Materials Passports:

Accelerating Material Reuse in Construction

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Contents

Our ambition is to create a process that is clear enough to understand, simple enough to use and cost effective enough to implement, to ultimately change how we value our existing and future built environment.

Context: London and the UK

In 2020, the Greater London Authority (GLA) introduced a requirement for certain schemes to submit a **Circular Economy statement** [1].

The Statement requires design teams to evidence a design process that considers circularity initiatives and report their progress against recommended target metrics.

This initiated a widespread consideration of circularity for GLA referable schemes in London, which has now trickled down into most major planning applications, for buildings within London boroughs.

The simultaneous requirement by the GLA for a **Whole Life Carbon statement** has created a process that illustrates the benefit of material retention in reducing the carbon impacts of development.

A subsequent industry interest and flurry of activity occurred in various research groups with the intention of increasing the amount of material reuse to demonstrate exemplary performance for both Statements.

Both Statements require the submission of **metrics**, for the purpose of benchmarking and to show a development's impact at differing stages. **Benchmarking** of **Whole Life Carbon** is relatively simple which has a clear, single metric [2]. However, metrics for **Circularity** have been particularly difficult to evaluate and standardise, and the value of differing circular economy initiatives are difficult to balance, seek and produce evidence for and set targets [3].

The **Circular Economy statement methodology** has encouraged a sensible approach, which requires teams to develop an appropriate strategy for the project by following a clearly defined process. The **outcomes** differ for each project and should in any case be specific to the context.

Metrics need to be collected for benchmarking purposes and for evaluating performance by teams and planning authorities, but the emphasis should be placed on delivering appropriate and **meaningful strategies.**

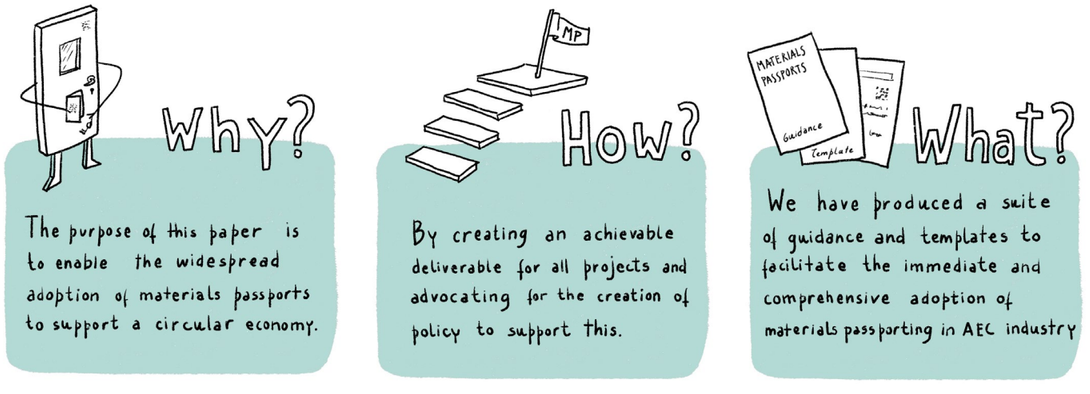

Figure 1 | *Policy Paper Purpose and Ambition*

Despite the focus on London context, the proposed Materials Passports guidance can be adopted at any scale, location or phase of design.

In 2021, Orms released a piece of research that focused on developing **materials passports for existing buildings** during the design process, to unlock material reuse for existing buildings [4].

In 2023, Ana Rute Costa (Lancaster University) and Orms received AHRC funding to **accelerate material reuse in construction**, advocate for the deconstruction (instead of demolition) of existing buildings, to support the integration of reused materials into the supply chain and enable the use of materials passports.

In this research we present Materials Passports as a way to support future **policy direction** around circularity and offer guidance on how teams should demonstrate this.

This research has been developed in **consultation and collaboration** with industry over the past three years and primarily focuses on experience in London [5].

The aspiration is for the guidance to be implemented and tested in a wider context so that it can be refined and adjusted to the market needs.

Summary and Recommendations

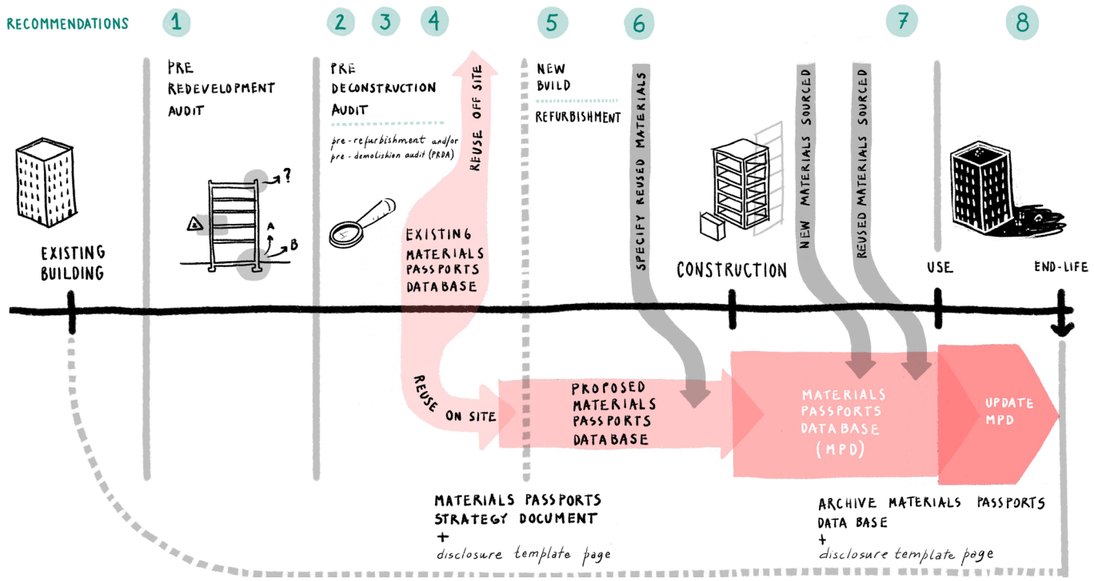

Figure 2 | *Implementation of Materials Passports Recommendations*

This paper provides clear recommendations on how to use materials passports to:

- **accelerate material reuse** in construction,
- **promote deconstruction** over demolition,
- increase **reused materials** into the supply chain,
- reduce construction and demolition **waste** (CDW) and
- increase **end of life value** in the built environment.

This furthers the development of the 2021 Orms work [4], which proposed the creation of a **materials passports database** in an open-source way. We now propose a **standardisation of materials passports types** and offer a nomenclature for reused and new materials, to facilitate the **consistency of data collation** and future interoperability across different platforms and databases.

The following Materials Passports **policy recommendations** seek to build upon current practices and knowledge in the industry, with the intention of continuing to encourage design teams and clients to demonstrate their **process and approach**, rather than set metric-based targets for circularity. The following list of activities and deliverables are encouraged to demonstrate this, with recommendations 1-4 building upon the GLA guidance [1].

1. Complete a Pre-Redevelopment Audit
2. Complete a Pre-Demolition or Pre-Refurbishment Audit
3. Prepare a Circular Economy Strategy
4. Gather and submit metric data
5. Develop and implement a Materials Passports strategy
6. Incorporate reused materials
7. Prepare a Deconstruction Plan
8. Support for local authorities to implement the proposed recommendations

Recommendation 1 | Complete a Pre-Redevelopment Audit

Where an asset exists on the site, it is recommended that a **Pre-Redevelopment Audit** [1] is carried out by clients and design teams at the earliest available opportunity. This would enable the evaluation of potential for refurbishment.

