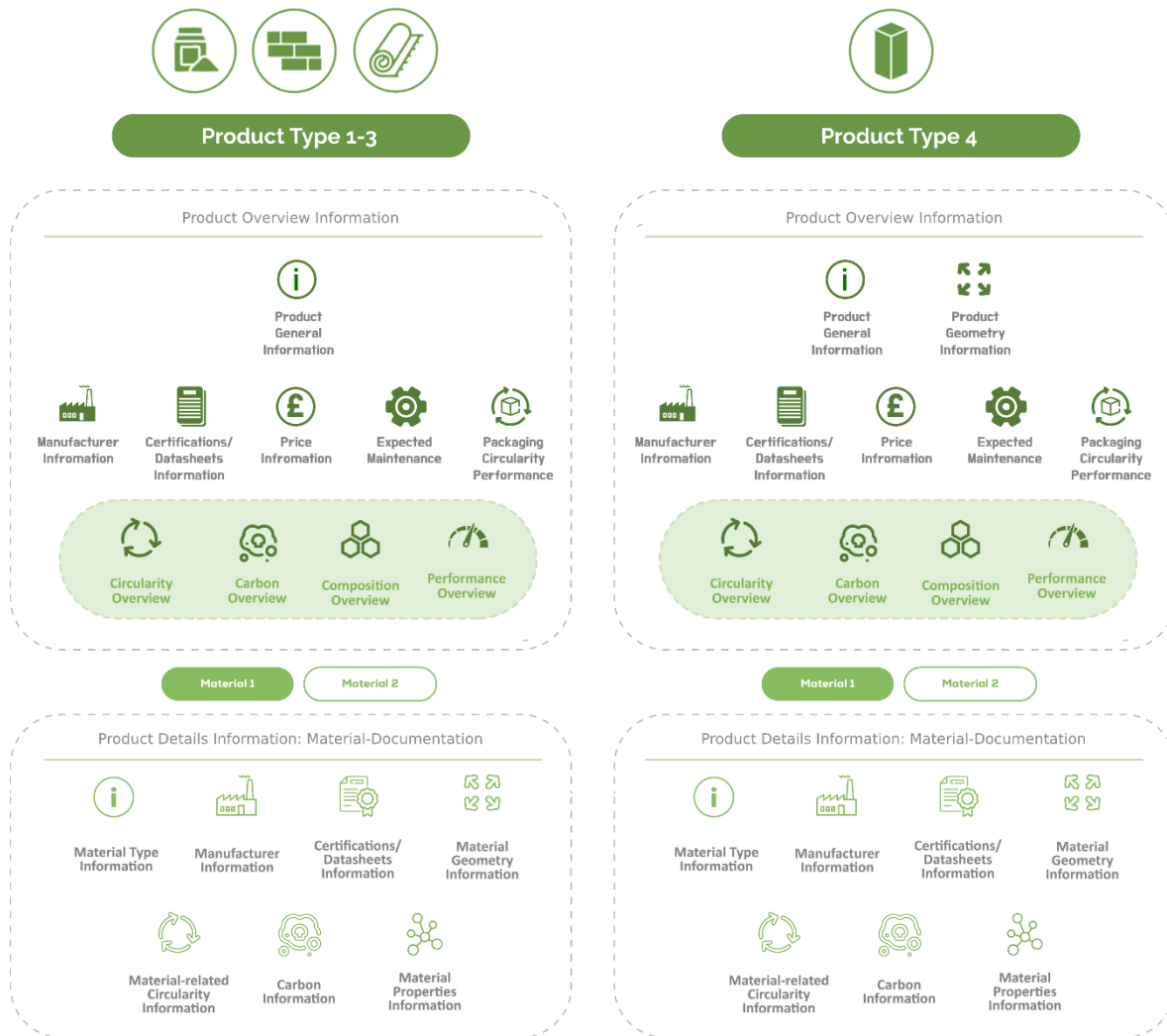


Figure 21. Illustrative overview of the structure and content of the product-level passports for the product types 1-4.

Table 5. List of the information fields in the “Product Overview Information” and material-related section with the same content when a product is composed of a single material.

Information fields with the same content when a Product is composed of one Material	
Product Overview Information	Material-Documentation Section
Product’s Manufacturer Information	Material’s Manufacturer Information
Product’s Certifications/ Datasheets Information	Material’s Certifications/ Datasheets Information
Product’s Circularity Overview	Material-related Circularity Information
Product’s Carbon Overview	Material-related Carbon Information
Product’s Performance Overview	Material Properties Information

Product Types 5- (Removable) Grouped Components

The content and structure of the "Product Details Information" section for products type 5 vary depending on the chosen documentation method. It can include documentation for the product elements or only for the material(s) used in the product.

Similar to the documentation of buildings' grouped components, there are two methods to document products type 5: (removable) grouped components. These methods are as follows:

- **Simplified method:** This method involves documenting the materials that form the product, but not the product components that compose it. In the simplified method, the "Product Details Information" section of products type 5: (removable) grouped components only includes material documentation. The material documentation section contains the same information as detailed in the previous section.
- **Detailed method:** This method involves documenting the product components that compose the product, along with their materials. Applying the detailed method, the "Product Details Information" of products classified as type 5 includes both product elements documentation and material(s) documentation. The product component documentation follows the same structure and content as the product-level passport for products type 4.

Products Type 5- Parent Grouped Components

The documentation of the products-parent grouped components follows the same principles as for the products type 5-grouped components. There are two identified methods to document the products type 5-parent grouped components, as follows:

- **Simplified method:** Documenting the product-removable grouped components that compose the product parent grouped component using the simplified documentation method, including the products type 4 (where applicable).
- **Mixed method:** Documenting the product-removable grouped components that compose the product type 5: parent grouped component using both the simplified method and detailed methods. In this method, certain product type 5: removable grouped components can be documented using the detailed method, while others can be documented using the simplified documentation method. This method also includes the products type 4 (where applicable).
- **Detailed method:** Documenting all the product-removable grouped components that compose the product type 5: parent grouped component using the detailed documentation method, including the products type 4 (where applicable).

The Materials Passports Protocol will provide clarity on when each method should be selected for both products type 5: (removable) grouped components and parent grouped components.

Figure 22 and **Figure 23** show the structure of the different types of product-level passports for product types 5.

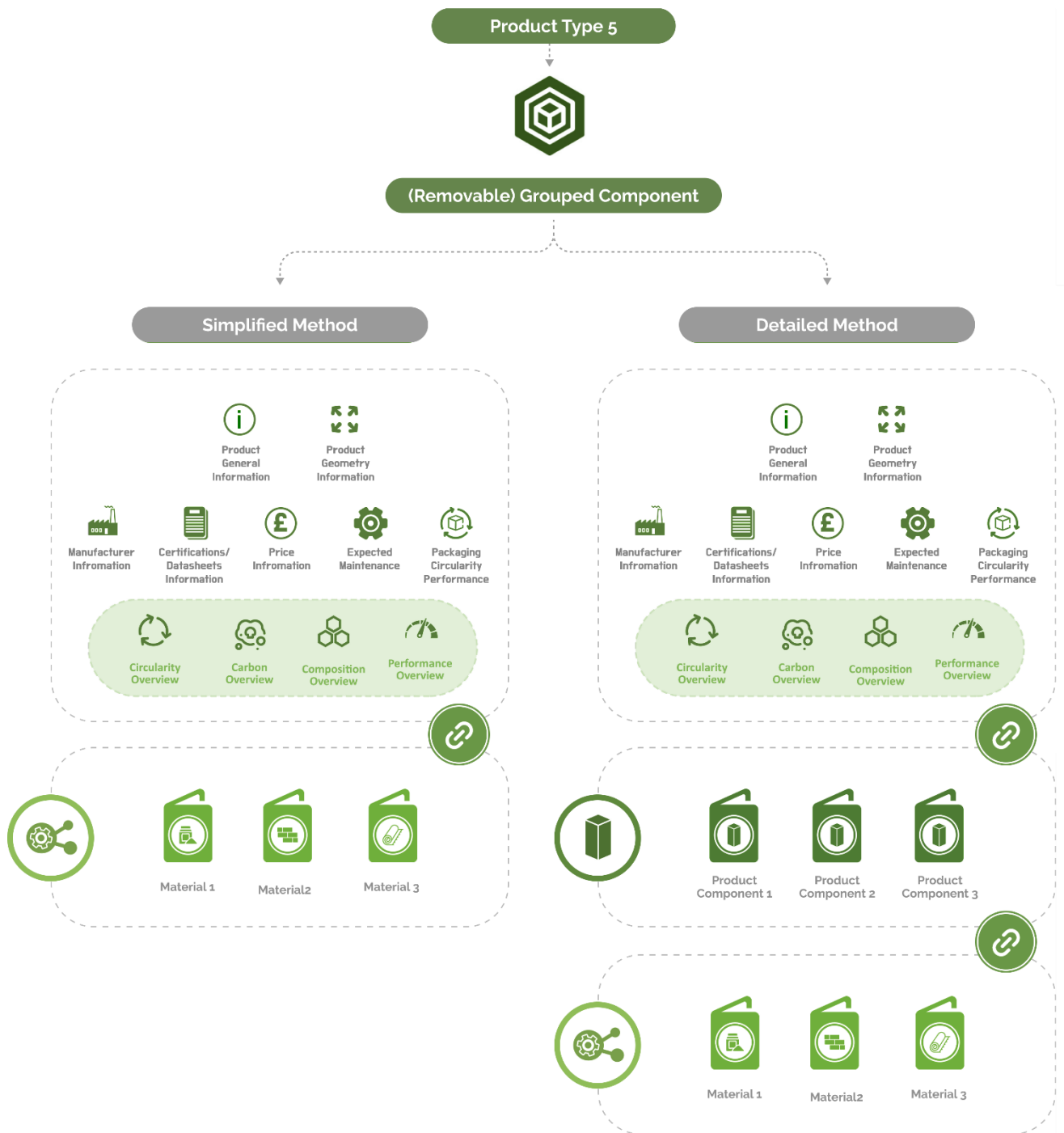


Figure 22. Overview of the structure and content of the product-level passports for the products type 5-(removable) grouped components following the simplified (left) and detailed (right) documentation method.

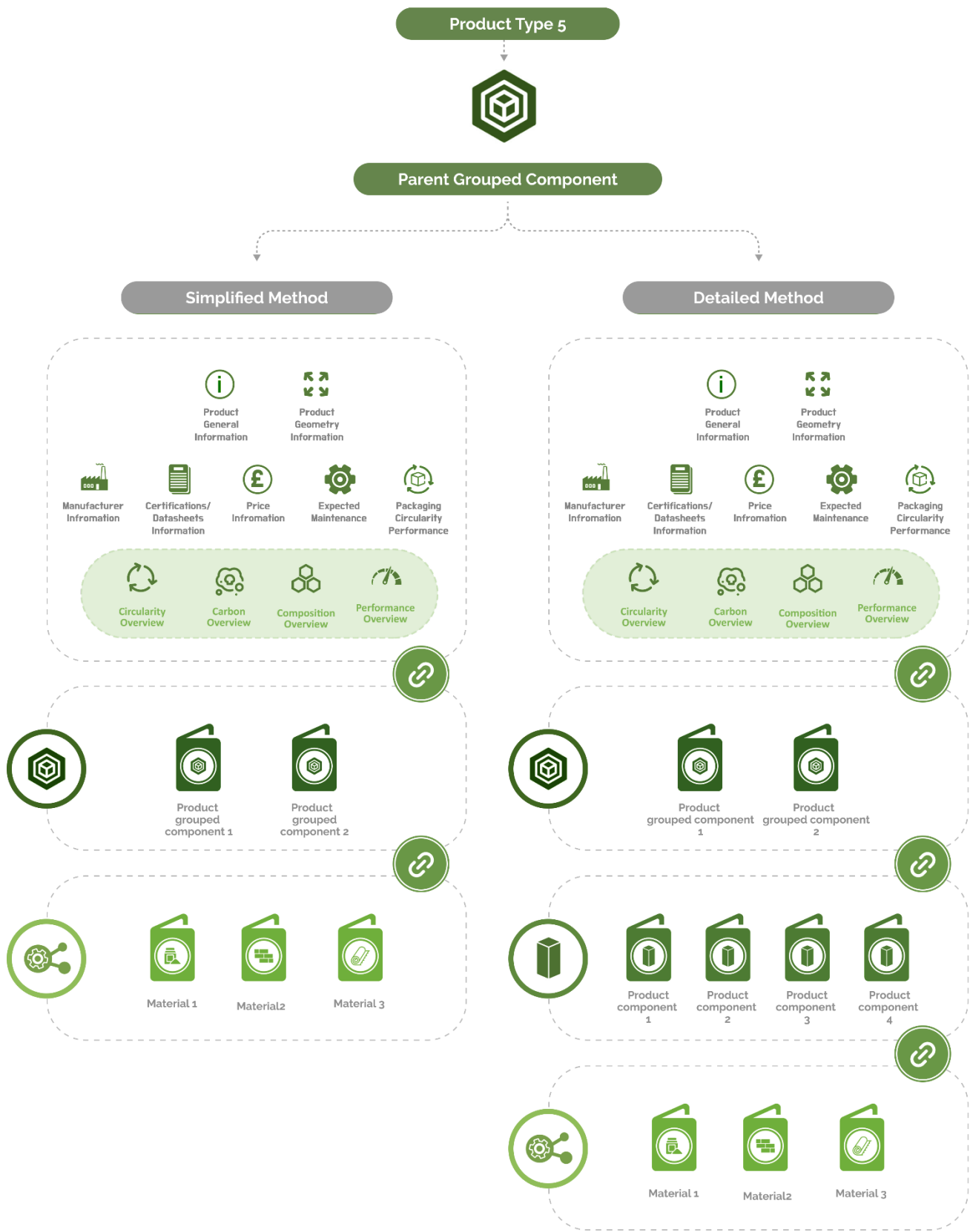


Figure 23. Overview of the structure and content of the product-level passports for the products type 5-parent grouped components following the simplified (left) and detailed (right) documentation method.

8. Materials Passports Data Structure

8.1 Buildings

The data in buildings' MPs follows a hierarchical structure, where higher-level MPs (elemental-, building-, complex-, and area-level passports) are obtained by aggregating data from lower-level MPs (material-, component-, and grouped component-level). The data presented at higher levels is generated by filtering and manipulating data from lower levels (raw data). A clear data structure is essential to ensure consistent and efficient data management, including data manipulation for the generation of information for the higher-level MPs.

Establishing a clear and efficient data structure for the buildings' MPs has been a crucial milestone in this framework as it lays the foundation for a standardised approach to collecting and manipulating data for the Materials Stock across the industry. This ensures the data is well-organised, easily accessible, and readily available for analysis and decision-making.

The following list summarises the key pillars of the proposed data structure for buildings' MPs data:

- The raw data is organised in three levels: material-, component-, and grouped component-level.
- The data for component- and grouped component-levels are always accompanied by material-level data.
- The component- and grouped component-level data record information for the same information categories, which are design-related, manufacturing-related, and construction-related information.
- The components and grouped components are classified in line with the NRM 1 (New Rules of Measurement), 3rd edition UK.
- A material can be used to compose different components and/or grouped components.
- A component can consist of many materials.
- A grouped component consists of more than one component and can be composed of more than one material.
- There are two types of grouped components (parent grouped component and removable grouped component). This allows parent grouped components to be linked to removable grouped components that need to be replaced throughout the lifecycle of the former.
- A parent grouped component can consist of one or more removable grouped components and components at the same time.
- Each element (parent grouped component, (removable) grouped component and component) and material has its own unique ID.
- The unique ID is used as a key to link data of different Levels.

Figure 24 illustrates the buildings' MPs data structure for the material-, component-, (removable) grouped component- and parent grouped component-level data.