Recommendation 2 | Complete a Pre-Demolition or Pre-Refurbishment Audit

The Pre-Redevelopment Audit should be followed by a **Pre-Demolition** [6] or **Pre-Refurbishment Audit** [7] as appropriate. These audits are collectively referred to as Pre-Deconstruction Audits throughout the document. This should include an audit of the interiors and fit out elements, which often see high turnover in commercial environments and frequent replacement before end of life.

Recommendation 3 | Prepare a Circular Economy Strategy

For all buildings, a Circular Economy Strategy should be developed [1]. Where undertaken, it should explain the outcomes of the audits and describe the design approaches that have been developed.

Recommendation 4 | Gather and submit metric data

For all buildings, the metrics contained within the **GLA Circular Economy Statement Template** [1](bill of materials and metrics for waste arisings, management routes, recycled content) should be prepared and reported to the local authority at planning application stage and post-completion as a demonstrator of exemplary performance. This will enable benchmarking of data at a much broader scale.

Recommendation 5 | Develop and implement a Material Passports strategy

For all buildings, the development and implementation of a **Materials Passports Strategy** (Appendix A) would be considered a demonstration of exemplary performance. This strategy can be applied to both the deconstruction and construction process. The written strategy should articulate how materials passporting will be implemented on a project, and can be included as a section within the sustainability statement, or provided as a standalone document.

The creation of a **Materials Passports Database** for new materials contained within the development is expected. This is essentially the completion of the provided spreadsheet template (see Appendix C). The **Materials Passports Handbook** (Appendix B) provides guidance on this process. For larger projects, an inexpensive database solution may be more appropriate, for which the template can be the starting point. There are also a number of subscription based platforms which may also be used. Where there is an existing asset on site, the creation of a **Basic Materials Passports Database** for existing materials to improve material reuse during deconstruction and construction is encouraged. Teams should prepare the **Disclosure Page** (Appendix D) to illustrate the scope and level of detail that is being pursued, this should be updated pre-commencement and post-construction.

Recommendation 6 | Incorporate reused materials

Where an existing asset is present, stakeholders should make every effort to incorporate **materials arising** from the deconstruction into the new development. On all projects, reused materials should be sourced in lieu of purchasing new wherever possible. It is noted that some of the reused materials may not have all of the typical documentation requirements (e.g. EPD, warranty, certification), that may exist for a new material. However, whenever possible, all stakeholders should facilitate the adoption and installation of reused materials.

Teams should prepare **flexible material specifications** to enable adjustments at the procurement phase, facilitate reuse and reduce waste. This may involve down rating and oversizing of reused materials to offer a greater safety factor, and carrying out tests on the material. A simple version of the **Materials Passports Database** (Basic Materials Passports) should be created to record the information available at each stage of the project.

Recommendation 7 | Prepare a Deconstruction Plan

For all buildings, as part of the Building Passport, a **Deconstruction Plan** should be created to demonstrate exemplary performance. For existing buildings, the deconstruction plan should be informed by the **Pre-Redevelopment** and **Pre-Demolition** or **Pre-Refurbishment Audit** (PRDA) and by the **Basic Materials Passports** database. For a proposed development, the Deconstruction Plan should be developed during the design process and be informed by the Materials Passports database.

Recommendation 8 | Support for local authorities to implement the proposed recommendations

It is recognised that many local authorities are already very capable of, and have been encouraging the implementation of circular strategies. However, **additional resources** to support the implementation of the recommendations, and enable **upskilling** to support a local authority in developing competency within the planning department or other enforcing authority is critical. As identified in the future research topics, the development of a **centralised national or regional database** will provide additional opportunities around material reuse, and local authorities will be instrumental in supporting this work.

Figure 2 presents the recommendations proposed above in a graphic summary.

Accelerating Material Reuse in Construction with Materials Passports

The construction industry is one of the most **resource intensive** industries, being responsible for enormous quantities of waste generation, and nearly 40% of global energy-related CO_2 emissions [8]. Furthermore, accurately quantifying Construction and Demolition (C&D) waste is challenging [9], demolition is an environmentally damaging process and there is a level of uncertainty of where waste goes.

The construction of new buildings can represent more than 50% of its total life cycle emissions [10]. According to the operational and embodied carbon trajectories proposed by LETI [2], when meeting the current building regulations in the UK, **embodied carbon** in the construction phase of a building's life typically equates to 30/35% of its total life cycle emissions. However, if we design ultra-low energy buildings where the operational carbon represents less than 20% of the whole life carbon, the embodied carbon can equate to more than 80%. Therefore, the focus on embodied carbon is a fundamental step towards meeting **Net Zero targets**, as defined by the UK government. Since 80% of buildings that will exist in 2050 have already been built, it is imperative that we make the most of the **materials already in existence**.

Below, we present an **alternative construction cycle**, to implement materials passports and accelerate material reuse in construction. This approach will enable us to reduce waste, reuse resources, reduce embodied carbon expenditure and address Net Zero Targets [11].

Figure 3 illustrates a reuse focused construction cycle and how material reuse in construction can be accelerated by using materials passports. The cycle may vary according to different types of buildings, context and construction date.

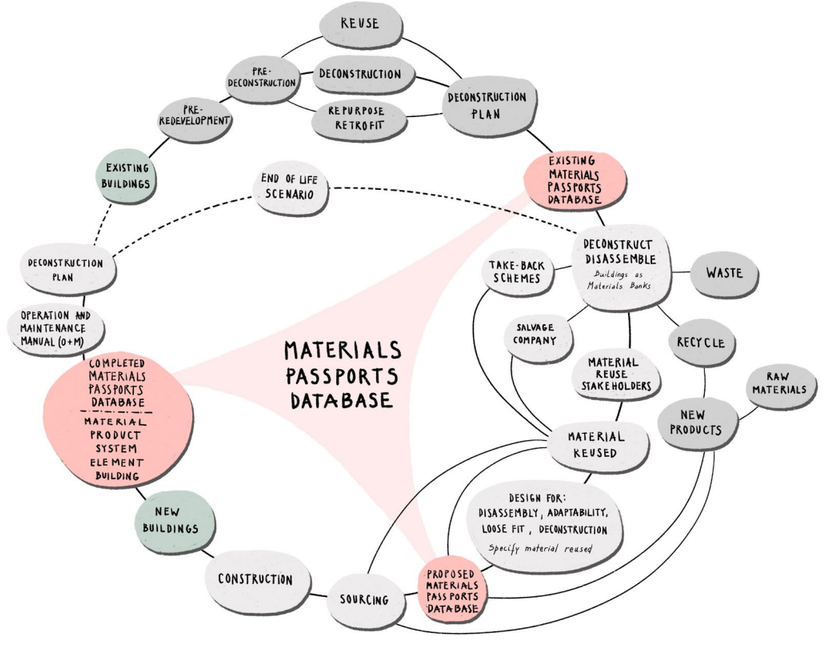

Figure 3 | *Accelerating Material Reuse in Construction with Materials Passports: an overview*

“A misuse of material resources is not just suicidal for future human generations but catastrophic for the future of life”

Michael Braungart

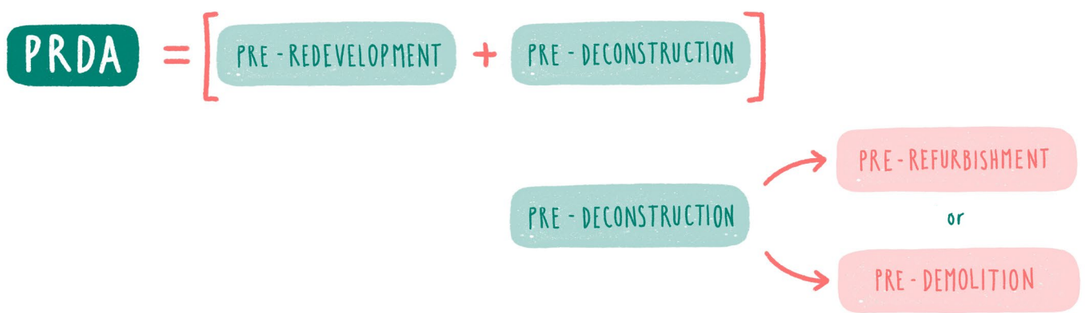

Figure 4 | *The PRDA consists of a pre-redevelopment and pre-deconstruction audit. The pre-deconstruction audit consists of a pre-refurbishment or pre-demolition audit, as applicable.*

The **pre-redevelopment and pre-deconstruction audits** (which include pre-demolition / pre-refurbishment audit as applicable) (Figure 4) will:

- inform potential outcomes for existing buildings,
- facilitate exploration of retention and retrofit opportunities and
- identify waste arisings and the routes for treating the waste streams.

These studies will in turn:

- Encourage the reuse of the whole building.
- Prioritise deconstruction over demolition

A **materials passports database** can be developed to facilitate these discussions and decisions. The level of detail within the database should be aligned with the design stage and information availability:

- A **Basic Materials Passports Database:** is for existing materials within existing buildings. Enough information should be gathered to avoid material waste and maximise material reuse.
- A **Full Materials Passports Database**: should be prepared for all proposed development projects, it should contain full passports to enable future material reuse.

In both cases, the involvement of stakeholders across the industry is crucial to enable material reuse and to extend the lifecycle of materials.

Prior to a building being deconstructed, a **basic materials passports database** should be created to enable quantification of materials, record details of the specification and current condition to determine the reuse viability of deconstructed elements. It is important to determine potential recipients for the materials prior to deconstruction, to facilitate a smooth programme, help the business case for reclamations and reduce transportation and storage costs.

Depending on materials properties, qualities and reuse potential, different reuse approaches may be applicable, e.g. take-back schemes, salvage company, re-manufacturing, repair, material reuse re-certification stakeholders and recycling facilities (when this is the most viable option).

Where possible, reused materials should be integrated back into the **existing supply chain**, to encourage the transition to a circular economy. The supply chain in turn needs to be flexible and adaptive in recognising the carbon and physical value of reused construction materials, potential for alternative business models and their role in **supporting the industry** to meet Net Zero targets.

Once the reused materials have been recovered into the existing supply chain, they may undergo **refurbishment or testing** and made available for re-specification and installation in new projects. Alongside this shift in the supply chain, the design teams should be aware of the **reuse market** possibilities and specify reused materials as often as possible.

The industry is facing an enormous challenge to achieve Net Zero targets. Material reuse in construction is part of the solution, but it has its own challenges. Materials passports can unlock some of those challenges and enable a circular economy.

There are multiple **barriers** to achieving Material Reuse:

1. **Cost.** It is often easier and financially cheaper to demolish and build new rather than deconstruct/retrofit and reuse, particularly for interiors and fit out elements. This is often attributed to extending the programme, or risk to the programme due to uncertainty;
2. **Risk.** Lack of data available for materials in existing buildings and risks associated with reuse. (e.g. H&S and insurance) Require bespoke expertise and time, and additional hurdles may arise while on site;
3. **Contemporary construction techniques.** Most of our buildings are not designed for end life. Contemporary construction favours chemical fixing (such as adhesives)

over mechancial fixings which inhibits disassembly for reuse. Furthermore, Modern Methods of Construction (MMC) such as prefabrication do not necessarily prioritise design for end of life and disassembly. When considered, MMC could easily be designed for disassembly and facilitate reuse;

4. **Expertise.** It requires the involvement of all Architecture, Engineering and Construction (AEC) stakeholders at different stages to enable material reuse and implement materials passports;

5. **Logistics.** The existing supply chain is not yet set up to streamline and accept material reuse. There are also challenges around materials storage, and transportation.

Equally there are many **opportunities** to increase material reuse and where materials passports can support this process:

1. **Resource efficiency.** Reduce the extraction of raw materials by reusing materials already in existence;

2. **Embodied carbon.** Reduce the whole life embodied carbon of a building by utilising less new materials and extending the life cycle of the existing materials;

3. **De-risk reuse.** Gathering materials passports for existing buildings establishes a due diligence process and methodology, therefore reducing risk and potential barriers around material reuse

4. **Reduce waste.** Give materials an identity that facilitates material reuse and reduces waste;

5. **Future reuse.** Design for disassembly and deconstruction at end of life and use materials passports to support this process;

6. **Operation and Maintenance.** Facilitate better maintenance and refurbishment of buildings, to prevent early replacement and extend life expectancy of materials.

Understanding Materials Passports

Materials passports are a tool to enhance the reclamation of materials and facilitate material reuse, not only for existing buildings but also for new builds. Similar to **Digital Products Passports (DPP)** currently being developed by the European Commission [12], materials passports need to have **standardisations and specifications to ensure interoperability, security and acceptance by all stakeholders**. The need to implement these in a sector-specific manner has been identified by the **Construction Product Regulation (CPR)** that focus on the unique challenges and demands of the construction industry [13]. Similar to CPR, materials passports can act as **economic actors** through circular value retention and optimisation, generate new job opportunities and businesses focused on reuse, repair, recertification, remanufacture, repurposing and recycling.

A lack of information and knowledge base is one of the major barriers to achieving a circular economy [14]. Material passports should be seen as an **enabling tool** to promote a circular economy and resource efficiency in the construction industry. They provide **digital sets of data** that can describe defined characteristics of materials and components for both products and systems, that give them value for present use, recovery, and reuse [15]. This structured data on existing and future building materials offers the opportunity of storing, linking, preserving and providing relevant information to all of the actors across the construction cycle.

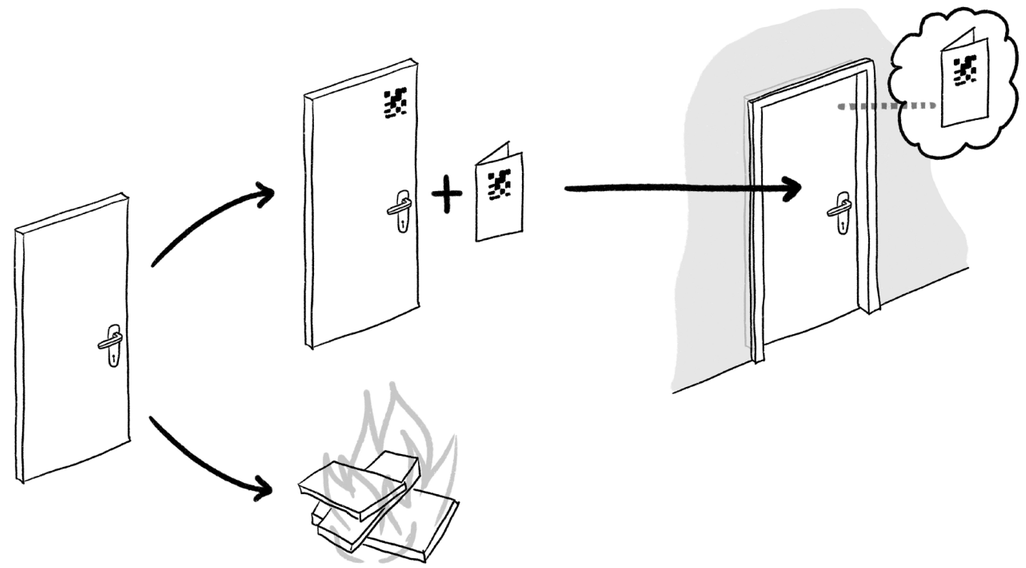

Figure 5 | *Materials Passports enabling Material Reuse*

The **EU Horizon 2020 project Buildings as Materials Banks (BAMB)** was an important initiative to raise awareness and provide guidance on Materials Passports. The Materials Passport Framework produced by BAMB [16] has inspired and guided the development of different product data initiatives [17] and other research projects, e.g. Facilitating the Circulation of Reclaimed Building Elements (FCRBE) [18], Circular Construction 2023 [19] and Waterman Materials Passports Framework [20].