Buildings' Materials Passports-Data Structure

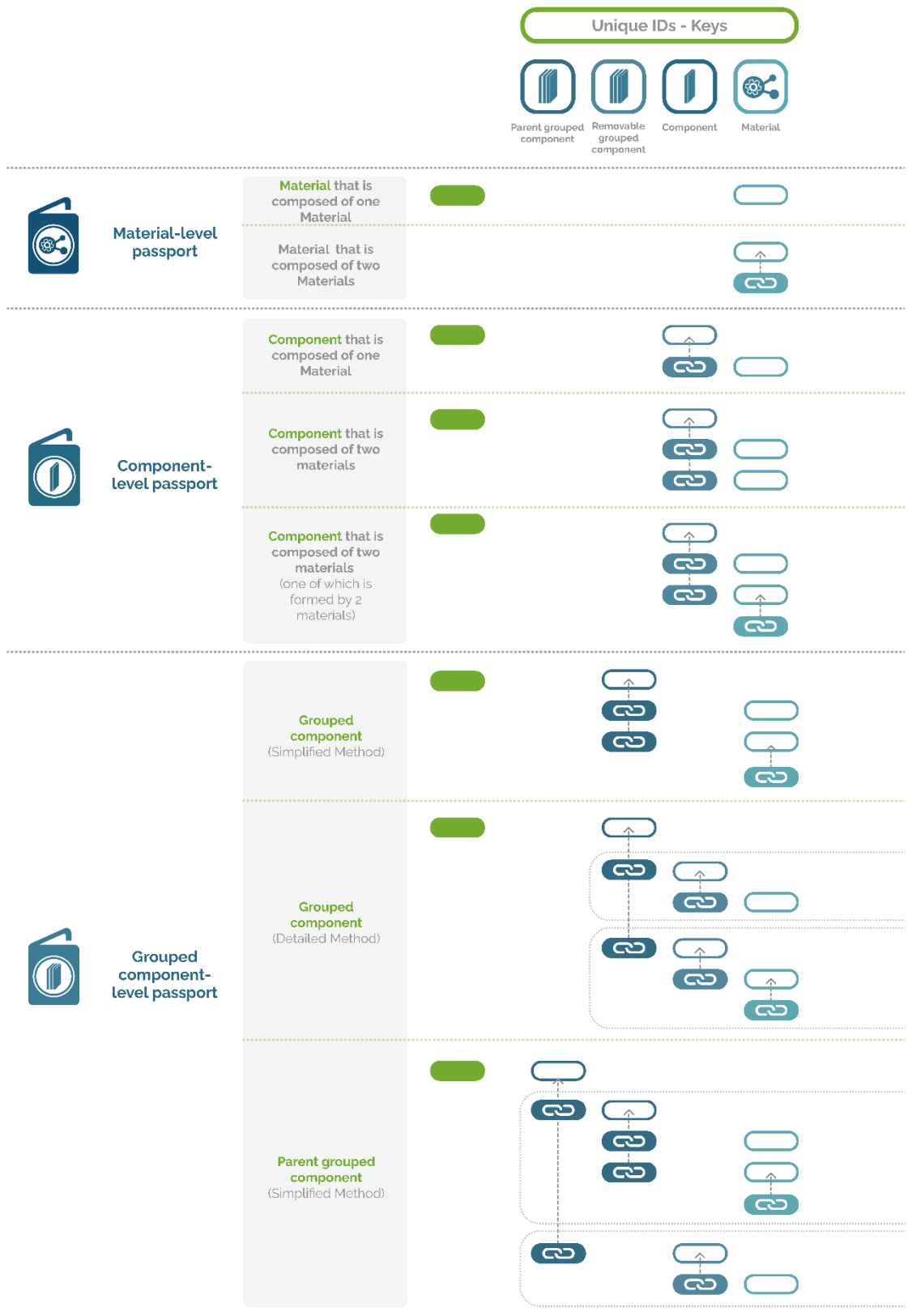


Figure 24. Illustration of the buildings' Materials Passports data structure for buildings.

Component & Grouped-Component Level Information

Material Level Information

Design-related

Manufacturing-related

Construction-related



Component-Level Data

Material-Level Data

Component-Level Data

Material-Level Data

Material-Level Data

Component-Level Data

Material-Level Data

Grouped component-level Data

Material-Level Data

Material-Level Data

Material-Level Data

Material-Level Data

Material-Level Data

Grouped component-level Data

Material-Level Data

Material-Level Data

Material-Level Data

Component-Level Data

Material-Level Data

Component-Level Data

Material-Level Data

Material-Level Data

Parent Grouped component-level Data

Grouped component-level Data

Material Level Passport

Material Level Passport

Material Level Passport

Component-Level Data

Material Level Passport

8.2 Products

The data structure for product-level passports follows the same principles as the buildings' MPs data structure. This enables the automation of transferring data from the product-level passports to the buildings' MPs.

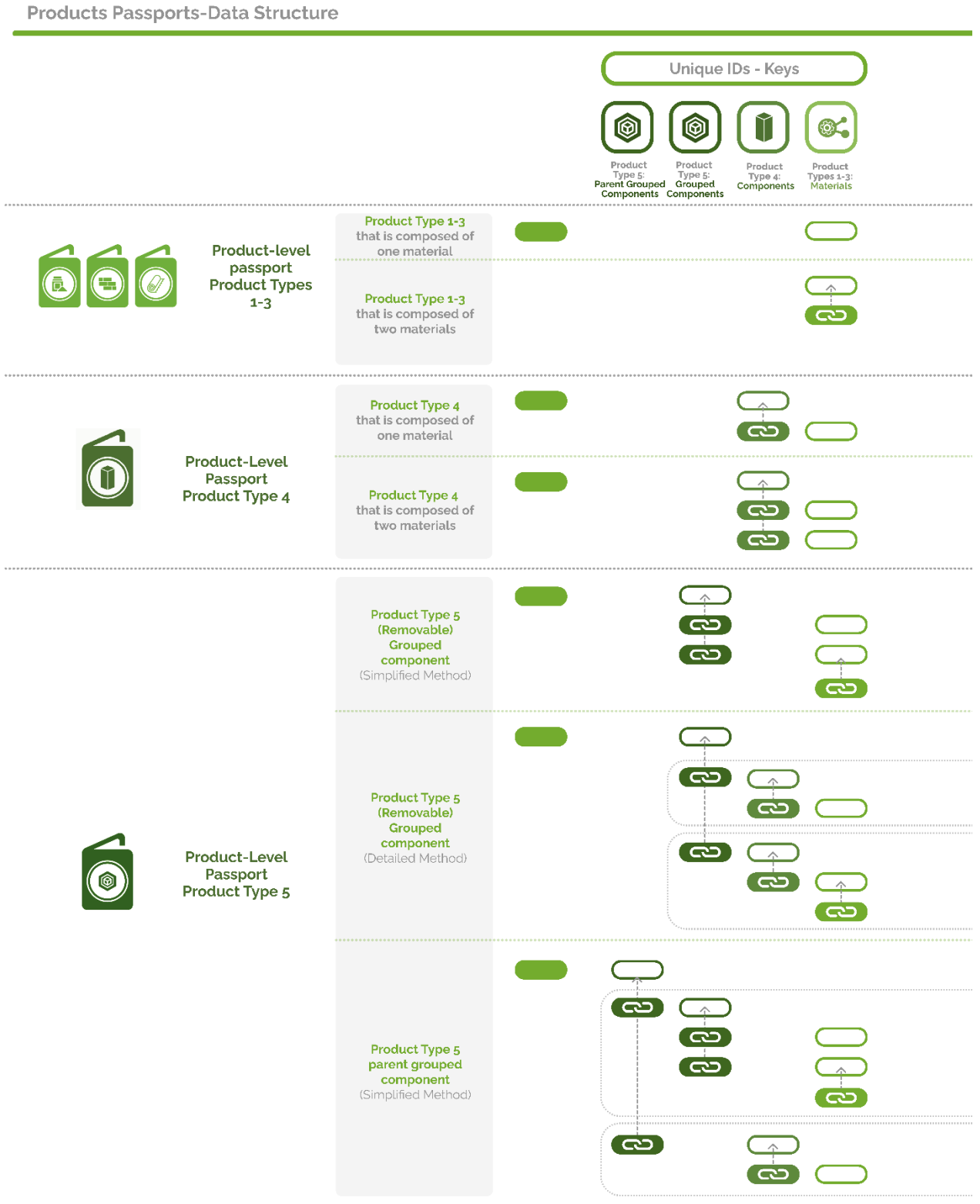
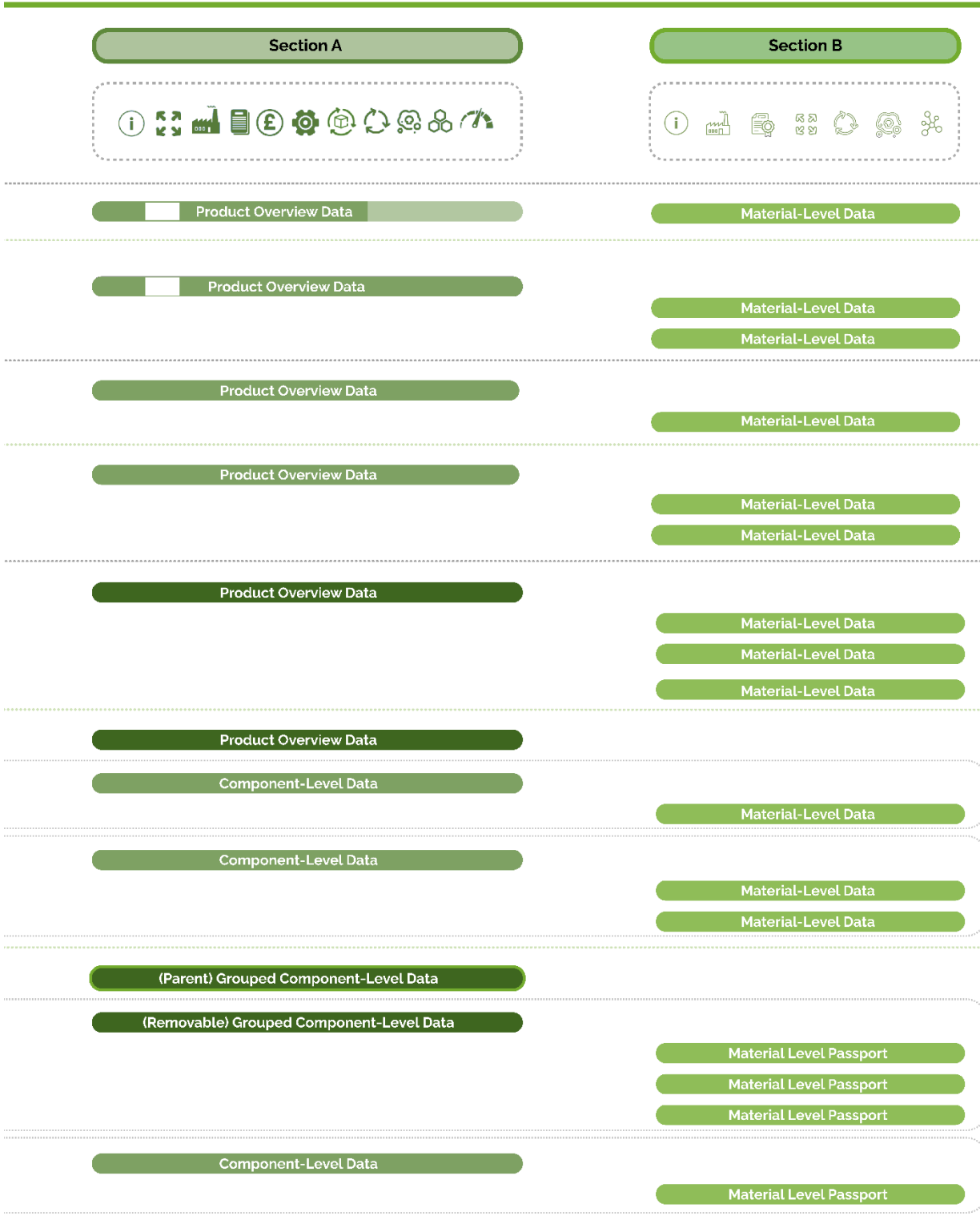
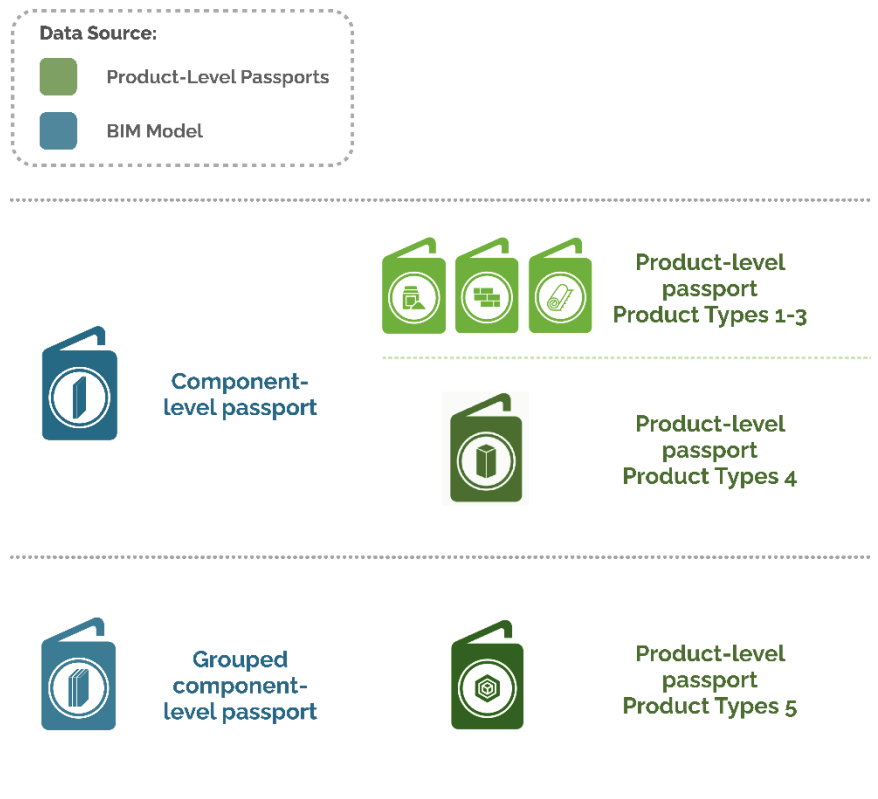


Figure 25. Illustration of the products' Materials Passports data structure.



The following list summarises the key pillars of the proposed data structure for products' MPs data:

- Each product has its own product-level passport number.
- A product-level passport can have different product data levels, depending on the product type.
- There are unique identifiers for each product data level (product type 5: parent grouped component-level, product type 5: (removable) grouped component-level, product type 4: component-level, product types 1-3: material-level).
- The unique identifiers (Unique IDs) are used as keys to link data of different levels.
- The data of the product-level passports are organised into two main sections:
 - **Section A:** Product overview (relevant to all product types)
 - **Section B:** Product components and (removable) grouped component(s) documentation (only relevant to product type 5)
- The Product overview data is always accompanied by material-level data.
- The MPs data for product types 1-4 include the product overview data and material-level data.
- The material-level data can be provided for more than one material (if the product is composed of more than one material).
- The data structure of products type 5: (removable) grouped component depends on the documentation method that is followed:
 - **Simplified method:** The MPs data for product type 5: (removable) grouped component include the product overview data and material-level data.
 - **Detailed method:** The MPs data for product type 5: (removable) grouped component include the product overview data, product components data, and material-level data.



The data structure of products type 5: parent grouped component follows the same principles as for products type 5: (removable) grouped component. **Figure 25** provides an illustration of the product-level passports data structure for product types 1-4 and product type 5, respectively.

8.3 Links between Products and Buildings

Automating and simplifying the process of generating MPs for buildings is essential to prevent human errors and saves time and effort. Linking product-level passports and buildings' MPs can significantly aid in achieving this goal. As part of this framework, establishing a direct connection between the data structures of products and buildings has been a key priority. The ultimate intention is to fully automate the production of buildings' MPs by linking BIM models and product-level passports. This can be accomplished by storing the product-level passports number into BIM objects and linking BIM software to MPs software.

Figure 26 illustrates the information in the buildings' MPs that can be populated from the product-level passports and the information that can be stored in the BIM model. In summary, the manufacturing-related data, including the material-Level data, can be automatically populated from the product-level passports. The design-related and construction-related information can be derived from the BIM models.

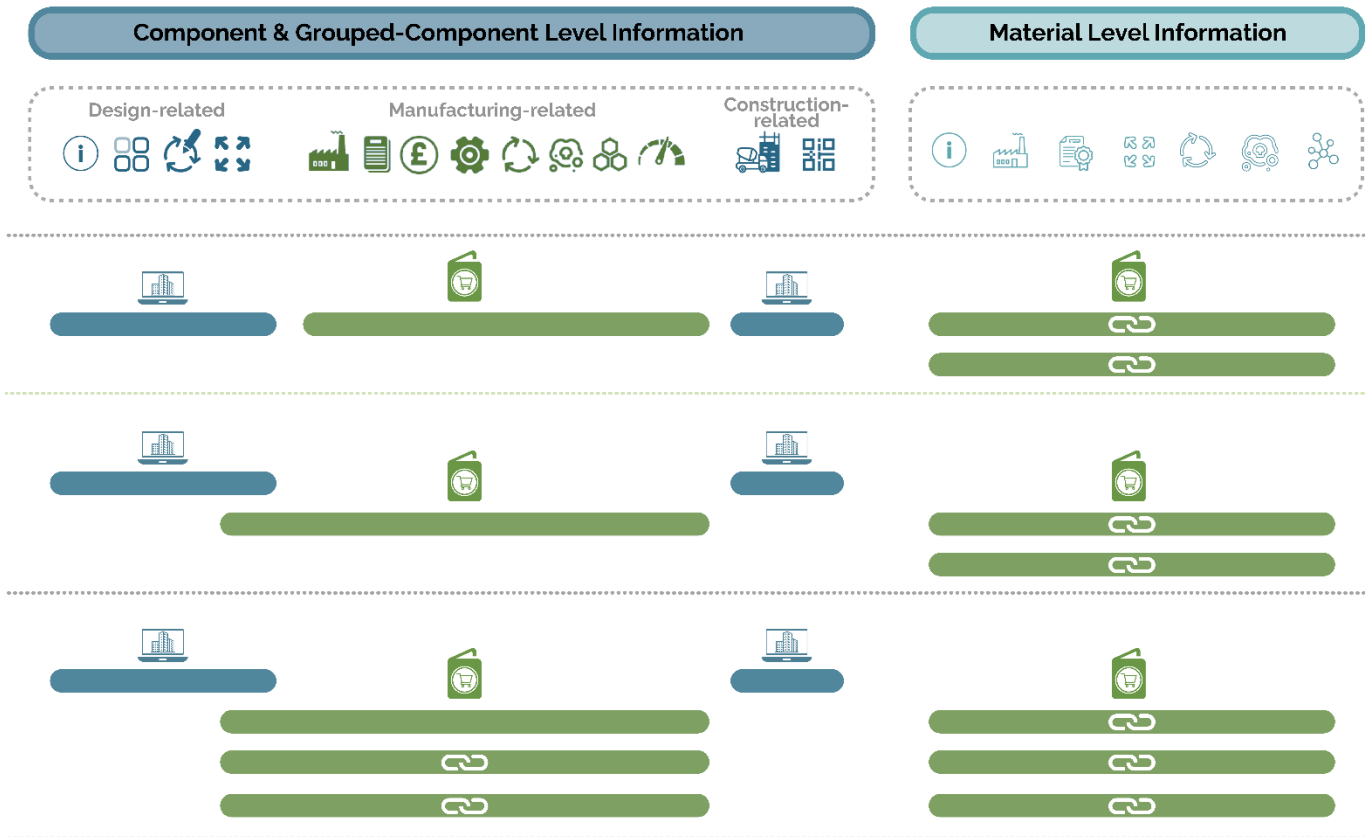


Figure 26. Illustration of the links between the product-level passports and buildings' MPs.

9. Materials Passports and BIM

9.1 What is BIM

There are three common interpretations of the BIM acronym:

- Building Information Model
- Building Information Modelling
- Building Information Management

Building Information Management (BIM) is the foundation of digital transformation in the architecture, engineering and construction (AEC) industry. BIM also stands for Building Information Model and Building Information Modelling which are both important parts of the overall information management and delivery processes. BIM as a model, is a digital representation of the physical and functional characteristics of a building or infrastructure, usually at a single snapshot in time. BIM technology allows architects, engineers, builders, and other construction professionals to spatially coordinate, create and manage information about a building project and can be applied at any point during its lifecycle, from design and construction to operation and maintenance. It allows for an object-oriented approach to modelling building elements and systems by representing them as objects with defined properties, which can be manipulated and combined to create a complete model of the building or infrastructure.

BIM terminology has evolved over the years through the standards that have emerged, and to help readers that may have a vague awareness of BIM, [Appendix H](#) draws from historical definitions of some terms as they help introduce the connections with those in the circular economy discourse. One key term and definition to draw attention to is Asset Information, and the need to define Asset Information Requirements. The relationship between MPs and Information Requirement is effectively synonymous and therefore the BIM process provided in ISO 19650 has a relevance to the implementation of this framework.

9.2 How BIM is linked to Materials Passports Framework

BIM models are a highly effective tool for supporting the production of MPs, due to their ability to provide a comprehensive digital representation of the physical and functional characteristics of objects within a building or infrastructure project. By creating a detailed digital model, BIM allows for the recording of important information for each object, such as its classification, geometry and location in the building, including materials. Additionally, BIM enables the storage of additional information for each object that is crucial for producing MPs, such as design-related circularity information, contractor and data-carrier information, including product-Level Passport numbers. By efficiently linking BIM models and product-level MPs, the process of producing MPs can be automated, saving time and resources while ensuring accurate and up-to-date information.

While BIM models offer numerous benefits, as part of this Framework their use is not recommended for storing all the information related to MPs, but it is proposed in conjunction with specialised MPs software, due to several key factors:

- A BIM model represents objects in one building, allowing for the capture of information for an element and its material(s) for only a key snapshot within a lifecycle. In contrast, MPs software

can collect information from each BIM model that represents the specific element and/or material in different buildings or infrastructure projects, capturing information for its multiple lifecycles.

- Adding extensive information to a BIM model can make it cumbersome and inefficient and a repository for unmaintained data, whereas by storing only limited information within the model and linking it to an external database, the BIM model remains lightweight and agile while the large amount of MPs information is managed in the MPs software.
- MPs software, which is designed for data manipulation and communication, does not require specialised BIM skills and can therefore be easily used by a broad range of stakeholders, in contrast to BIM, which requires specific technical knowledge and expertise.

Overall, utilising BIM models in conjunction with specialised MPs software allows for a more comprehensive and streamlined approach to managing the information needed to create up-to-date and accurate Materials Passports.

9.3 Introduction to Open BIM and IFC

- **Open BIM:** Open BIM is a collaborative approach to BIM that promotes the use of open standards and workflows to facilitate interoperability between different software applications used in the AEC industry. The goal of Open BIM is to improve collaboration and communication among project stakeholders, regardless of the software they use, by enabling the exchange of data in a common format. Open BIM is based on the use of open standards, which are maintained by buildingSMART International, a non-profit organisation that develops and promotes open data standards for the AEC industry.
- **IFC:** IFC (Industry Foundation Classes), which is a key component of Open BIM, is an open data standard for the AEC industry that allows information to be exchanged between different software applications used in the design, construction and operation of buildings and infrastructure. IFC provides a common language for describing building elements and their relationships, allowing for better collaboration and coordination among stakeholders, regardless of the software they use. Its open nature promotes interoperability and innovation within the AEC industry, enabling the development of new software applications and tools that can work with existing ones.
 - **IFC data model:** IFC data model utilises data schemas to define many object and conceptual classes for how data is structured, organised, and exchanged. These data schemas facilitate standardisation in the representation and sharing of data related to infrastructure and building projects, promoting interoperability and enabling data exchange between different software applications and systems. These schemas can be extended to meet the specific requirements of different projects, providing adaptability and flexibility.

9.4 IFC object classes relevant to the key concepts of this Framework

This section provides an overview of IFC object classes which are related to the key concepts and terms of this Framework.

Table 6. Links to IFC object classes which are related to the key concepts and terms of this Framework.

	IFC Object Class When used in a project	IFC Object Class When expressed independent to a project
Products	<u>IfcProduct</u>	<u>IfcTypeProduct</u>
Materials	<u>IfcRelAssociatesMaterial</u>	<u>IfcMaterial</u> <u>IfcRelAssociatesMaterial</u>
Components	<u>IfcElementComponent</u> ¹	<u>IfcElementComponentType</u>
Grouped Components	<u>IfcGroup</u> <u>IfcRelAssignsToGroup</u> <u>IfcRelDecomposes</u>	<u>IfcRelDecomposes</u> <u>IfcRelAssignsToGroup</u>
Parent grouped components	<u>IfcGroup</u> <u>IfcRelAssignsToGroup</u> <u>IfcRelDecomposes</u>	<u>IfcRelDecomposes</u> <u>IfcRelAssignsToGroup</u>
Building	<u>IfcBuilding</u>	

- **IfcProduct:** The definition of [IfcProduct](#) broadly relates well to the definition of a product in this document. It is a general class from which the physical object classes derive irrespective of whether those classes are intended to describe parts of an object or the whole of an object.
- **IfcMaterial:** An [IfcMaterial](#) is defined as a “homogenous or inhomogeneous substance that can be used to form elements (physical products or their components)”. This mean that an [IfcMaterial](#) can include a single material, or more than one. For example, bricks and mortar could be defined as one [IfcMaterial](#) rather than two separate materials (mortar and bricks).

Based on its definition, the [IfcMaterial](#) is formless, however it has the ability to hold properties which could include a dimensional property. Therefore, the distinctions between the Material Types I, II & III introduced in this Framework (Ingredients, Modular, Sub-component) can be applied to the [IfcMaterial](#) definition.

- **IfcRelDecomposes:** It is defined as a relationship class between physical object classes, it “defines the general concept of elements being composed or decomposed.” It is this class that effectively allows for objects to be made up of parts in a parent-child structure. Note: most modelling software doesn’t support this class in their IFC exporter, however, most have some sort of native concept of containing geometry in groups and being able to collate groups.
- **IfcBuildingElement:** Based on the [IfcBuildingElement](#) definition “the building element comprises all elements that are primarily part of the construction of a building, i.e., its structural and space separating system. Building elements are all physically existent and tangible things.”
- **IfcBuilding:** The entity is defined as “a structure that provides shelter for its occupants or contents and stands in one place. The building is also used to provide a basic element within

¹ For the purposes of this document, this reference the object classes covered by the current standard ISO 16739-1:2018, but it should be noted that some of the names of these classes are undergoing revision in the next version and can be browsed at <https://technical.buildingsmart.org/standards/ifc/ifc-schema-specifications/>

the spatial structure hierarchy for the components of a building project (together with site, storey, and space)”).

9.5 Required input for IFC Models

The following table provides an overview of the information that is proposed to be captured in the IFC models for each object:

Table 7. Overview of the information categories that that is proposed to be captured in the IFC models for each object.

Domain	Information Categories Group of Properties ²	information Fields <u>IfcProperty</u>
Design-related	Component Type Information	Component ID Component Type
	Classification	Building element category- Level 1 Building element category- Level 2 Building element category- Level 3 Floor
	Geometry Information	Element Mass Element Volume Element Length Width Height
	Design-related Circularity Information	Design for Disassembly Connection Types Accessibility
Manufacturing-related		Product Passport Number
Construction-related	Contractor Information	Contractor Name
	Data Carrier Information	Data Carrier Type Data Carrier Location Recorded Information

The following table shows the properties that are proposed to be used to for recording information in the Ifc model for each object and their data type. It is proposed that the properties would be a subclass of [IfcProperty](#), but since each BIM software handles this differently, and in some cases don't support the export of these Ifc classes, the general principle is that they are all definable with a subclass of [IfcPropertySingleValue](#) to have the widest potential of implementation across BIM software and their export limitations.

² As defined in ISO 23386

Table 8. Overview of the properties that are proposed to be used to for recording information in the Ifc model for each object and their data type.

Information Fields	Ifc Object Class	Data Type	Input required
Component ID	IfcPropertySingleValue	IfcURIReference	No input is required
Component Type	IfcPropertyEnumeratedValue	IfcLabel	Input is required
Building Element Category-Level 1, Level 2, Level 3	IfcPropertyEnumeratedValue	IfcLabel	No input is required
Floor	IfcPropertySingleValue ³	IfcLabel	No input is required
Element Mass	IfcPropertySingleValue ⁴	IfcMassMeasure	Input is required
Element Volume	IfcPropertySingleValue ⁵	IfcVolumeMeasure	No input is required
Element Length	IfcPropertySingleValue ⁵	IfcLengthMeasure	No input is required
Element Width	IfcPropertySingleValue ⁵	IfcLengthMeasure	No input is required
Element Height	IfcPropertySingleValue ⁵	IfcLengthMeasure	No input is required
Design for Disassembly	IfcPropertySingleValue	IfcLabel	Input is required
Connection Types	IfcPropertySingleValue ⁵	IfcText	Input is required
Accessibility	IfcPropertySingleValue	IfcText	Input is required
Product Passport Number	IfcPropertySingleValue	IfcLabel	Input is required
Contractor Name	IfcPropertySingleValue	IfcLabel	Input is required
Data Carrier Type	IfcPropertyEnumeratedValue	IfcLabel	Input is required
Data Carrier Location	IfcPropertySingleValue	IfcText	Input is required
Recorded Information	IfcPropertySingleValue	IfcText	Input is required

Table 8 has been devised with consideration to both the Ifc schema and the capabilities of current exporters in outputting these properties. In most software implementations, only the most generic parts of the schema are supported. For example, all the properties at the very least could be exportable as an [IfcProperty](#) and each software has its own implementation of a feature that allows extensibility of properties and object classes within its own native data structure.

Table 9 below illustrates a few of the [IFC certified software](#).

³ Potentially exchangeable derived from the relationship [IfcRelContainedInSpatialStructure](#) or directly written to an IfcProperty

⁴ Potentially exchangeable within predefined [QuantitySets](#) for the relevant object class

⁵ Potentially obtainable from the relationship [IfcRelConnectsWithRealizingElements](#) where software supports the use of this class however in most cases this class is not modelled or exported so a direct IfcProperty would be more widely achievable by most software.

Table 9. Overview of IFC certified software.

Software	Object Class extension Feature	End user Configuration Format	Property Extension Feature	End user Configuration format
Revit	NA (not extensible)		Shared Parameters	Text file tab delimited
ArchiCad	Ifc Project Manager	XML file	Ifc Project Manager	XML file
	Classification Manager	XML file	Property Manager	XML file
Rhino	NA (not extensible)		User Text	CSV file
Sketchup	Classification Manager	XSD/SKC file	Classification Manager	XSD/SKC file
			Dynamic Component	No configuration file
Microstation	NA (not extensible)		Item Types	Valid Excel file

9.6 IFC Strategy: Materials Passports Model View Definition

A model view definition is a tailored view of the whole model filtered to specific conditions. Due to the varying nature of the software implementations, this document has not sought to provide each configuration file for the definitions listed in **Table 8**. A further development of this framework should look to expand on this and provide the full detail that would aid implementation. The benefit of doing this is so that everything about the property definition is identical. For example, then spelling of the property name, its data type, its GUID which is required by some software to register it against objects. It is recommended therefore that the properties in this framework are developed into a full data dictionary definition in accordance with ISO 23386 and data templates for the levels (material, component, grouped component, and building) are developed to ISO 23387 and adopt RFC 4122 Method 5 for the generation of each GUID.

9.7 Considerations for BIM software that allow the production of MPs

Different BIM software has different limitations in terms of supporting the modelling of materials, the different levels identified in this framework (components, grouped components etc.), programmable interfaces etc. Therefore, it is important to have a flexible and extensible system that can link to other specialised software to overcome limitations and achieve the desired scope. Key characteristics that are essential for the choice of software for the production of MPs include the extensibility for properties at the various object levels and support for exchange to open structured formats.

The following section provides an overview of characteristics to assess a selected software's capability to support the MPs production in line with this framework. The selected BIM software should:

- Allow the organisation of information in line with the levels described in this framework (products, materials, components, grouped components, and parent grouped components).
- Have extensible classifications.
- Provide ways of handling mappings between its own modelling classifications and industry recognised classification systems at all levels in ISO 12006-2:2015.
- Allow the modelling and exchange of materials and properties on materials.