Research evidence shows multiple **advantages** of materials passports methodology:

1. provide deconstructability score, recovery score and environmental score [21];
2. quantify building material and component stock and flows [22];
3. enable measurement of the circularity of materials by quantifying their in-use occupation [23];
4. improve recyclability of new buildings as well as making assumptions for materials arising through displaying embedded materials [17];
5. outstanding advantage regarding recycling and reuse [24];
6. digital interface composing a certified identity of a single identifiable product [25].

Unlocking the Circular Economy

Materials passports can be adopted at any point in the life cycle of materials, and for this reason may have **different levels of detail at different moments in time**.

In its simplest form, the passports hold **digital information** that may be available for an object. This could include aesthetic, performance, testing and certification, health and safety, operation and maintenance or environmental data [15]. Much of this information may already exist for new materials, but by consolidating this information in a single digital location, it enables the creation of a **database** where all of the information about the building is stored, organised and easily accessible to unlock circularity opportunities [4].

In the diagram below we highlight how some of this data may be gathered at different stages of a material's life and can be aligned with the different **scales of data collection**.

This list of data is indicative and can be **applied, reduced, or expanded according to each individual product, project and context**.

From this perspective, more than providing an identity to a material, **materials passports are used to organise the available data** to ensure that information does not get lost, and **travels** with the products/materials once they get deconstructed and reused.

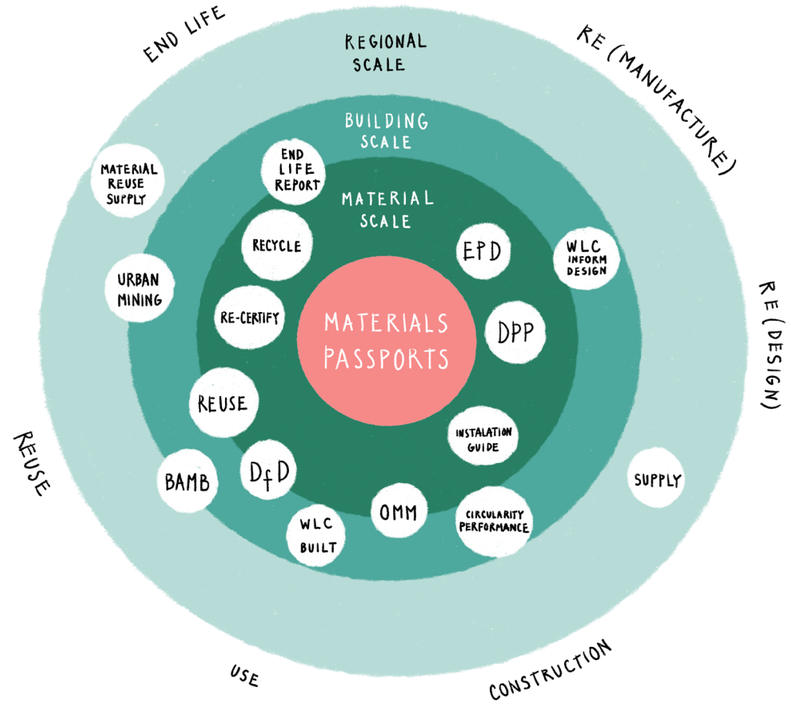

Figure 6 | *Contents of materials passports*

Materials Passports Framework

In practice the term **'Materials Passports'** is used to refer to many different types of digital passports which can have different characteristics. Similarly, the required information gathered for passports at different stages of construction may vary [20]. For instance, if we are creating **materials passports** for an existing building, it would be difficult to trace back the material properties and provenance. However, if we are producing new **materials passports** for a new build, we should aim for complete materials passports.

Based on the hierarchy **'levels'** proposed by Luscuere and Mulhall (2017) and referenced by BAMB [15, 16, 26], we propose the following Materials Passports **'types'**: Material, Product, System, Element and Building Passports.

Materials passports **'types'** are equivalent to materials passports **'levels'** in other frameworks. We prefer to use **'types'** instead of **'levels'** because it enables us to identify a category with similar characteristics, but that can also be independent and not necessarily integrated into a level hierarchy.

These proposed **types** are aligned with the **Uniclass classification system** [27] and provide a systematic approach to categorising materials across different projects and specialisms. The AEC industry is already widely using the Uniclass classification system for structuring specifications and data on BIM projects. By proposing an integrated **materials passports classification system**, we will be able to optimise the current practice and increase acceptance by all stakeholders.

In our proposed **types**, the materials (e.g. glass, aluminium) must have **material passports** and may be organised into components (e.g. glass panel) which may be catalogued with a **product passport** and then assembled with a **system passport** (e.g. window), which may ultimately fall within an **element passport** which in turn would be contained within a **building passport**.

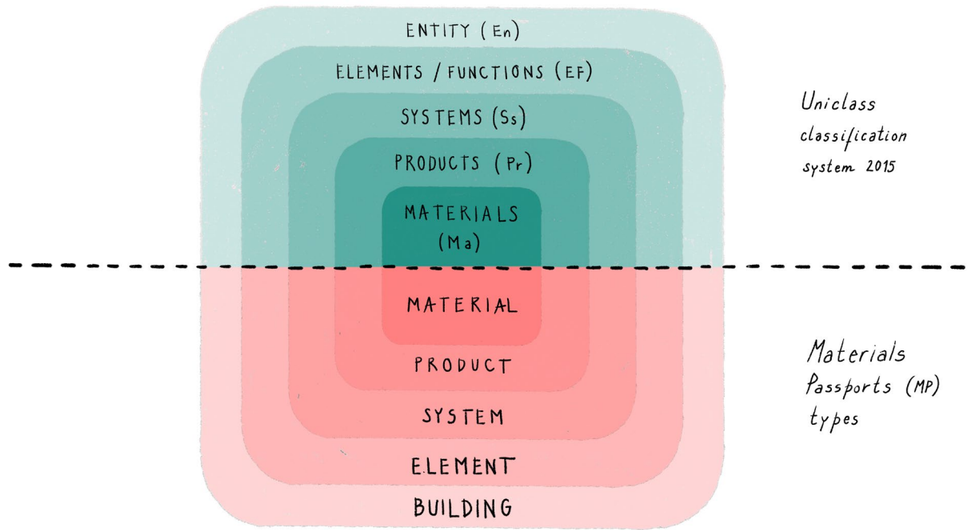

Figure 7 | *Materials Passports Types aligned with Uniclass classification system*

The **Materials Passports** types are:

Material Passports (MP) type fall under the Materials (Ma) category of Uniclass and are applicable to all of the individual materials and components that can be isolated and classified in a building. These can be nested under the other types of materials passports.