- Form unique identifiers for each object in the model.
- Have extensible object properties model.
- Allow for the exchanging of [IfcRelDecomposes](#) for where it provides its own native nested grouping feature.

Suggested BIM software for the production of MPs are listed on [BuildingSmart's](#) IFC certified software however particular attention should be made as to how well it exports the information and be extended to support MP specific information.

10. Materials Passports Implementation Process

Producing MPs for a building can be a complex task due to the large amount of information that needs to be documented and managed, as well as the increased number of stakeholders involved in providing the required information throughout the lifecycle of a material.

Figure 27 illustrates the different stakeholders responsible for providing information for MPs during the various stages of a material's lifecycle:

- The **manufacturing stage** is documented by the **Manufacturers** (product-level passport).
- The **construction stage** is documented by the **Principal Contractors** (component-level passport/grouped component-level passport).
- The **use stage** is documented by the **Facility Manager** (component-level passport/grouped component-level passport).
- The **deconstruction stage** is documented by the **Deconstruction/Strip out Contractor** (Reused product-level passport).
- The **end-of-life stage** is documented by the **Waste Contractor** (component-level passport/grouped component-level passport).



Figure 27. Overview of the Stakeholders that document the Lifecycle Material Passport.

Standardisation is essential for the successful implementation of MPs. With a large volume of information to manage and multiple stakeholders to coordinate, a clear and standardised framework is necessary to ensure clarity in the process. This framework should outline the requirements, roles, responsibilities, and timelines.

This document aims to provide the initial step of this standardised framework, which will be further developed through engagement with the wider industry. The previous chapters have provided clarity on the information recorded within the different levels of MPs. This chapter, however, focuses on providing clarity on the process, requirements, roles, responsibilities, and timescales for implementing MPs during the RIBA Stages 2 to 6.

10.1 New Components

Figure 28 provides an overview of the required steps for the production of MPs for new components from RIBA Stages 2 to 6, along with the responsible parties for each step:

1. Project Team Coordination
2. Production of Employers Requirements Specification Document for MPs
3. Collection of the required information
4. Production of MPs Model
5. MPs Model Ownership
6. MPs verification

The following sections provide clarity on the content and required actions at each step.

Project Team Coordination

Initially, it is crucial for the project team to coordinate and identify the scope of works for MPs in each project between RIBA Stages 2-3. It is recommended that all key members of the project team get involved at this step. However, the critical stakeholders are the Building Developer, Project Manager, the Sustainability Consultant and the core Design-team. The scope of works definition includes:

- **Type of MPs that will be recorded:** Depending on the type of project, there may be different types of components in the building, such as new, reused, or existing elements.
- **In Scope building element categories:** It is highly recommended to record all building element categories, but if there are limitations in terms of cost and time, it is essential to identify which building element categories will be recorded through MPs.
- **In Scope materials/Systems:** Similar to the building element categories, it is suggested to document all materials and systems in the building through MPs. If it is not feasible, specific materials/systems can be identified for recording with MPs. It is suggested to prioritise materials/systems that can be disassembled, easily reused, and have high embodied carbon.
- **BIM Model:** Agreement on the production of an as-built model in a software that allows the export of the model as an IFC file.
- **MPs ownership:** It is recommended to develop a strategy at this step for MPs ownership and data updates.

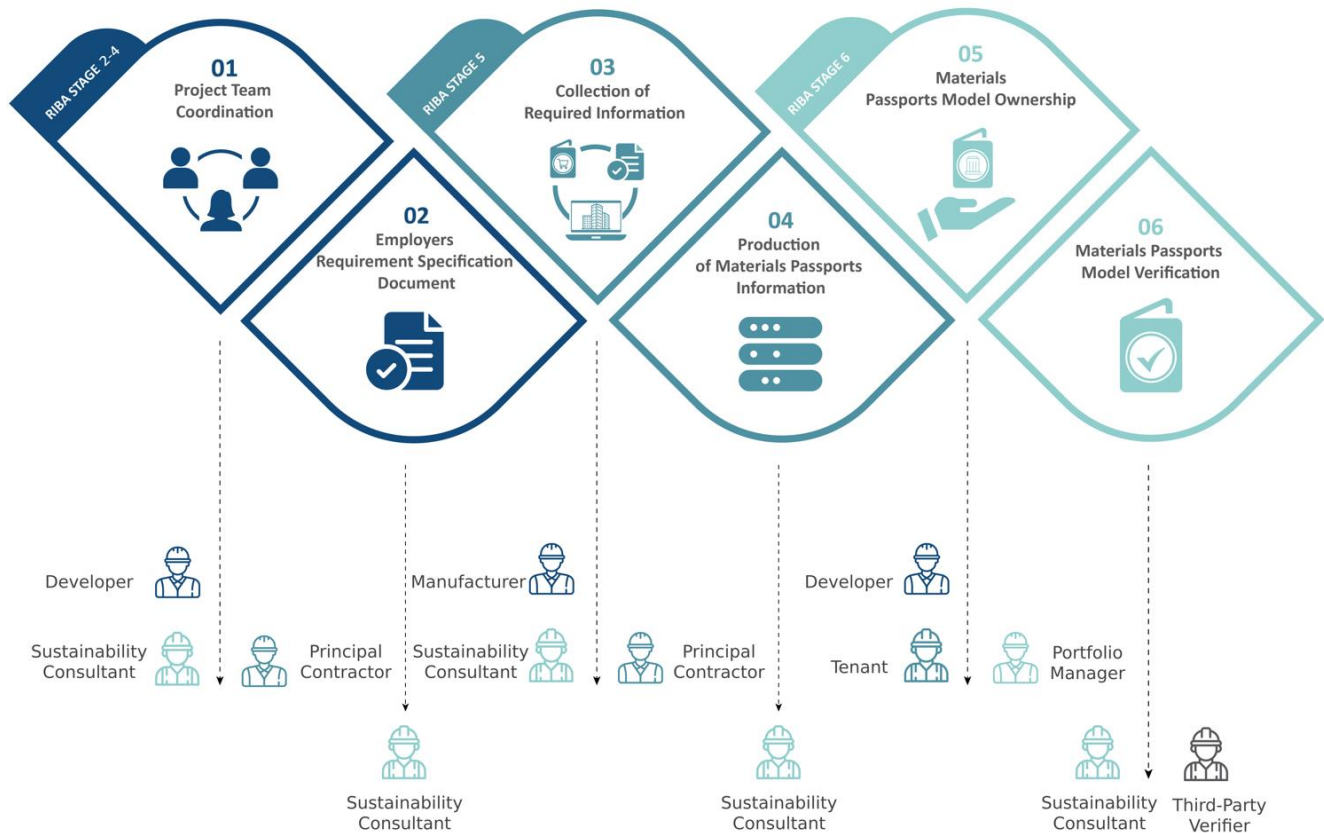


Figure 28. Overview of the Suggested Steps for the Materials Passports Implementation Process.

Employer’s Requirements Specifications Document

Following team coordination, it is suggested that, prior to the appointment of the Principal Contractor the Sustainability Consultant produces an Employer's Requirements Specifications Document for MPs. This document should define the requirements for the Principal Contractor regarding MPs. The document can include:

- Agreed Scope of Works for MPs.
- Description of the information required from the Principal Contractor.
- Description of the information required from the manufacturers and subcontractors.
- Clarification of the format for the required information.
- Specifications for data carriers.
- Specifications for the as-built BIM model.
- Timescales.
- Coordination framework between the Principal Contractor and Sustainability Consultant.

After the Principal Contractor is appointed, they will be responsible for incorporating the relevant requirements into the contracts with the manufacturers and subcontractors.

Collection of the Required Information

To collect the necessary information for the production of MPs for new components, the following steps should be followed:

- **Manufacturers** and **subcontractors** should provide **Product-level passports** for their products in the format specified by the Sustainability Consultant in the Employer's Requirements Specification Document.
- During the **construction stage** (RIBA Stage 5), the **Principal Contractor** is responsible for:
 - Adding the MPs Requirements into their Employer's Requirements Specification Document, which will be provided to the subcontractors.
 - Collecting the product-level passports from the manufacturers/subcontractors.
 - Producing the as-built BIM model for the project.
 - Adding the product-level passport numbers and additional required information into the 3D model.
 - Collecting any remaining required supporting evidence.
 - Completing the MPs Excel Template.
 - Submitting the above to the Sustainability Consultant in parts, following the Construction Program and timescales detailed in the Employer's Requirements Specification Document.
- During the **construction stage** (RIBA Stage 5) and **post-construction** (RIBA Stage 6), the **Sustainability Consultant** is responsible for:
 - Ensuring the collection of information from the Principal Contractor.
 - Reviewing the information submitted by the Principal Contractor.
 - Conducting Quality Assurance of the overall information.

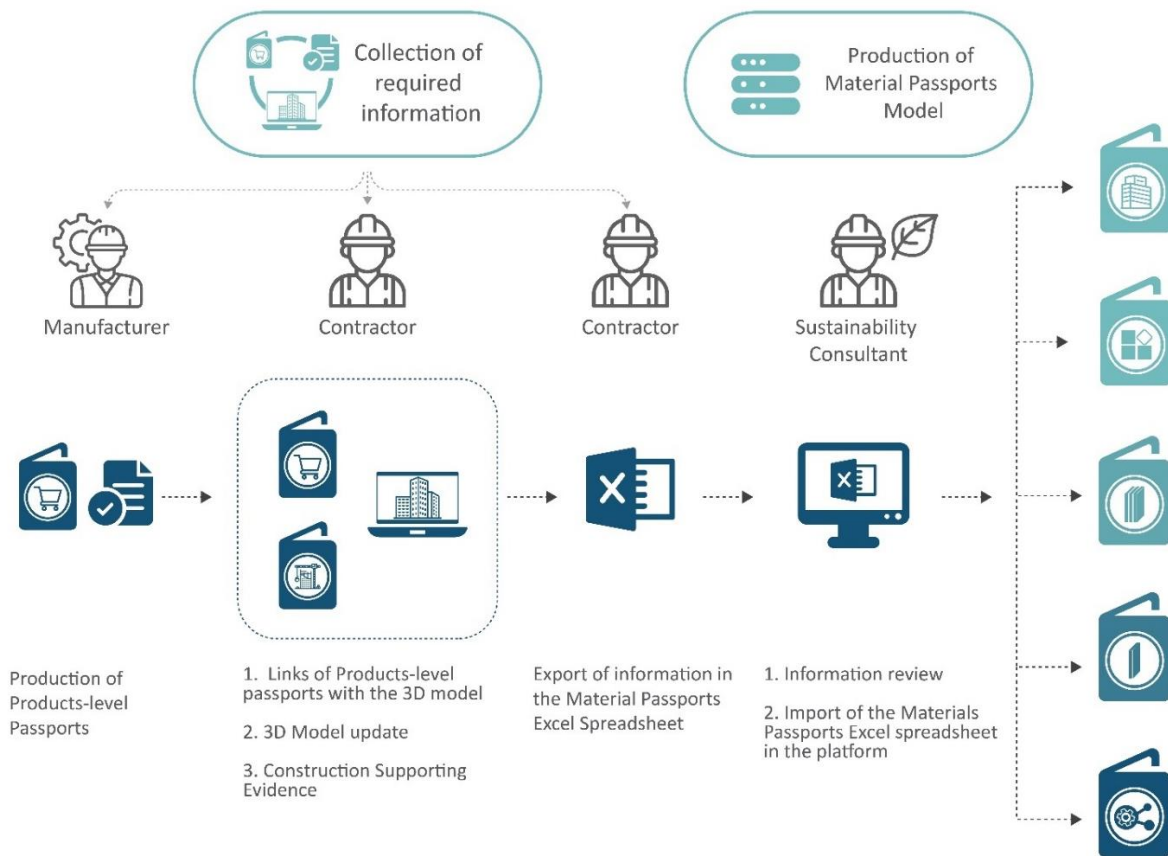


Figure 29. Illustration of the key steps and roles involved in collecting the required information and producing the MPs Model.

Production of Materials Passports Model

The project's Sustainability Consultant should be responsible for producing the MPs for the building using an MPs Platform. The MPs Model can be created by importing the necessary information into the MPs Platform.

It is suggested that the MPs Model is developed incrementally, in parallel with the Construction Program. To manage the increased amount of data and its complexity, it is proposed to import a limited amount of information at a time. For example, information for a specific material or building element category can be imported into the MPs Platform. This approach allows for better data control and minimises the risk of errors.

Materials Passport Model Ownership

After completing the MPs Model, it is crucial to determine the ownership of the MPs. The MPs Owner is responsible for updating the information on MPs throughout the building and materials' lifecycle, including maintenance and replacement. The ownership of MPs can be transferred to different parties at various stages of the materials' lifecycle.

Materials Passport Model Verification

Third-party mechanisms are considered vital for the implementation of MPs. It is proposed that once an MPs Model is completed, it should undergo verification by a third-party. This independent quality assurance and verification process will ensure the validity and robustness of the data. After the verification process, the data can be stored in a centralised database, enabling the production of area-level passports and the UK Materials Stock Database.

10.2 Existing Elements

The documentation of existing elements in buildings serves various purposes, including:

1. Conducting pre-redevelopment audits to understand and evaluate the existing resources in a building.
2. Documenting all materials in a building (existing and added) as part of a refurbishment project, including estimating and demonstrating carbon savings.
3. Documenting the existing materials stock in the built environment to facilitate the creation of benchmarks.

There are two methods for creating MPs for existing elements, the simplified method and the detailed method.

Simplified Method

The simplified method involves recording the existing materials in the building, to provide an overview of the material types, classification, quantities and condition. This approach is suggested as part of the pre-redevelopment audits to understand and evaluate the existing resources in a building. It enables the identification of materials and elements with high reuse potential and the elements that have reached their end of life.

The steps involved in the simplified method are as follows:

- Search available resources (building files, Operation and Maintenance Manual, etc.) to collect information on available materials.
- Conduct surveys to identify the types and quantities of materials present in the building.
- Undertake surveys to assess the condition of the existing materials.
- Produce the bill of materials for the key building element categories (substructure, superstructure, internal finishes, FF&E) for key types of materials including their condition.

Detailed Method

This method involves recording the existing elements in the building in addition to materials. It includes recording element classification, geometry, certificates, condition, as well as material types and properties. The detailed method should be followed to identify elements that can be reused on-site or off-site. The steps involved in the detailed method are as follows:

- Initially, follow the same steps as for the simplified method.
- Create a 3D model of the existing building.
- Create material-level passports.
- Link the 3D model with the material-level passports.
- Link the 3D model with the MPs software (via an MPs software plugin) or complete the MPs Excel Template.

Appendix E provides clarity on the information that should be recorded for existing elements. The methodology for producing MPs for existing elements will be further developed as part of the Materials Passports Protocol.

It is suggested that the elements and materials with high reuse potential are documented with the detailed method while the elements that have been identified as not reusable are documented with the simplified method. **Figure 30** shows the proposed MPs strategy and output in line with the Waste Hierarchy.

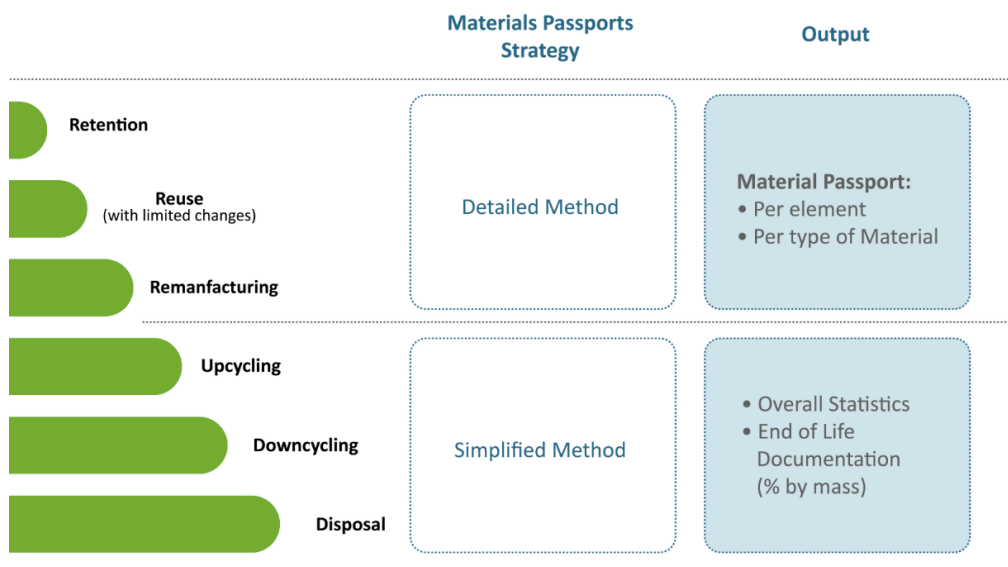


Figure 30. Materials Passports Strategy for Existing Elements Diagram.