Product Passports (PP) types are aligned with Products (Pr) category of Uniclass. Product Passports can integrate multiple MP or be applied to individual products within a building.

System Passports (SP) types are aligned with Systems (Ss) category of Uniclass. System Passports normally integrate a combination of MP and PP. SP can be assembled onsite or offsite.

Element Passports (EP) types are aligned with Elements/Functions (EF) category of Uniclass. EP can integrate MP, PP and SP and are used for distinct elements with a specific function, e.g. building structure.

Building Passport (BP) type is aligned with Entity (En) category of Uniclass and it will integrate all the MP, PP, SP and EP referenced above and have complementary data that refers to the whole building, e.g. Golden thread information, deconstruction plan, energy performance certificate.

When the building is integrated in a wider complex, the Building Passports can be grouped as a **Complex Passport (CP)** type, aligned with Uniclass Complexes (Co). The building passport and/or complex passports can be integrated into a wider database gathered for a specific regional scale. The area of the regional scale should be defined according to existing political boundaries (e.g. Council/County) and or economic boundaries. The building passports can inform the **building cadastre**, an official record of the owners of land/buildings and be used to inform urban mining databases. The buildings at the regional scale are then presented as material banks [16] that will be made available in that area once they reach their end of life.

Basic Materials Passports

Data collection can be progressive. To accelerate material reuse in construction and facilitate the reuse of deconstructed materials, it is necessary to collect basic information that provides an identity to that material and avoids the material going to waste.

When creating Basic Materials Passports, the key information to be collected are dimensions, quantity and current condition.

This information can be gathered according to the **materials passports types** defined above, however they may not have all the data fields completed.

A pre-deconstruction audit is a good starting document which can be used to create Basic Materials Passports.

Once the material has been salvaged, the information in the materials passports can be updated. Further testing may be carried out to enable re-certification, demonstrate compliance with regulation and safety standards, or enable warranties to be procured. Materials passports should be seen as **live documents** that can be expanded or simplified according to the circular economy requirements.

A key recommendation of this paper is to 'start small' because doing something is better than doing nothing.

If the team is implementing materials passports for the first time, don't try to fully passport the whole building. Start by creating materials passports for a material/product/system with high reuse potential. Learn from that process and then expand the database.

Please consult the **Materials Passports Database** template (Appendix C) where the recommended minimum information required for basic Material Passports is identified.

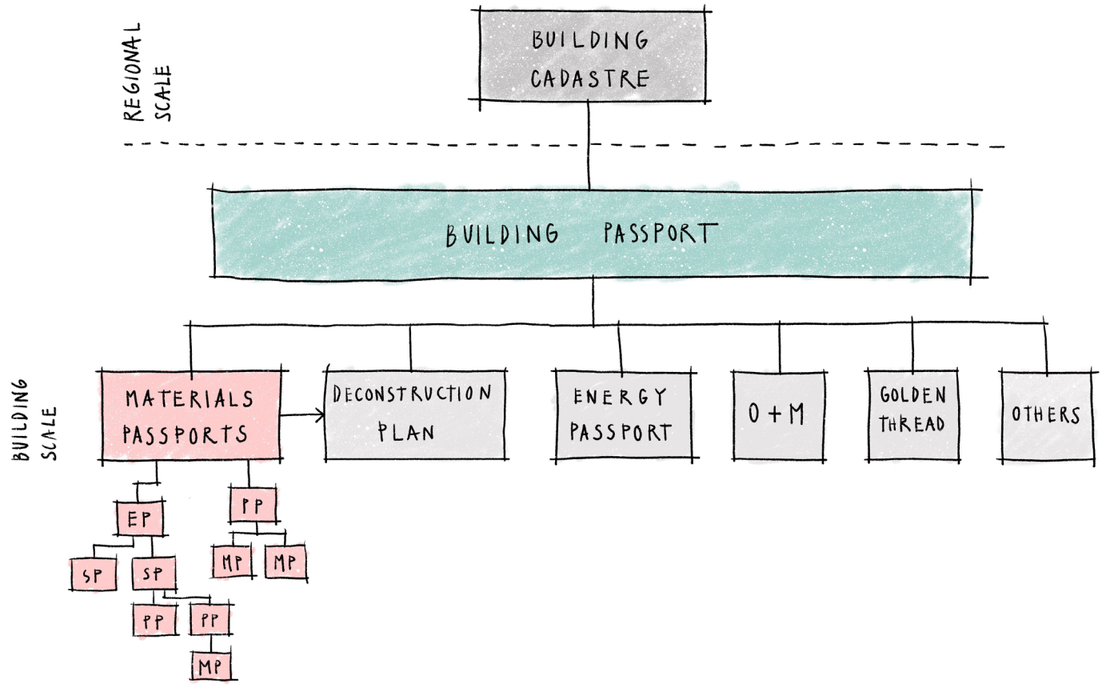

Figure 8 | *Building Passports: diagram adapted from 'Classification of materials passports from a building and regional scale' by Heinrich [10]*

Organising the Data

To ensure interoperability between systems, the data must be collected in an organised and standardised way.

The proposed process can be applied to **all construction projects**, from light touch refurbishments of existing buildings, through various levels of retrofit and to new builds on greenfield sites. For existing buildings, the process should be initiated during the design stage, enhanced during construction and result in a populated materials database for design teams of the future. It is recommended that the data collation is standardised to facilitate interoperability between projects, for sharing materials, normalising the process across the industry and enabling future interoperability between the numerous commercial platforms that are being created to facilitate this.

To create this data structure, we recommend the adoption of the already widely utilised **Uniclass classification system** [27]. Uniclass allows for information from all disciplines to be classified and is already a common deliverable on many BIM projects.

By adopting Uniclass, the building data is categorised into a multiple level hierarchy, separating the population of data into different levels of complexity, from **element passports** down to **material passports**. Uniclass can also be easily assigned to existing materials, products and systems as they classify what an object is, and this can be determined by visual inspection alone. This allows for a database to be built and a name generated for an item, without requiring much existing information at all.

The collation of digital information is a normal part of today's construction, as evidence of due diligence by all parties. This approach simply organises an existing process, in a way that maximises the benefit of data availability now and in the future. Linking the **digital object** to its **physical representation** is just an extension of this. It is already a common activity for facilities management teams to use **data carriers** such as QR codes attached to equipment to support the identification and maintenance of them.

We propose that all materials passports should have a **unique identifier code** aligned with the Uniclass classification system and BIM terminology. This unique identifier consists of the Uniclass code followed by a suffix denoting the type, and a suffix denoting the instance. Should neither of these suffixes be required, the fields can be left as XX.

Materials Passports types	Related term(s) in BIM	Uniclass Tables	Unique ID
MATERIAL PASSPORTS	Material data sheet	MATERIALS (Ma)	Ma_xx_xx_xx_xx_Type_Instance
PRODUCT PASSPORTS	Product data sheet	PRODUCTS (Pr)	Pr_xx_xx_xx_xx_Type_Instance
SYSTEM PASSPORTS	System data sheet	SYSTEMS (Ss)	Ss_xx_xx_xx_xx_Type_Instance
ELEMENT PASSPORT	Element data sheet	ELEMENTS/FUNCTIONS (EF)	EF_xx_xx_xx_xx_Type_Instance
BUILDING PASSPORT	Entity data sheet	ENTITIES (En)	En_xx_xx_xx_xx_Type_Instance
COMPLEX PASSPORT	Complex data sheet	COMPLEXES (Co)	Co_xx_xx_xx_xx_Type_Instance

Figure 9 | *Unique Identifier Naming Convention*

Project teams can select how to name their types and instances. For example, they may choose to follow the consultant's naming conventions, or alternatively GTIN numbers from barcodes could be used.