It is proposed that elements with high reuse potential are documented through 3D Model. The 3D model will enable the documentation of geometry, location and classification of each element and the production of unique IDs for each of them. All the elements with the same material will have the same documentation in terms of material type, properties etc, but with key differences in terms of classification, location, and condition. The elements with high-reuse potential can be grouped based on their type of material, condition and dimensions. This can support the process of cataloguing them and distributing them for reuse, storage, or remanufacturing.

10.3 Reused Elements

Currently, there is no consistent and standardised approach for producing MPs for reused elements, which poses several challenges:

- **Inconsistent data:** Reused materials can come from various sources and may have incomplete or inconsistent information regarding their composition and history.
- **Limited availability of data:** Information about the properties and specifications of reused materials may not be readily available, and it can be challenging to identify the geometry of each individual element.
- **Time-consuming process:** Automating the process is difficult, resulting in increased manual work, longer processing times, and the potential for human error.
- **Lack of standardised format:** There is currently no standardised format for recording the type of information that needs to be documented and the required format.

To address these challenges, it is recommended to document any materials or elements identified for reuse before they are deconstructed from their original building. This documentation process can help avoid inconsistent data, gather information about the materials' specifications from the building's operation and maintenance manual or other relevant sources, and record the geometry of the elements using the building's drawings, 3D models, or technologies like 3D scanning. Additionally, this process allows for the identification of the elements' residual value.

The following steps are proposed for generating MPs for reused materials and elements:

1. Produce **MPs for the existing elements** while they are still in-situ in their original building (as detailed in section 10.2). These MPs should capture as much manufacturing-related information as material-level passports for the existing elements, including their age and condition.
2. Create **unique identifiers**, such as serial numbers or barcodes, for the elements that will be reused. These identifiers can be scanned to access the elements' information.
3. **Label the elements** with their unique identifier.
4. **Update the MPs** for the existing elements pre-construction to document any **re-manufacturing** process that may occur.
5. Generate a **BIM model** of the development in which the elements will be **reused**. The model should include the unique identifiers of the existing elements, linking them to the BIM objects and the existing elements' MPs (Steps 1 and 4). Additionally, the BIM model should incorporate the design-related and construction-related information for the elements' new lifecycle, as detailed in chapters 7.2.1 and 7.2.3.
6. Combine the **information from the existing elements' MPs and the BIM model** to produce the MPs

for the reused elements. This information can be documented in the MPs Excel Template for the development in which the elements are/will be reused or by linking the BIM models with the MPs software using an MPs software plugin.

Appendix E provides clarity on the information that should be recorded for the reused elements. The methodology for producing MPs for reused elements will be further developed as part of the Materials Passports Protocol.

The below figure visualises the different types of MPs depending on when they are being produced throughout the life cycle of an element or material, including different studies in which they can be incorporated.

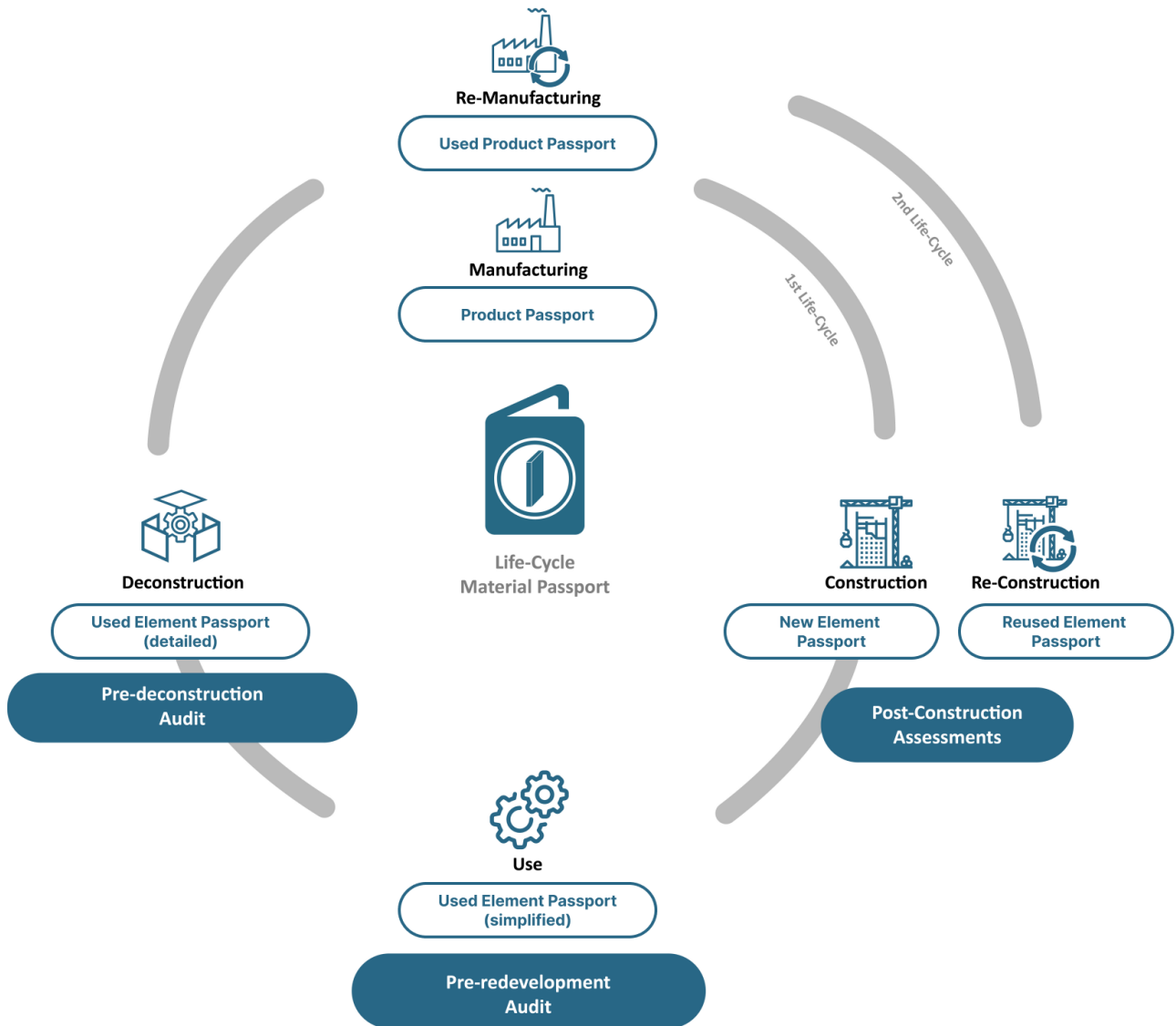


Figure 31. Types of Material Passports depending on when they are being produced.

11. Next Steps

MPs have a huge potential to help tackle the climate emergency. This document aims to be an initial step towards formulating a standardised framework protocol. This section details the next steps that are considered critical for the full adoption of MPs across the built environment, all with the aim of kick-starting a thriving circular economy:

- **Industry Engagement:** This document will be presented to various industry bodies to initiate a dialogue and foster industry engagement. As part of this process, different stakeholders, such as academia, designers, consultants, contractors, developers, asset managers, manufacturers, agents, councils, policy makers, and other relevant organisations, will be invited to share their comments, feedback, experience, insights, and requirements. This collaborative approach will ensure that the final Materials Passports Protocol meets the needs of all stakeholders.
- **Development of Materials Passports Protocol:** Following industry engagement, a Materials Passports Protocol needs to be developed which can build upon the framework that this document has introduced and cover areas that are not developed in this document, such as definition of:
 - The information that should be captured for materials and elements for the use stage, Deconstruction, Remanufacturing and end-of-life;
 - Materials' Properties that need to be recorded per type of material and elements' functional performance that needs to be documented per building element category;
 - The required documentation method for grouped components per building element category and for products type 5 of different product type categories;
 - Detailed links of BIM objects and MPs per building element category.

The Materials Passports Protocol should set up a standardised approach for the production and lifecycle management of MPs for buildings and infrastructure.

- **Examples and Case Studies:** Examples and Case Studies should be developed to demonstrate how MPs can be produced for different types of products, materials and elements:
 - **Products:** examples of product-level passports for each product type (1-5)
 - **Materials:** examples of Material-Level Passports for certain key types of materials such as concrete, steel, aluminium, glass, brick.
 - **Elements:** examples of component-level and grouped component-level passports for typical Elements per building element category, which can be grouped in three main Categories:
 - **Structural Elements:** substructure, frame, upper floors and roof structure;
 - **Architectural Elements:** external walls and windows, roof covering, internal walls, partitions and doors, finishes and external works; and
 - **Building Services Elements:** main heating, cooling and ventilation systems, water and electrical installations.
- **Buildings' MPs Case Study- Edenica:** Waterman has pioneered the implementation of MPs on this project, introducing and applying a methodology for MPs production which forms the basis of this document. Edenica successfully demonstrated that this methodology can be applied to

other projects, making it a proof of concept. The Edenica Case Study will provide a detailed account of how MPs are being implemented on the project, which can serve as a guide for other teams looking to produce MPs for other projects. The goal of this Case Study is to offer a practical example of how the framework outlined in the document can be applied effectively in a project setting.

- **MPs software:** Release of MPs software which allow the production of MPs in line with the Materials Passports Protocol, that demonstrate the automation of production of MPs for buildings.
- **Links with Disassembly Manuals:** Establishment of a standardised methodology for the production of disassembly manuals which can be directly linked with MPs.
- **MPs Policy Requirement Roadmap:** In collaboration with Policy Makers, a roadmap should be established for the introduction of policy requirements for the production of Materials Passports for products and buildings. An indicative roadmap is provided in **Figure 32**.

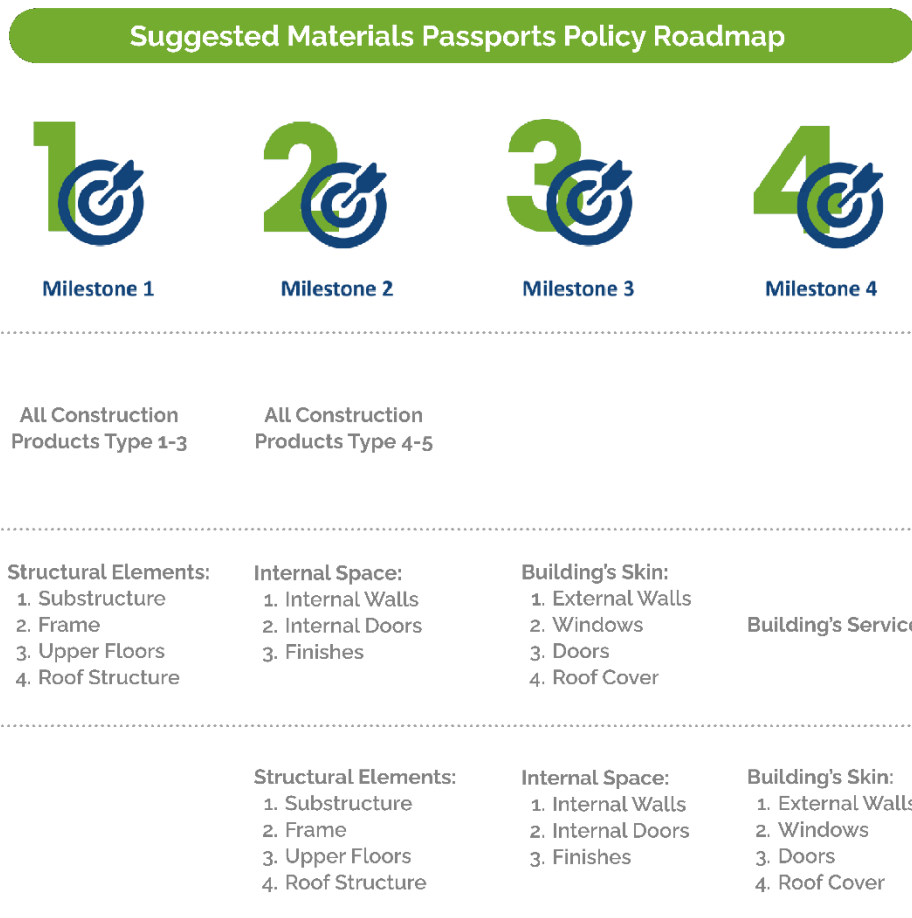


Figure 32. Proposed Policy Requirements Roadmap for Materials Passports.

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13. Appendices

A. RICS NRM classification system

Building Element Categories		
Level 1	Level 2	Level 3
0 Facilitating works	0.1 Toxic/hazardous/contaminated material treatment	0.1.1 Toxic or hazardous material removal
		0.1.2 Contaminated land
		0.1.3 Eradication of plant growth
	0.2 Major demolition works	0.2.1 Demolition works
		0.2.2 Soft strip works
	0.3 Temporary support for adjacent structures	0.3.1 Temporary support for adjacent structures
	0.4 Specialist groundworks	0.4.1 Site dewatering and pumping
		0.4.2 Soil stabilisation measures
		0.4.3 Ground gas venting measures
	0.5 Temporary diversion works	0.5.1 Temporary diversion works
	0.6 Extraordinary site investigation works	0.6.1 Archaeological investigation
		0.6.2 Reptile/wildlife harm mitigation measures
		0.6.3 Other extraordinary site investigation works
1 Substructure	1.1 Substructure	1.1.1 Standard foundations
		1.1.2 Specialist foundations
		1.1.3 Lowest floor construction
		1.1.4 Basement excavation
2 Superstructure	2.1 Frame	2.1.1 Steel frames
		2.1.2 Space frames/decks
		2.1.3 Concrete casings for steel frames
		2.1.4 Concrete frames
		2.1.5 Timber frames
		2.1.6 Specialist frames
	2.2 Upper floors	2.2.1 Floors
		2.2.2 Balconies
		2.2.3 Drainage for balconies
	2.3 Roof	2.3.1 Roof structure
		2.3.2 Roof coverings
		2.3.3 Specialist roof systems
		2.3.4 Roof drainage
		2.3.5 Roof lights, skylights and openings
		2.3.6 Roof features
	2.4 Stairs and ramps	2.4.1 Stair/ramp structures
		2.4.2 Stair/ramp finishes
		2.4.3 Stair/ramp balustrades and handrails

		2.4.4 Ladders/chutes/slides
	2.5 External walls	2.5.1 External enclosing walls above ground level
		2.5.2 External enclosing walls below ground level
		2.5.3 Solar/rain screening
		2.5.4 External soffits
		2.5.5 Subsidiary walls, balustrades and proprietary balconies
		2.5.6 Facade access/cleaning systems
	2.6 Windows and external doors	2.6.1 External windows
		2.6.2 External doors
	2.7 Internal walls and partitions	2.7.1 Walls and partitions
		2.7.2 Balustrades and handrails
		2.7.3 Moveable room dividers
		2.7.4 Cubicles
	2.8 Internal doors	2.8.1 Internal doors
3 Internal finishes	3.1 Wall finishes	3.1.1 Wall finishes
	3.2 Floor finishes	3.2.1 Finishes to floors
		3.2.2 Raised access floors
	3.3 Ceiling finishes	3.3.1 Finishes to ceilings
		3.3.2 False ceilings
		3.3.3 Demountable suspended ceilings
4 Fittings, furnishings and equipment	4.1 Fittings, furnishings and equipment	4.1.1 General fittings, furnishings and equipment
		4.1.2 Domestic kitchen fittings and equipment
		4.1.3 Special-purpose fittings, furnishings and equipment
		4.1.4 Signs/notices
		4.1.5 Works of art
		4.1.6 Non-mechanical and non-electrical equipment
		4.1.7 Internal planting
		4.1.8 Bird and vermin control
5 Services	5.1 Sanitary installations	5.1.1 Sanitary appliances
		5.1.2 Sanitary ancillaries
	5.2 Services equipment	5.2.1 Services equipment
	5.3 Disposal installations	5.3.1 Foul drainage above ground
		5.3.2 Chemical, toxic and industrial liquid waste drainage
		5.3.3 Refuse disposal
	5.4 Water installations	5.4.1 Mains water supply
		5.4.2 Cold water distribution
		5.4.3 Hot water distribution
		5.4.4 Local hot water distribution
		5.4.5 Steam and condensate distribution
	5.5 Heat source	5.5.1 Heat source
		5.6.1 Central heating systems