The materials passporting process is naturally suited for projects working to the **ISO 19650** BIM standard, where structured data collection is a project deliverable. But it is acknowledged that even with the growing use of BIM, **not every project will be a BIM project**. However this does not necessarily have to be a barrier to implementing and benefitting from the materials passports process.

By applying the proposed materials passports types, every project can have a **materials passports database**. This standardisation will enable the future use of the data stored in a material database and allow it to be integrated into a future BIM project. The Waterman Materials Passports Framework [20] contains a detailed analysis of the integration of materials passports on a BIM project. This may prove useful for teams aligning to ISO standards.

Circular economy data is often structured using the **Shearing Layers** or Building Layers approach. [28]

The Building Layers have been aligned with the **Building System Carbon Framework** which has been proposed by the World Business Council for Sustainable Development [29]. It can be used to provide standardised data. In the table below we highlight how the building layers can map to the materials passports types, which in turn can be used to structure a **deconstruction plan**.

To maximise future reuse potential, it is advisable that every completed project should have a **deconstruction plan** prepared alongside the already required Health and Safety file, and Operation and Maintenance manual.

It is recommended to create a **deconstruction plan** that considers the life expectancy of each building layer. This should also identify where the detailed information on how to deconstruct the element can be accessed through material passports.

MATERIALS PASSPORTS

BUILDING LAYERS	MATERIAL PASSPORTS	PRODUCT PASSPORTS	SYSTEM PASSPORTS	ELEMENT PASSPORT	BUILDING PASSPORT
STUFF	e.g. gravel	e.g. chair			
SPACE		e.g. carpet	e.g. partitions		
SERVICES			e.g. MVHP		
STRUCTURE				e.g. concrete structure	
SKIN	e.g. timber cladding	e.g. clading tiles	e.g. curtain wall		
SITE					

Figure 10 | *Materials Passports aligned to Building Layers*

Passports During a Material's Lifecycle

Materials passports are an essential tool to promote a circular economy and expand the lifecycle of the materials.

The diagram below presents the **lifecycle** of construction materials and the potential **life events** of materials passports, e.g. where the material goes once it has been salvaged. The materials passports should be regularly updated and used by different stakeholders across the building industry.

Extraction of Raw Materials

The basic principle is that a passport is created as soon as a material is 'born'. As that material travels throughout its life, its **material passport** remains with it. The material will likely become part of a product, system or building, and its material passport will be filed away. However, upon deconstruction of the building, system or product, the material passport may be re-examined for information, and the material may **travel** with it once again.

Once the raw materials are extracted, a material passport should be created which will store information about material's health, source/origin, material properties, financial value, certificates, environmental product declarations (EPD), modern slavery declarations and other characteristics considered necessary. This could be provided in a spreadsheet, to facilitate easy import to the material database. It could also be aggregated from pre-existing data sheets, declarations and certificates.

Note: *Figure 11 focuses on the materials lifecycle perspective and does not show the building's lifecycle.*

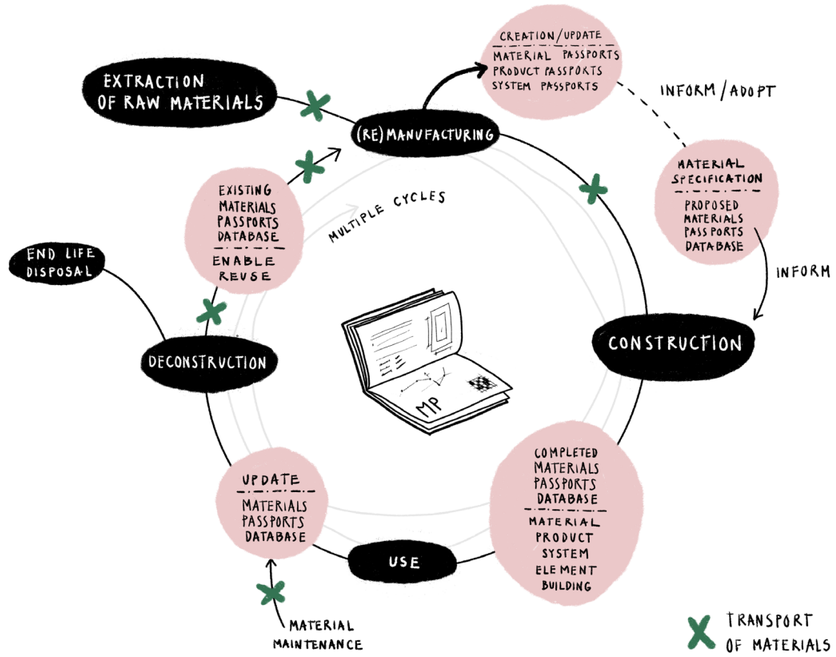

Figure 11 | *Materials Passports supporting a long material life*

(Re) Manufacturing

Many of these materials will likely be transported to a manufacturing facility that will transform them into a new component/product. At this gateway, the manufacturing company should update the **material passports** and/or create a **product passport** which contain or link to the previous **material passports**. These material/ product passports should have complementary information with assembly/disassembly guidance, EPD, user's manual and other characteristics considered necessary.

Designers and clients should refer to the relevant passport data at the design stage to **specify materials consciously** and make **ethical decisions** about the selected materials. Once a material passport becomes affiliated with a project, a placeholder should be created in the material database for later population with more detailed information.

Construction

When the materials are transported to a construction site, the **material passports** and **product passports** can then be integrated into the **system passports** and/ or **element passports**, depending on the specification and use of each material. A nominated party (contractor / materials passports consultant) should be elected and carry the responsibility for creating these passports and record information about the material's design, e.g. dimensions, size, location). Once the building is completed, a whole **building passport** can be created.

If the building is part of a broader context, a **complex passport** can be created to incorporate all the existing building passports on site.

The **distribution and transportation** information could be recorded within the passports to enable embodied carbon accountability. This would allow for improved calculation of the **whole life carbon** for those materials and establish comparison benchmarks.

Use

During the **use and maintenance** of the building, clients, technical teams and users can access the **materials passports database** to understand how to use the material / component / products / systems / elements and maintain them. Clients and users should be encouraged to update the passports within the database during their life cycle as they are repaired, refurbished and replaced.

Deconstruction

The Materials Passports database can be consulted before and during the **disassembly process**. The passports should inform the **deconstruction plan** and will be able to travel (physically and digitally) with the materials once they have been recovered. During this phase, the deconstruction contractor will be able to update the relevant passport to record the **recovery** of materials and products, their proposed **outcome** and next **destination**.

Materials Passports align with the digitalisation of the construction sector and provides a decentralised ledger approach system to ensure information is accurate, reliable, has a time stamp and a potential audit trail.

Creating a Materials Passports Database

The **Materials Passports Handbook** (Appendix B) provides detailed guidance for teams undertaking materials passports on projects.

Step 1: Identify the purpose of the materials passports

Understand **client ambitions** and **project opportunities** to develop an appropriate materials passports strategy for the project.

Step 2: Select a format and location for the database

Before creating the materials passports database, it is important to consider the **scope and scale** of the data that you wish to collate. Note that the materials passports database template provided (Appendix C) is in a **spreadsheet** format to enable flexibility for teams to adjust, and therefore encourage wider adoption.

While a basic spreadsheet is an excellent starting point and simple to use on **small projects**, this simple flat file database can quickly become unmanageable for **larger projects** or scopes.