	5.6 Space heating and air conditioning systems	5.6.2 Local heating systems
		5.6.3 Central cooling systems
		5.6.4 Local cooling systems
		5.6.5 Central heating and cooling systems
		5.6.6 Local heating and cooling systems
		5.6.7 Central air conditioning systems
		5.6.8 Local air conditioning systems
	5.7 Ventilation systems	5.7.1 Central ventilation systems
		5.7.2 Local and special ventilation systems
		5.7.3 Smoke extraction/control systems
	5.8 Electrical installations	5.8.1 Electrical mains and sub-mains distribution
		5.8.2 Power installations
		5.8.3 Lighting installations
		5.8.4 Specialist lighting installations
		5.8.5 Local electricity generation systems
		5.8.6 Earthing and bonding systems
	5.9 Fuel installations	5.9.1 Fuel storage
		5.9.2 Fuel distribution systems
	5.10 Lift and conveyor installations	5.10.1 Lifts and enclosed hoists
5.10.2 Escalators		
5.10.3 Moving pavements		
5.10.4 Powered stairlifts		
5.10.5 Conveyors		
5.10.6 Dock levellers and scissor lifts		
5.10.7 Cranes and unenclosed hoists		
5.10.8 Car lifts, car stacking systems, turntables, etc.		
5.10.9 Document handling systems		
5.10.10 Other lift and conveyor installations		
5.11 Fire and lightning protection	5.11.1 Firefighting systems	
	5.11.2 Fire suppression systems	
	5.11.3 Lightning protection	
5.12 Communication, security and control systems	5.12.1 Communication systems	
	5.12.2 Security systems	
	5.12.3 Central control/building management systems	
5.13 Specialist installations	5.13.1 Specialist piped supply installations	
	5.13.2 Specialist refrigeration systems	
	5.13.3 Specialist mechanical installations	
	5.13.4 Specialist electrical/electronic installations	
	5.13.5 Water features	

	5.14 Builder's work in connection with services	5.14.1 Builder's work in connection with services
6 Prefabricated buildings and building units	6.1 Prefabricated buildings and building units	6.1.1 Complete buildings
		6.1.2 Building units
		6.1.3 Pods
7 Work to existing buildings	7.1 Minor demolition and alteration works	7.1.1 Minor demolition and alteration works
	7.2 Repairs to existing services	7.2.1 Repairs to existing services
	7.3 Damp-proof courses/fungus and beetle eradication	7.3.1 Damp-proof courses
		7.3.2 Fungus/beetle eradication
	7.4 Facade retention	7.4.1 Facade retention
	7.5 Cleaning existing surfaces	7.5.1 Cleaning
		7.5.2 Protective coatings
	7.6 Renovation works	7.6.1 Masonry repairs
		7.6.2 Concrete repairs
		7.6.3 Metal repairs
7.6.4 Timber repairs		
7.6.5 Plastics repairs		
8 External works	8.1 Site preparation works	8.1.1 Site clearance
		8.1.2 Preparatory groundworks
	8.2 Roads, paths, pavings and surfacings	8.2.1 Roads, paths and pavings
		8.2.2 Special surfacings and pavings
	8.3 Soft landscaping, planting and irrigation systems	8.3.1 Seeding and turfing
		8.3.2 External planting
		8.3.3 Irrigation systems
	8.4 Fencing, railings and walls	8.4.1 Fencing and railings
		8.4.2 Walls and screens
		8.4.3 Retaining walls
		8.4.4 Barriers and guardrails
	8.5 External fixtures	8.5.1 Site/street furniture and equipment
		8.5.2 Ornamental features
	8.6 External drainage	8.6.1 Surface water and foul water drainage
		8.6.2 Ancillary drainage systems
8.6.3 External chemical, toxic and industrial liquid waste drainage		
8.6.4 Land drainage		

B. Material-level passport

It is recommended that material-level passports are mandatory for elements composed of up to three materials. For elements comprising more than three materials, a bill of materials can be generated to

illustrate the mass percentage contribution of each material, as part of the component-/ grouped component-level passport.

Material-level passport						
Property Name	Description	Dependent on	Response Type	Unit	Input Validity	Priority Level
Material-Type Information						
Material Photo	File that shows a photo of the material	N/A	Image	N/A	N/A	Optional
Product Registration Number	Global Trade Item Number (GTIN) standard from the GS1 organisation	N/A	Number	N/A	Existing GTIN	Optional
Material Type-Level 1	Selection of the material type – level 1 from pre-defined list	N/A	Text	N/A	Materials Types List	Required
Material Type-Level 2	Selection of the material type – level 2 from pre-defined list	Material Type- Level 1	Text	N/A	Materials Types List	Required
Manufacturer Information						
Manufacturer Name	Name of the manufacturer company	N/A	Text	N/A	N/A	Required
Manufacturer Address	Address of the manufacturer company	N/A	Text	N/A	Valid address	Optional
Manufacturing Address	Address of the manufacturing location (factory) of the manufacturer company	N/A	Text	N/A	Valid address	Required
Manufacturer Website	Link of the website of the manufacturer company	N/A	Text and number	N/A	Valid link	Optional
Manufacturer Contact e-mail	Contact e-mail of the manufacturer company	N/A	Text	N/A	N/A	Optional
Material Certification/ Datasheet Information						
For each certification/ datasheet:						
Certificate/ Datasheet Name	Title of the document (Certificate/ Datasheet)	File of certificate	Text	N/A		Required
Certificate/ Datasheet Type	Selection of the certificate type from a list with different options of certificate types	Certificate Name	Text	N/A	Certificate Types List	Required
Certificate/ Datasheet Description	High level description of the key information that is provided within the Certificate/ Datasheet	Certificate Name	Text	N/A	N/A	Optional
Certificate/ Datasheet Expiration Date	Recording of the Certificate/ Datasheet expiration date (where applicable)	Certificate Name	Date	N/A	Date after the date of the input	Optional
Material Geometry Information						
Material Density	Reporting the material density in kg/m ³	N/A	Number	Kg/m ³	Positive number	Required
Material Length	Varies depending on the material category (see chapter 7.1)					

Material-level passport						
Property Name	Description	Dependent on	Response Type	Unit	Input Validity	Priority Level
Material Width						
Material Height						
Material-related Circularity Information						
Expected Lifespan	How many years the material can be used before it begins to degrade or fail?	N/A	Number	Years	Positive number	Required
Recycled Content (% by mass)	What is the percentage of the mass of the material that contains recycled material?	N/A	Number	%	0-100	Required
Take-Back Scheme	Does the manufacturer support a take-back scheme (Yes/ No)?	N/A	Text	N/A	List: Yes, No	Required
Reuse Potential	Can the material be reused (Yes/ No) ?	N/A	Text	N/A	List: Yes, No	Required
Separability	(Applicable when there are more than one materials that consist an element) Can the material be separated from the other materials that form the element (Yes/ No)?	Number of Materials that make up an Element	Text	N/A	List: Yes, No	Required (when applicable)
% by mass Recycling	What is the percentage of the mass of the material that is anticipated to be recycled at the end of material's life?	N/A	Number (0-100)	%	0-100	Required
% by mass Downcycling	What is the percentage of the mass of the material that is anticipated to be downcycled at the end of material's life?	N/A	Number (0-100)	%	0-100	Required
% by mass Energy Recovery	What is the percentage of the mass of the material that is anticipated to be used for energy recovery at the end of material's life?	N/A	Number (0-100)	%	0-100	Required
% by mass Landfill	What is the percentage of the mass of the material that is anticipated to be sent to landfill at the end of material's life?	N/A	Number (0-100)	%	0-100	Required
Carbon Information						
Carbon Datasheet Type	Selection of the carbon datasheet type that has been used to provide information for the material's carbon performance.	N/A	Text	N/A	List: EPD, Product-Specific LCA Study, Other	Required

Material-level passport						
Property Name	Description	Dependent on	Response Type	Unit	Input Validity	Priority Level
Declared Unit	What is the functional unit that has been used for defining material's carbon performance?	N/A	Text	N/A	N/A	Required
Manufacturing Carbon (A1-3)	What is the manufacturing carbon (A1-A3) of the material for the selected functional unit in kgCO ₂ eq?	N/A	Number	kgCO ₂ eq/ Declared Unit	Positive Number	Required
Sequestered Carbon	If applicable, what is the sequestered carbon of the material for the selected functional unit in kgCO ₂ eq?	N/A	Number	kgCO ₂ eq/ Declared Unit	Negative Number	Optional
Use Stage Carbon (B1-B3)	If applicable, what is the use stage carbon (B1-B3) of the material for the selected functional unit in kgCO ₂ eq?	N/A	Number	kgCO ₂ eq/ Declared Unit	Positive Number	Optional
End-of-Life Carbon (C1-C4)	What is the end-of-life carbon (C1-C4) of the material for the selected functional unit in kgCO ₂ eq?	N/A	Number	kgCO ₂ eq/ Declared Unit	Positive Number	Optional
Material Properties						
Optical Properties	To be defined at the Materials Passports Protocol.					
Structural Properties						
Thermal Properties						
Acoustic Properties						
Material Health						
Fire Resistance						

C. Component-level passport

1. DESIGN-RELATED INFORMATION

Component-level passport						
Design-related Information						
Property Name	Description	Dependent on	Response Type	Unit	Input Validity	Priority Level
Component Type Information						
Component ID	Unique ID of the component in the building. If there is a 3D model this ID should be derived from the 3D Model	3D Model (if applicable)	Number or/ and Text	N/A	N/A	Optional (if there is not a 3D model)
Component Photo/ Visualisation	File that shows a photo of the component or 3D visualisation from the model	Name of the File of Component Photo/ Visualisation	Image	N/A	N/A	Optional
Component Type	Definition of the component type	N/A	Text	N/A	List: New component, Reused component, Existing component, To be demolished	Required
Component Classification						
Building Element Category- Level 1	Building element classification in line with the New Rules of Measurement - Group Element	N/A	Number and Text	N/A	Building Element Category- Level 1 (Appendix A)	Optional
Building Element Category- Level 2	Building element classification in line with the New Rules of Measurement - Element	Building Element Category- Level 1	Number and Text	N/A	Building Element Category- Level 2 (Appendix A)	Optional
Building Element Category- Level 3	Building Element Classification in line with the New Rules of Measurement - Sub-Element	Building Element Category- Level 2	Number and Text	N/A	Building Element Category- Level 3 (Appendix A)	Required
Floor	Floor that the component is located on	Number of floors of the building	Number	N/A	Number of floors of the building	Optional
Component Geometry Information						
Component Mass	Overall mass of the component	N/A	Number	tonnes	Positive number	Required
Component Volume	Overall volume of the component	N/A	Number	m ³	Positive number	Required
Component Length	Overall length of the component	N/A	Number	m	Positive number	Required

Component Width	Overall width of the component	N/A	Number	m	Positive number	Required
Component Height	Overall height of the component	N/A	Number	m	Positive number	Required
Component Design-related Circularity Information						
Design for Disassembly	Information if the component can be disassembled from its adjacent components (Yes/ No response)	N/A	Text	N/A	List: Yes, No	Required
Connection Types	Type of connection with bearing component.	N/A	Text	N/A	List: Glued, Welded, Mechanical.	Required
Accessibility	Information for the accessibility to the connections	N/A	Text	N/A	List: Directly accessible connection, Hidden Connection Layer(s) to be removed – no damages, Layer(s) to be removed-damages, Not accessible connection.	Required

2. MANUFACTURING-RELATED INFORMATION

Component-level passport						
Manufacturing-related Information						
Property Name	Description	Dependent on	Response Type	Unit	Input Validity	Priority Level
Component Manufacturer Information						
Manufacturer Name	Name of the manufacturer company	N/A	Text	N/A	N/A	Required
Manufacturer Address	Address of the manufacturer company	N/A	Text	N/A	Valid address	Optional
Manufacturing Address	Address of the manufacturing location (factory) of the manufacturer company	N/A	Text	N/A	Valid address	Required
Manufacturer Website	Link of the website of the manufacturer company	N/A	Text and number	N/A	Valid link	Optional
Manufacturer Contact e-mail	Contact e-mail of the manufacturer company	N/A	Text	N/A	N/A	Optional
Component Certification/ Datasheet Information						
For each certification/ datasheet:						
Certificate/ Datasheet Name	Title of the document (Certificate/ Datasheet)	File of certificate	Text	N/A		Required
Certificate/ Datasheet Type	Selection of the certificate type from a list with different options of certificate types	Certificate Name	Text	N/A	Certificate Types List	Required

Component-level passport						
Manufacturing-related Information						
Property Name	Description	Dependent on	Response Type	Unit	Input Validity	Priority Level
Certificate/ Datasheet Description	High level description of the key information that is provided within the Certificate/ Datasheet	Certificate Name	Text	N/A	N/A	Optional
Certificate/ Datasheet Expiration Date	Recording of the Certificate/ Datasheet expiration date (where applicable)	Certificate Name	Date	N/A	Date after the date of the input	Optional
Component Value Information						
Value	Product's price (£) when it was bought to be placed to the building	N/A	Number	£	Positive Number	Optional
Priced Unit	Unit linked to the manufacturer's price	N/A	Number and Text	N/A	N/A	Optional
Warranty	Years of warranty after purchase (where applicable)	N/A	Number	Years	Positive number (0-120)	Optional
Component Expected Maintenance						
Annual Replacement Percentage	What percentage of the mass of the component is expected to need to be replaced annually?	N/A	Number	%	0-100	Required
Maintenance Guidance	Text with maintenance guidance from the manufacturer	N/A	Text	N/A	N/A	Required
Component Circularity Overview						
Expected Lifespan	How many years the component can be used before it begins to degrade or fail?	(Material-Level Input)	Number	Years	Positive number	Required
Recycled Content (% by mass)	What is the percentage of the mass of the component that contains recycled material?	(Material-Level Input)	Number	%	0-100	Required
Take-Back Scheme	Does the manufacturer support a take-back scheme (Yes/ No)?	(Material-Level Input)	Text	N/A	List: Yes, No	Required
Reuse Potential	Can the component be reused (Yes/ No) ?	(Material-Level Input)	Text	N/A	List: Yes, No	Required
Separability	(Applicable when there are more than one materials that consist the component) % by mass of the materials of the component that can be separated	(Material-Level Input)	Number	%	0-100	Required (when applicable)
% by mass Recycling	What is the percentage of the mass of the component that is anticipated to be	(Material-Level Input)	Number	%	0-100	Required

Component-level passport						
Manufacturing-related Information						
Property Name	Description	Dependent on	Response Type	Unit	Input Validity	Priority Level
	recycled at the end of component's life?					
% by mass Downcycling	What is the percentage of the mass of the component that is anticipated to be downcycled at the end of component's life?	(Material-Level Input)	Number	%	0-100	Required
% by mass Energy Recovery	What is the percentage of the mass of the component that is anticipated to be used for energy recovery at the end of component's life?	(Material-Level Input)	Number (0-100)	%	0-100	Required
% by mass Landfill	What is the percentage of the mass of the component that is anticipated to be sent to landfill at the end of component's life?	(Material-Level Input)	Number (0-100)	%	0-100	Required
Component Carbon Information						
Carbon Datasheet Type	Selection of the carbon datasheet type that has been used to provide information for the material's carbon performance.	N/A	Text	N/A	List: EPD, Product-Specific LCA Study, Other	Required
Declared Unit	What is the functional unit that has been used for defining material's carbon performance?	N/A	Text	N/A	N/A	Required
Manufacturing Carbon (A1-3)	What is the manufacturing carbon (A1-A3) of the material for the selected functional unit in kgCO ₂ eq?	N/A	Number	kgCO ₂ eq/ Declared Unit	Positive Number	Required
Sequestered Carbon	If applicable, what is the sequestered carbon of the material for the selected functional unit in kgCO ₂ eq?	N/A	Number	kgCO ₂ eq/ Declared Unit	Negative Number	Optional
Use Stage Carbon (B1-B3)	If applicable, what is the use stage carbon (B1-B3) of the material for the selected functional unit in kgCO ₂ eq?	N/A	Number	kgCO ₂ eq/ Declared Unit	Positive Number	Optional
End-of-Life Carbon (C1-C4)	What is the end-of-life carbon (C1-C4) of the material for the selected functional unit in kgCO ₂ eq?	N/A	Number	kgCO ₂ eq/ Declared Unit	Positive Number	Optional
Component Composition Overview						

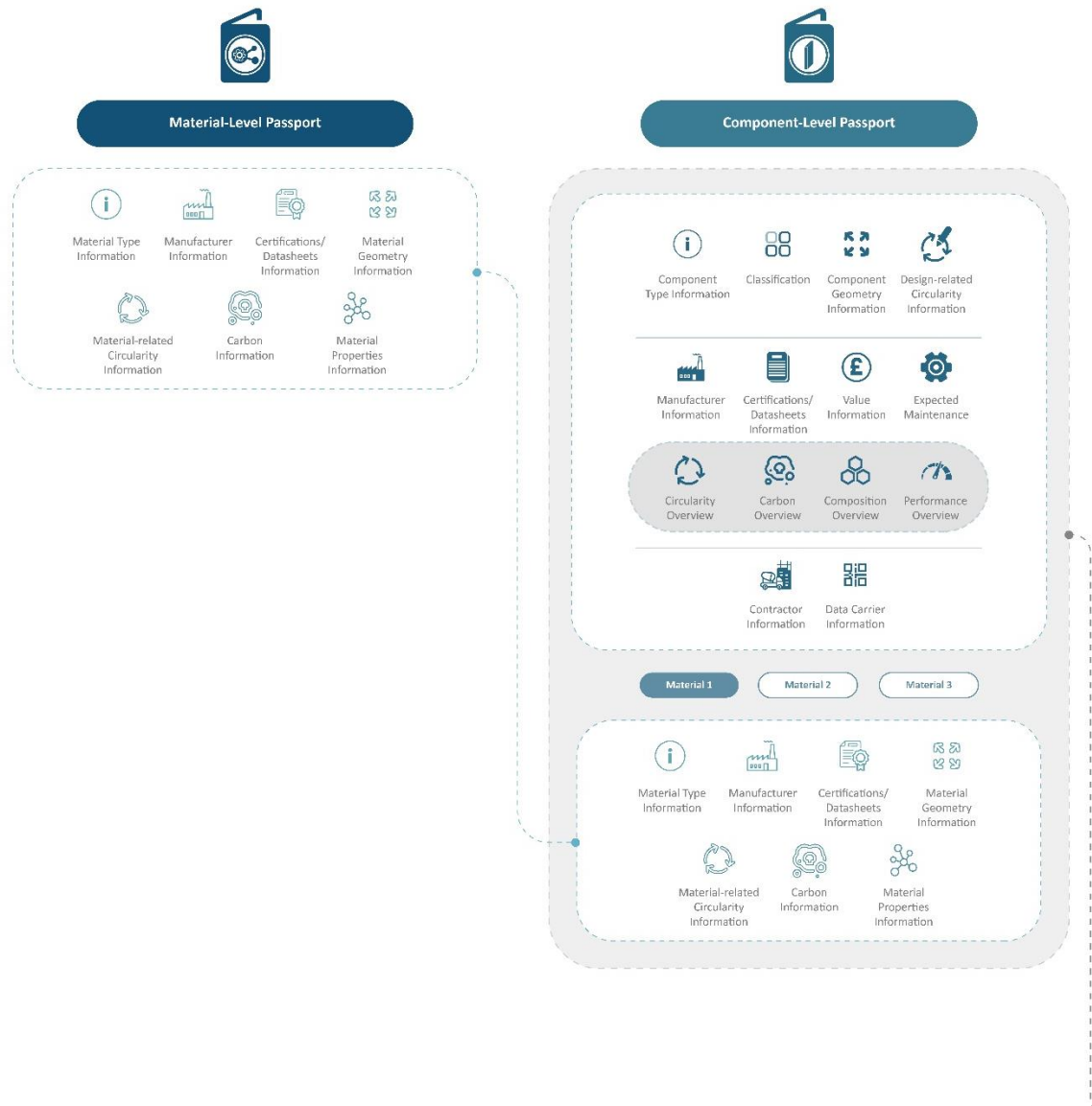
Component-level passport						
Manufacturing-related Information						
Property Name	Description	Dependent on	Response Type	Unit	Input Validity	Priority Level
Number of material(s)	What is the number of the materials that compose the component?	Material-Level Input	Number	N/A	Positive Number	Required
Component Performance Overview						
Optical Properties	To be defined at the Materials Passports Protocol.					
Structural Properties						
Thermal Properties						
Acoustic Properties						
Material Health						
Fire Resistance						

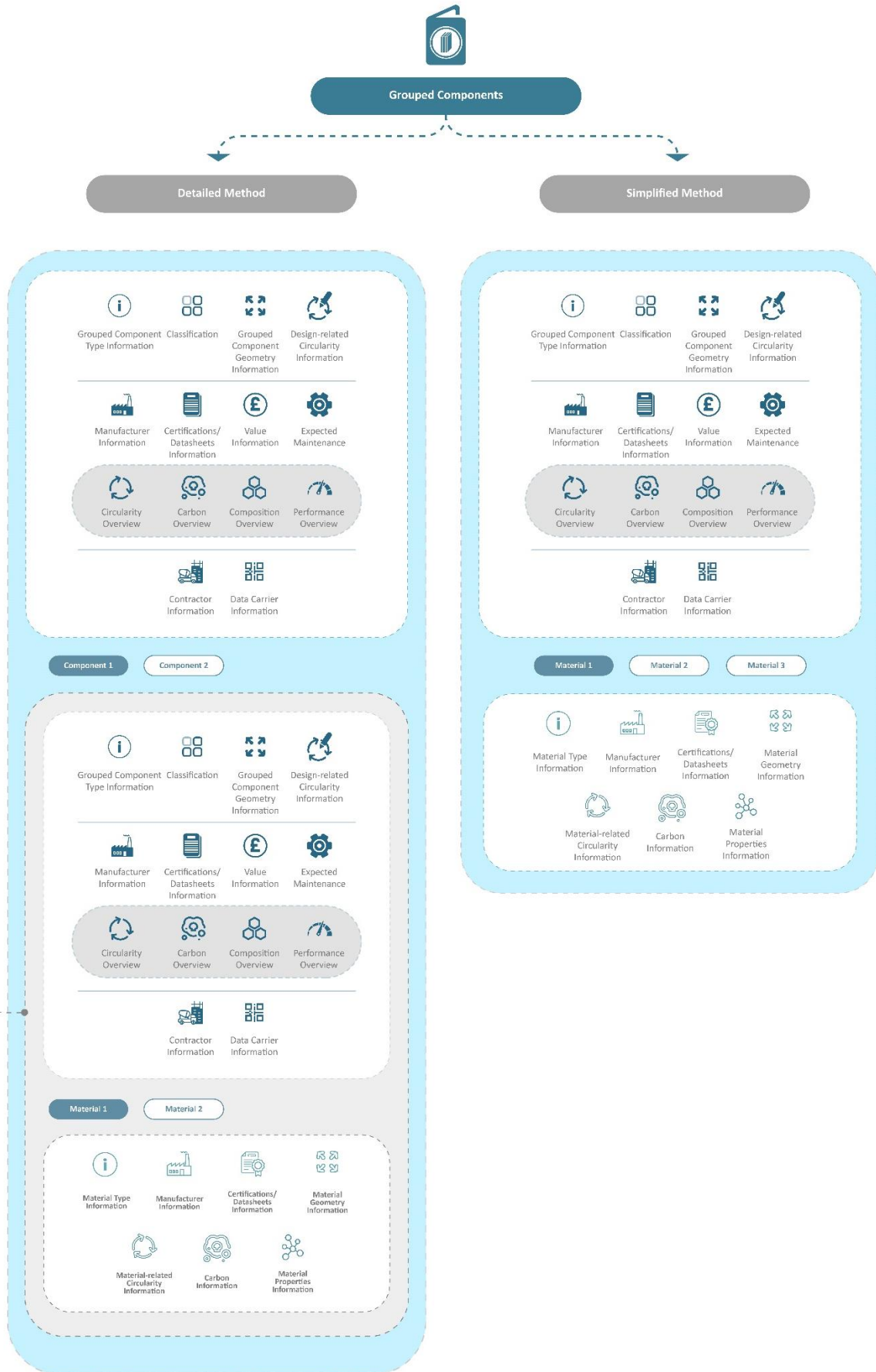
3. CONSTRUCTION-RELATED INFORMATION

Component-level passport						
Construction-related Information						
Property Name	Description	Dependent on	Response Type	Unit	Input Validity	Priority Level
Component Type Information						
Contractor Name	Name of the contractor company	N/A	Text	N/A	N/A	Required
Contractor Address	Address of the contractor company	N/A	Text	N/A	Valid address	Optional
Contractor Website	Link of the website of the contractor company	N/A	Text and number	N/A	Valid link	Optional
Contractor Contact e-mail	Contact e-mail of the contractor company	N/A	Text	N/A	N/A	Optional
Component Data Carriers Information						
Data Carrier Type	Type of data carrier that has been placed in the component	N/A	Text	N/A	List: No data carrier, RFID tag, NFC tag, QR codes, Smart label, Other	Required
Data Carrier Location	Description of the location where the data carrier placed in the component	N/A	Text	N/A	N/A	Optional
Recorded Information	Description of the information that is recorded in/on the data carrier	N/A	Text	N/A	N/A	Optional



D. Relationships between material-, component- and grouped component level passport





E. Existing and reused elements documentation

			NEW ELEMENTS	EXISTING ELEMENTS	REUSED ELEMENTS
Component/ Grouped component-Level Passports					
Design-Related Information	Element Type Information	Element ID	Optional (if there is not a 3D model)	Optional (if there is not a 3D model)	Optional (if there is not a 3D model)
		Element Photo/ Visualisation	Optional	Optional	Optional
		Element Type	Required	Required	Required
	Element Classification Information	Building Element Category- Level 1	Optional	Optional	Optional
		Building Element Category- Level 2	Optional	Required	Optional
		Building Element Category- Level 3	Required	Optional	Required
		Floor	Optional	Optional	Optional
	Element Geometry Information	Element Mass	Required	Required	Required
		Element Volume	Required	Required	Required
		Element Length	Required	Optional (if there is not a 3D model)	Required
		Element Width	Required	Optional (if there is not a 3D model)	Required
		Element Height	Required	Optional (if there is not a 3D model)	Required
	Design-related Information	Design for Disassembly	Required	Optional	Required
		Connection Types	Required	Optional	Required
		Accessibility	Required	Optional	Required
	Manufacturing-Related Information	Element Manufacturer Information	Manufacturer Name	Required	Optional
Manufacturer Address			Optional	Optional	Optional
Manufacturing Address			Required	Optional	Optional
Manufacturer Website			Optional	Optional	Optional
Manufacturer Contact e-mail			Optional	Optional	Optional
Element Certifications/ Datasheets Information		Certificate/ Datasheet Name	Required	Optional	Optional
		Certificate/ Datasheet Type	Required	Optional	Optional
		Certificate/ Datasheet Description	Optional	Optional	Optional
		Certificate/ Datasheet Expiration Date	Optional	Optional	Optional

			NEW ELEMENTS	EXISTING ELEMENTS	REUSED ELEMENTS
	Value information	Value	Optional	Optional	Optional
		Priced Unit	Optional	Optional	Optional
		Warranty	Optional	Optional	Optional
		Annual Replacement Percentage	Required	Optional	Required
		Maintenance Guidance	Required	Optional	Required
	Element Circularity Overview	Expected Lifespan	Required	Required	Required
		% by mass Recycled Content	Required	Optional	Optional
		Take-Back Scheme	Required	Optional	Optional
		Reuse Potential	Required	Required	Required
		Material Separability	Required (when applicable)	Optional	Optional
		% by mass Recycling	Required	Required	Required
		% by mass Downcycling	Required	Required	Required
		% by mass Energy Recovery	Required	Required	Required
		% by mass Landfill	Required	Required	Required
	Element Carbon Overview	Carbon Datasheet Type	Required	Optional	Optional
		Declared Unit	Required	Optional	Optional
		Manufacturing Carbon (A1-3)	Required	Optional	Optional
		Sequestered Carbon	Optional	Optional	Optional
		Use Stage Carbon (B1-B3)	Optional	Optional	Optional
		End-of-Life Carbon (C1-C4)	Optional	Optional	Optional
Performance Overview	To be defined at the Materials Passports Protocol				
Construction-Related Information	Contractor information	Contractor Name	Required	Optional	Required
		Contractor Address	Optional	Optional	Optional
		Contractor Website	Optional	Optional	Optional
		Contractor Contact e-mail	Optional	Optional	Optional
	Data Carrier	Data Carrier Type	Required	Optional	Required
		Data Carrier Location	Optional	Optional	Optional
		Recorded Information	Optional	Optional	Optional

			NEW ELEMENTS	EXISTING ELEMENTS	REUSED ELEMENTS
Material-Level Passports					
Material-related information	Material Type Information	Material Photo	Optional	Optional	Optional
		Product Registration Number 2	Optional	Optional	Optional
		Material Type- Level 1	Required	Required	Required
		Material Type- Level 2	Required	Required	Required
		% to the overall mass	Required	Required	Required
	Material Manufacturer Information	Manufacturer Name	Required	Optional	Optional
		Manufacturer Address	Optional	Optional	Optional
		Manufacturing Address	Required	Optional	Optional
		Manufacturer Website	Optional	Optional	Optional
		Manufacturer Contact e-mail	Optional	Optional	Optional
	Material Certification/ Datasheets Information	Certificate/ Datasheet Name	Required	Optional	Optional
		Certificate/ Datasheet Type	Required	Optional	Optional
		Certificate/ Datasheet Description	Optional	Optional	Optional
		Certificate/ Datasheet Expiration Date	Optional	Optional	Optional
	Material Geometry Information	Material Density	Required	Optional	Optional
		Material Length	Required for Material Types 2-3		
		Material Width			
		Material Height			
	Material-related Circularity Information	Expected Lifespan	Required	Required	Required
		% by mass Recycled Content	Required	Optional	Optional
		Take-Back Scheme	Required	Optional	Required
		Reuse Potential	Required	Required	Required
		Material Separability	Required (when applicable)	Optional	Optional
		% by mass Recycling	Required	Required	Required
		% by mass Downcycling	Required	Required	Required
		% by mass Energy Recovery	Required	Required	Required
		% by mass Landfill	Required	Required	Required
	Material Carbon Information	Carbon Datasheet Type	Required	Optional	Optional
		Declared Unit	Required	Optional	Optional
		Manufacturing Carbon (A1-3)	Required	Optional	Optional
		Sequestered Carbon	Optional	Optional	Optional

			NEW ELEMENTS	EXISTING ELEMENTS	REUSED ELEMENTS
Material-Level Passports					
		Use Stage Carbon (B1-B3)	Optional	Optional	Optional
		End-of-Life Carbon (C1-C4)	Optional	Optional	Optional
	Material Properties		To be defined at the Materials Passports Protocol		