There are many other ways of creating a database, by using **collaboration** software for BIM, **cloud based** services or a combination of the above to create a more sophisticated relational database.

A major advantage of these softwares is the capability to export the materials passports database into a spreadsheet at any point. This in turn permits **interoperability** between systems and **longevity** of the data archives. A spreadsheet format can be easily stored and opened into the future, mitigating some of the risks around long term data storage. It is also a common input for most database solutions, and material passport platforms.

Step 3: Understand how the database will be used

It is proposed that the database is used to create **itemised inventories**. The digital materials passports database contains the information about the **physical assets** within a building. These can be inputted into the database during its design and construction by the designers, consultants or contractors and supported by manufacturers or material suppliers. **Responsibility** for data population and checking for accuracy needs to be allocated to **nominated parties**.

The database should be accessed and updated throughout the building's life cycle, from design to demolition. If this is not possible, then an **archive** copy should be stored for use by future design teams. This can then be used as a basis for a validation survey by future design teams, prior to deconstruction.

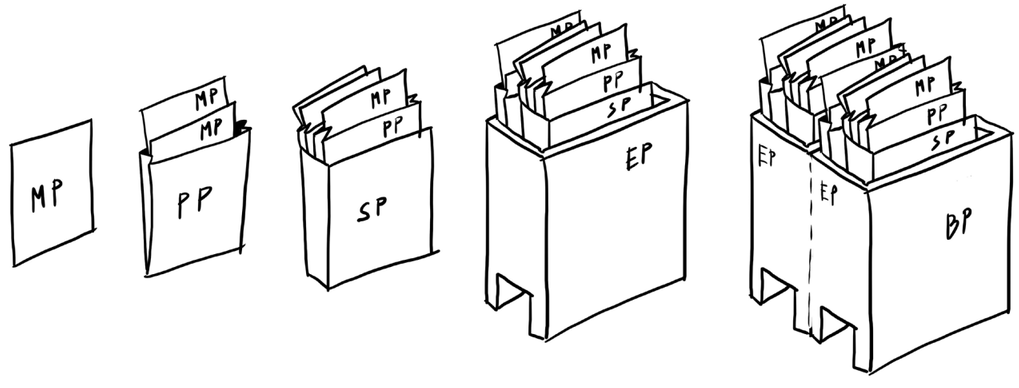

Figure 12 | *Material Passports, Product Passports, System Passports, Element Passports all filed into a Building Passport*

“Treating Buildings as Material Banks is seeing them as repositories or stockpiles of valuable, high quality materials that can easily be taken apart and recovered”

EU BAMB 2020 Research Group

Implementing Materials Passports on a Project

In the table below, we present an overview of how to accelerate material reuse in construction and use materials passports across the RIBA work stages [30], by treating **Buildings as Material Banks**.

When intervening in a site with existing buildings, at **RIBA Stage 0-1**, project teams should complete a Pre Redevelopment Audit to GLA Requirements [1]. This requires teams to carefully assess the existing building condition and identify development opportunities to maximise material retention and reuse. The potential integration of **reused materials** within the subsequent design proposal can be specifically identified and discussed with the client to ensure that this approach is aligned with client aspirations, values and requirements.

During **RIBA Stage 1**, the feasibility study should analyse how to maximise the potential reuse of materials and inform the project brief. If the site has an existing building, a pre-demolition or pre-refurbishment audit to GLA [1] and BREEAM [6,7] requirements should be procured to understand the quantity and quality of the existing materials and potential likelihood and options for reuse or recycling.

Existing information about the asset should be requested from the building owner and gathered from other sources such as previous tenants or previous design teams. Particular attention should be paid to as-built, record information and O+M manuals which often contain details such as the original data sheets and warranties. At this stage, the reuse brief should be included within the project brief.

During concept design phase, from **RIBA Stage 2**, the materials database should be created. If there is an existing asset on site, basic materials passports should be developed as the existing materials are studied to determine if they can be reused on site or off site.

For the materials to be **reused off site**, different levels of information may be required, depending on who is taking or buying these materials and how they are intending to reuse or commercialise them.

For the materials to be retained for **reuse on site**, more detailed surveys can be undertaken by the design team or relevant specialists. The available existing information should be reviewed and all relevant information **populated** in the

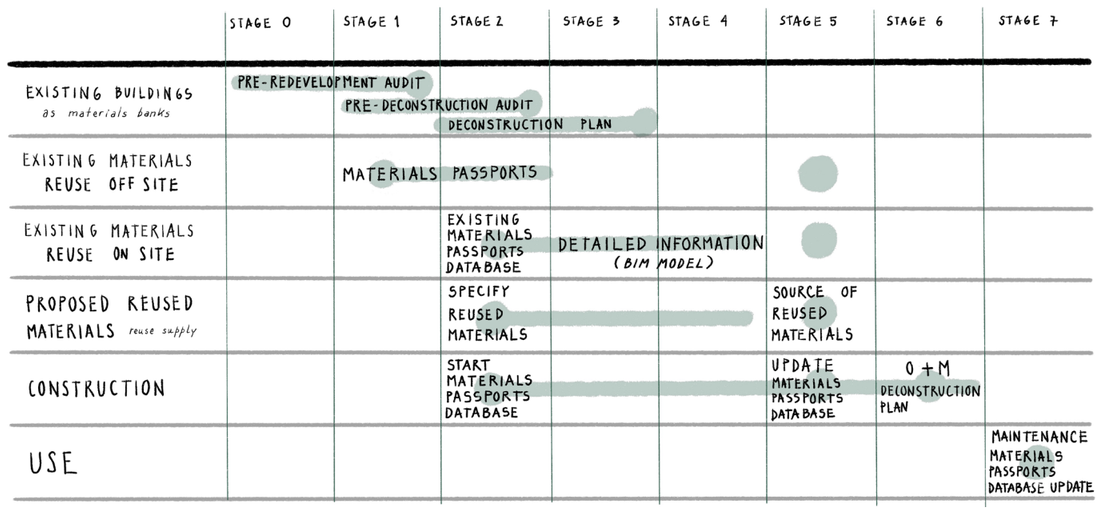

Figure 13 | *Materials Passports process within the RIBA Stages*

materials passports database. However, there may be limited data availability at this stage and some assumptions would be necessary. Depending on the location and function of the material, many types of information may be necessary to de-risk reuse, e.g. characteristics, aesthetics specifications, manufacturer details, disassembly guidance. At this stage, the design team and different stakeholders can define their **reuse brief** within the project brief strategy, a nominated party within the design team will be responsible for ensuring that the materials passports database is being populated as planned.

The materials may require an **advanced level** of information gathered from activities such as trial removal or performance testing. These materials can impact architectural and engineering designs and need to be spatially coordinated. As the design develops, the CAD drawings / BIM model need to reflect dimensions of the reused materials. Advanced information, such as current condition, needs to be considered but not necessarily incorporated into the CAD/BIM Model if it is recorded in the database.

Prior to submission of the **Planning Application**, a Materials Passports Strategy (Appendix A) can be discussed and developed for the project, and the Disclosure Page (Appendix D) prepared to reflect the strategy. These documents should be added to the application.

At **RIBA Stage 2** and **RIBA Stage 3**, the design team can take into consideration the reused materials available on the market, design for loose fit and specify reused materials to be incorporated in the design. The materials passports strategy should be implemented for all **proposed materials**, with the database expanded and populated as appropriate for the project. Creating **element** and **system** passports should be the focus at these stages.