F. Elemental-level passport

Component-Level Passports	Elemental- Level Passports	
Information Categories	Elemental Level Indicators Description	Examples
Elements type information	Overall number of documented components per building element category (BEC)	For BEC- Level 2: 2.1 Frame 350 Documented Components
	Overall number of documented components per component type (new component, reused component etc.) per BEC	For BEC- Level 2: 2.1 Frame 53 Documented Reused Components 122 Documented New Components 175 Documented Existing Components
	Percentage of each component type to the overall number of documented components per BEC	For BEC- Level 2: 2.1 Frame 15% Documented Reused Components 35% Documented New Components 50% Documented Existing Components
Classification	The breakdown of the percentage of the number of documented components per BEC- level 2 to the overall number of documented components for BEC- level 1	For BEC- Level 1: Finishes Documented Number of Components: 55% Floor Finishes 35% Wall Finishes 15% Ceiling Finishes
	The breakdown of the percentage of the mass of documented components per BEC- level 2 to the overall mass of documented components for BEC- level 1	For BEC- Level 1: Finishes Documented Mass: 47% Floor Finishes 42% Wall Finishes 11% Ceiling Finishes
	The breakdown of the percentage of the volume of documented components per BEC- level 2 to the overall volume of documented components for BEC- level 1	For BEC- Level 1: Finishes Documented Volume: 26% Floor Finishes 62% Wall Finishes 12% Ceiling Finishes
Mass information	Overall mass of the documented components per BEC	For BEC- Level 1: Finishes 16.5 tonnes
	Percentage of the mass of the documented components to the overall mass of each BEC	For BEC- Level 1: Finishes Documented Mass: 85% Not Documented Mass: 15%
Data carrier	Overall mass of documented components with data carrier per BEC	For BEC- Level 1: Finishes 9.5tonnes
	Percentage of the number of documented components with data carrier to the overall number of documented components per BEC	For BEC- Level 1: Finishes 58%
Contractors & manufacturers information	Number of contractors per BEC	For BEC- Level 2: 2.1 Frame 3 Contractors
	Number of manufacturers per BEC	For BEC- Level 2: 2.1 Frame 10 Manufacturers
	Breakdown of the recorded mass by manufacturing location by BEC	For BEC- Level 2: 2.1 Frame 30% Ireland 70% UK

Component-Level Passports	Elemental- Level Passports	
Information Categories	Elemental Level Indicators Description	Examples
Design-related circularity information	Overall number of documented components that can be disassembled by BEC	For BEC- Level 2: 2.1 Frame 150 Documented Components
	Percentage of the documented components that can be disassembled to the overall number of documented components by BEC	For BEC- Level 2: 2.1 Frame 43%
	Mass of documented Components that can be disassembled per BEC	For BEC- Level 2: 2.1 Frame 4,160,457kg
	Breakdown of the recorded mass by types of connections per BEC	For BEC- Level 2: 2.1 Frame 59% welded 41% glued
	Breakdown of the recorded mass by the level of accessibility to the connections	For BEC- Level 2: 2.1 Frame 52% 1. Directly accessible connection 21% 2. Hidden Connection 27% 3. Layer(s) to be removed – no damages
Material-related circularity information	Overall number of documented components that can be reused per BEC	For BEC- Level 2: 2.1 Frame 75 Documented Components
	Percentage of the documented components that can be reused to the overall number of documented components per BEC	For BEC- Level 2: 2.1 Frame 50%
	Overall number of documented components that are supported by take-back scheme per BEC	For BEC- Level 2: 2.1 Frame 0 Documented Components
	Average percentage of recycled content by mass per BEC	For BEC- Level 2: 2.1 Frame 63%
	Breakdown of the recorded mass by material recovery potential (recycling, downcycling and landfill) by BEC	For BEC- Level 2: 2.1 Frame Recycling: 57% Downcycling: 48% Landfill: 5%
Material type information	Overall recorded mass per material type level 1 per BEC	For BEC- Level 2: 2.1 Frame 153,000 kg Structural Steel 306 kg Intumescent Pain
	Breakdown of the percentage of recorded mass per materials to the overall recorded mass per BEC	For BEC- Level 2: 2.1 Frame 100% Structural Steel 0% Intumescent Paint
Value information	Overall materials' value per BEC	For BEC- Level 2: 2.1 Frame £ 25,454
Carbon information	Overall embodied carbon (tonnes CO ₂ eq) per BEC	For BEC- Level 2: 2.1 Frame 4,350 tonnesCO ₂ eq
	Embodied carbon per square meter GIA (kgCO ₂ eq/m ² GIA) per BEC	For BEC- Level 2: 2.1 Frame 350kgCO ₂ eq/m ² GIA

G. Building-level passport

Building-Level Passport	
Information Categories	Building Level Indicators Description
Building information	Building name Building use (i.e., commercial, residential, retail etc.) Project type (i.e., new building, refurbishment, extension etc.) Scope areas (i.e., whole building, specific floors, specific areas within the building etc.) Building Address
Component type information	Overall number of documented components
	Overall number of documented components per component type (new component, reused component etc.)
	Percentage of each component type to the overall number of documented components
Mass information	Overall Mass of the documented components
	Percentage of the mass of the documented components to the overall mass
Data carrier	Overall mass of documented components with data carrier
	Percentage of the number of documented components with data carrier to the overall number of documented components
Contractors & manufacturers information	Number of contractors
	Number of manufacturers
	Breakdown of the recorded mass by manufacturing location
Design-related circularity information	Overall number of documented components that can be disassembled
	Percentage of the Documented Components that can be disassembled to the overall number of Documented Components
	Mass of Documented Components that can be disassembled
	Breakdown of the recorded mass by types of connections
	Breakdown of the recorded mass by the level of accessibility to the connections
Material-related circularity information	Overall number of documented components that can be reused
	Percentage of the documented components that can be reused to the overall number of documented components
	Overall number of documented components that are supported by take-back scheme
	Average percentage of recycled content by mass
	Breakdown of the recorded mass by material recovery potential (recycling, downcycling and landfill)
Material type information	Overall recorded mass per material type level 1
	Breakdown of the percentage of recorded mass per materials level 1 to the overall recorded mass
	Overall recorded mass per material type level 2
	Breakdown of the percentage of recorded mass per materials level 2 to the overall recorded mass
Value information	Overall materials' value
Carbon information	Overall embodied carbon (kgCO ₂ eq)
	Embodied Carbon per square meter GIA (kgCO ₂ eq/m ² GIA)

Product-level passport

Product Overview Information							
Property Name	Description	Priority Level	Product Type				
			1	2	3	4	5
Product General Information							
Product Name	Name of the product	Required	Yes				
Product Registration Number	Global Trade Item Number (GTIN) standard from the GS1 organisation	Optional					
Product type Category	Product type category from pre-defined list	Required					
Product type	Type of the Product: <ul style="list-style-type: none"> • Product type 1: Material Category I (Ingredients) • Product type 2: Material Category II (Modular) • Product type 3: Material Category III (Sub-Components) • Product type 4: Components • Product type 5: Grouped Components 	Required					
Product Geometry							
Product Mass	Overall mass of the product in kg	Required only for Product type 4 and 5	N/A			Yes	
Product Volume	Overall volume of the product in m ³						
Product Length	Overall length of the product in m						
Product Width	Overall width of the product in m						
Product Height	Overall height of the product in m						
Product Manufacturer Information							
Manufacturer Logo Image	Image of the logo of the product manufacturer	Required	Yes				
Manufacturer Name	Name of the product manufacturer	Required					
Manufacturer Address	Address of the product manufacturer	Optional					
Manufacturing Address	Address of the manufacturing location (factory) of the manufacturer company	Required					
Manufacturer Website	Link of the website of the product manufacturer	Optional					
Manufacturer e-mail	Contact e-mail of the product manufacturer	Optional					
Product Certification/ Datasheet Information							
For each certification/ datasheet:							

Product Overview Information							
Property Name	Description	Priority Level	Product Type				
			1	2	3	4	5
Certificate/ Datasheet Name	Title of the document (Certificate/ Datasheet)	Required					
Certificate/ Datasheet Type	Selection of the certificate type from a list with different options of certificate types	Required					
Certificate/ Datasheet Description	High level description of the key information that is provided within the certificate/ Datasheet	Optional					
Certificate/ Datasheet Expiration Date	Recording of the certificate/ datasheet expiration date (where applicable)	Optional					
Product Price Information							
Product's Price	Product's price	Required					
Priced Unit	Unit for which the price is provided	Required					
Guarantee	Years of guarantee after purchase	Required					
Product Expected Maintenance							
Annual Replacement Percentage	What percentage of the mass of the product is expected to need to be replaced annually after its construction?	Required					
Maintenance Guidance	Text providing maintenance guidance	Required					
Product Packaging Circularity Performance							
Recycled Packaging Material	Percentage of recycled content by mass of the packaging material(s) that is/are used for the product packaging	Required					
Recyclable Packaging Material	Percentage by mass of the packaging material that can be recycled	Required					
Product Circularity Overview							
Expected Lifespan	How many years the product can be used, after purchase, before it begins to degrade or fail?	Required					
Recycled Content (% by mass)	What is the percentage of the mass of the Product that contains recycled material?	Required					
Take-Back Scheme	Does the manufacturer support a take-back scheme (Yes/ No)?	Required					
Reuse Potential	Can the product be reused (Yes/ No) ?	Required					
Separability	(Applicable when there are more than one materials that consist the component) % by mass of the materials of the product that can be separated	Required					

Product Overview Information							
Property Name	Description	Priority Level	Product Type				
			1	2	3	4	5
% by mass Recycling	What is the percentage of the mass of the product that is anticipated to be recycled at the end of its life?	Required					
% by mass Downcycling	What is the percentage of the mass of the product that is anticipated to be downcycled at the end of its life?	Required					
% by mass Energy Recovery	What is the percentage of the mass of the product that is anticipated to be used for energy recovery at the end of component's life?	Required					
% by mass Landfill	What is the percentage of the mass of the product that is anticipated to be sent to landfill at the end of its life?	Required					
Product Carbon Overview							
Carbon Datasheet Type	Selection of the carbon datasheet type that has been used to provide information for the product's carbon performance.	Required	Yes				
Declared Unit	What is the functional unit that has been used for defining product's carbon performance?	Required					
Manufacturing Carbon (A1-3)	What is the manufacturing carbon (A1-A3) of the Product for the selected functional unit in kgCO ₂ eq?	Required					
Sequestered Carbon	If applicable, what is the sequestered carbon of the product for the selected functional unit in kgCO ₂ eq?	Optional					
Use Stage Carbon (B1-B3)	If applicable, what is the use stage carbon (B1-B3) of the product for the selected functional unit in kgCO ₂ eq?	Optional					
End-of-Life Carbon (C1-C4)	What is the end-of-life carbon (C1-C4) of the Product for the selected functional unit in kgCO ₂ eq?	Optional					
Product Composition Overview							
Number of Material	What is the number of the materials that compose the product?	Required	Yes				
Number of Products Type 4: Components	What is the number of the products type 4: components that compose the product?	Optional	N/A				Yes
Number of Products Type 5: Removable Grouped Components	What is the number of the products type 5: removable grouped components that compose the product?	Required only for Products Type 5: Parents Grouped Components					

Product Overview Information							
Property Name	Description	Priority Level	Product Type				
			1	2	3	4	5
Product Performance Overview							
Optical Properties	To be defined at the Materials Passports Protocol.						
Structural Properties							
Thermal Properties							
Acoustic Properties							
Material Health							
Fire Resistance							

H. Relationship to BIM terminology

The following table provides a translation between the terms found within this framework and those found within BIM discourse. As with many terminologies, these often evolve, creating confusion when applying terms from other disciplines. These translations are offered so that alignments and connections to BIM discourse can be established.

Term in Protocol	Related Term(s) in BIM	Note
Passport	Data Sheet	A data sheet is a completed data template. As a passport is a completed set of data required, it might be describable as being a data sheet.
	Asset Information	PAS 1192-5 provided the following definition for Asset Information - "Data or information relating to the specification, design, construction or acquisition, operation and maintenance, and disposal or decommissioning of an item, thing or entity that has potential or actual value to an organization"
	Asset Information Requirements (AIR)	A Passport holds Asset Information, and the passport specification is therefore a collection of Asset Information Requirement as defined in BS EN ISO 19650-1
{Level} Passport	{ISO12006-2 Table} Data Sheet	ISO 12006-2 provides frameworks for classification systems and the breakdown of levels each having their own table. Uniclass2015 is an example of a classification system that conforms to ISO 12006-2
Product Passport	Product Data Sheet	Product Data Sheet is a catch-all term for data sheets. It often has ambiguity and might be describing grouped component levels as well as component levels.
Material Passport	Material Data Sheet	Material data sheet is not a widely used term in BIM discourse but follows the principle of having a {level}. The latest versions of classification systems from different countries that conform to ISO 12006-2 have developed a Materials table as well as a product table.
Component Passport	Product Data Sheet Component Data Sheet	Product Data Sheet is a catch-all term for data sheet. It often has ambiguity and might be describing grouped component levels as well as component levels. When it is explicitly known that the product is a single component, a more direct term 'component data sheet' might be appropriate although this might lead to some confusion for those familiar with COBie as the meaning of component can infer that the object is placed in the facility.
Grouped Components Passport	System Data Sheet	When objects are grouped together, it is often termed as being a system in BIM. Classification systems developed to ISO 12006-2 support this interpretation by having both a system level classification as well as a product level classification table. As noted above, some might refer to System Data Sheets as also being Product Data Sheets.
Building Passport	Building Data Sheet *Facility Data Sheet **Entity Data Sheet	*COBie Introduces the Facility concept often mapped to the Building level in information exchanges **ISO 12006-2 Introduces the Entity and Complexes concepts that hold classifications aimed at the building level and site level.
Passport Specification	Data Template	Data Templates are defined in ISO 23387 as a "data structure used

		<p>to describe the characteristics of construction objects”</p> <p>In the context of material passports, a data template is a specification of the information that’s required and how it is to be exchanged. The material protocol in this document is the beginnings of that specification, however for it to be a full specification, it would need to go further and be developed as a full data dictionary conforming to ISO 23386</p>
{Level} Passport Specification	{ISO12006-2 Table} Data Template	<p>See above for the notes on the various levels in conjunction with the Data Template note.</p>
Product Passport Specification	Product Data Template	
Material Passport Specification	Material Data Template	
Component Passport Specification	Product Data Template Component Data	
Grouped Components Passport	System Data Template	
Passport Protocol	Model View Definition (MVD)	ISO/DIS 29481-1 provides a definition for MVD as “A computer-interpretable definition of an exchange requirement, specifically bound to one or more particular standard information schemas “
	Information Exchange	<p>PAS 1192-2 provided the definition of Information Exchange as “Structured collection of information at one of a number of pre-defined stages of a project with defined format and fidelity”.</p> <p>IFC and COBie are examples of openBIM structured formats used to exchange. An information exchange is a key part of the protocol.</p>
	Industry Foundation Classes (IFC)	At the time of writing references were based on IFC4 Addendum 2 ISO 16739 as most software accommodates this and the previous version IFC2x3. Classes from the latest version IFC4.3 are not yet widely supported in software.
	Data Dictionary	<p>ISO 23386 and 23387 states that a data dictionary is a “centralised repository of information about data such as meaning, relationship to other data, origin, usage and format.”</p> <p>The specification provided in this document is the beginning of the production of a data dictionary to which material passport systems could refer to. For it to take on the full form of a dictionary, each property defined would need to be completed in accordance with ISO 23386.</p>
ID	GUID global unique identifier	<p>The standard, RFC 4122 provides the algorithms for producing a digitally unique identifier.</p> <p>For the purposes of this protocol a methodology primarily using SHA1 Method 5 within this standard might be more appropriate for the BIM implementation of properties that come from a passport provider source. Such a strategy would create a governance over the data that’s added / linked to the model as well as make provision for scenarios where there are multiple passport providers of the same object type.</p>

Waterman Materials Passports Framework

This publication sets the foundation for a standardised approach and framework to creating Materials Passports throughout the construction industry. Materials Passports will play a pivotal role in enabling material reuse, and will also streamline data collection practices across products, buildings and cities. The Waterman Framework establishes the Materials Passport levels, content and data interconnections, all while offering practical insights into their implementation and examining the role Building Information Modelling (BIM) plays in automating processes.

By introducing this Framework, Waterman aims to establish an industry standard for the creation of Materials Passports, driving collaboration and embedding circular economy principles within projects of every type across Europe. The Framework has been spearheaded by sustainability expert Anastasia Stella, with technical contributions by CIRCuiT's London cluster, and aligns with the forthcoming Digital Product Passport (DPP) requirements under the proposed Ecodesign for Sustainable Products Regulation (ESPR) in the European Union's European Green Deal.