Later, in **RIBA Stage 4**, these reused materials can be incorporated into the specifications as a first choice. An alternative new product specification should also be provided as a sister specification, for use if there are no reused materials available during **RIBA Stage 5**. Benchmarking and sampling of the different options should be requested, and a performance specification prepared, preferably with photographs explaining the acceptable aesthetic quality of the materials. **Early procurement** of the package may be required to ensure the design team has appropriate time to review and sign off sourced materials against the specification. **Product** and **material** passports should now begin to be added to the database.

During **RIBA Stage 5**, according to specifications provided, reused materials should be prioritised and the **contractor** should take on responsibility for the materials passports database. The database could be uploaded to a **materials passports platform** which may offer enhanced collaboration functionality. At this stage, contractors may consult designers to validate reused materials selected, the materials may require further testing and validation. As the works progress, **detailed information** is collected from sub-contractors, and the materials are **physically and digitally catalogued**, in accordance with the Materials Passports Strategy. By the end of **RIBA Stage 5**, the final BIM Model can be updated (if present), and the **materials passports database** should have achieved a comprehensive level of information - element, system, product and material passports should be available. This information can then be integrated into the Operation and Maintenance Manual (O+M) and inform **RIBA Stage 6** and **7**.

At **RIBA Stage 6**, the Operation and Maintenance manual can be prepared, and the population of the materials passports database completed. A copy of the database should be **archived** as a spreadsheet and may be uploaded to a chosen platform, and shared with the design team members and client. The **client** now takes responsibility for the database but may hand it over to a Facilities Manager for **RIBA Stage 7**.

During **RIBA Stage 7**, buildings are expected to be used and maintained efficiently. The materials passports information and BIM model can facilitate this process. **Changes** during this phase should be recorded within the O+M manuals, and in the materials passports database so that the information is kept up to date, for use in future retrofit, reuse and deconstruction phases.

Buildings as Materials Banks

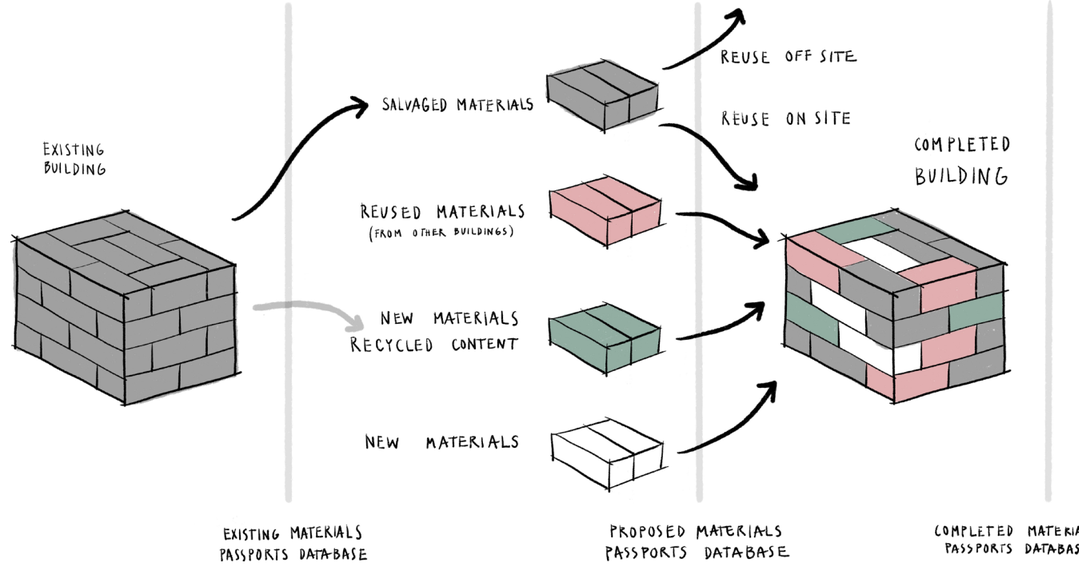

Figure 14 | *Buildings as Material Banks are enabled by Materials Passports*

By treating existing buildings as material banks, we can deconstruct the asset and enable the reuse of existing materials.

These materials can be reused **onsite or offsite**, ideally involving nearby sites and stakeholders. In this way we can extend the lifecycle of those materials and reduce carbon expenditure.

Currently in the UK, we do not have any **policy** that makes the deconstruction and reuse process mandatory. However, **encouragement** for deconstruction and preparation of end of life strategies can be found in BREEAM WST06 [6,7], which references ISO 20877:2020 requirement for a disassembly / adaptability manual [31] and GLA proposal for a pioneering end-of-life strategy [1].

Additionally there are a series of **case studies** and examples, mainly led by clients and designers (architects and engineers) that consider the cradle-to-cradle principles [32] and deliver a deconstruction process.

For an **existing building**, we propose that **basic materials passports** (material, product, system and element passports) can be created. However, the amount of data collected would be aligned with the reuse potential and it would be considerably reduced when compared with the data collected for new materials. Materials passports for an existing building are heavily **contextual**, affected by local conditions and each material's lifecycle. The amount of data required is influenced by different factors, e.g. market needs, stakeholders involved, building regulations and certification standards. As the **reuse market** becomes more capable and ambitious, **retesting bodies and recertification processes will be required** to deal with higher risk elements such as fire testing.

Taking the deconstruction of the Henri Sellier Buildings in Cenon, France [33] as a **case study**, the deconstruction plan enabled the creation of basic materials passports to enable reuse (e.g. Windows, doors, hand rails). The materials passports database was then shared with local stakeholders (e.g. architects, contractors, salvage companies) and used as a **digital interface** to facilitate the **material flows**. In this case, materials passports were used as a system enabler to connect different stakeholders and facilitate a circular economy [34].

The Facilitating the Circulation of Reclaimed Building Elements (FCRBE) project has created a series of useful **tools and guidance** to accelerate material reuse in construction [18]. This includes guidance on how to reclaim and reuse materials, along with a collection of detailed material datasheets. The Reuse Toolkit: the reclamation audit [18], provides an inventory template. This process of creating an inventory is equivalent to creating a **basic materials passports database**, with the advantage of recording the information in a way that is standardised and accessible to wider stakeholders. Furthermore, once the reused materials have been installed within the construction project, the initial materials passports can be easily updated/integrated.

A note on the Practical Implications of Material Reuse

Reuse is defined by ISO 20887 as the use of products or components more than once for the same, or other purposes, **without reprocessing** [31]. The option of reusing materials on site is the most carbon efficient solution as it minimises the carbon impacts of transportation. When using materials on site, it is imperative to understand how and when they need to be disassembled and where they can be stored during the refurbishment phase to be later reassembled. Consideration should be given to:

- **insurance** during the works and in operation,
- **on site logistics** to avoid the materials getting in the way,
- **protection** to ensure they are not accidentally damaged by construction activities or associated risks such as water ingress
- **potential for refurbishability**, as defined by ISO 20887, is the ability to restore the aesthetic and functional characteristics of a product, building or other constructed asset to a condition suitable for continued use [31]

When reusing materials off site, these can be bought or collected by a reseller company to be later commercialised and purchased by, or donated to, another building under construction.

Repurposing materials for another use is also a viable option, which can mitigate some of the risks associated with reuse. For example, a fire-rated door may be **repurposed** as a tabletop or decorative finish. While it is beneficial that the material is kept in use, it must be recognised that this is a **lower value** use and therefore reuse should always be prioritised over repurposing.

This is valid, not only for existing materials but also for new materials. If we do not have reuse practices in place, despite having materials passports in place, the materials cannot be reused. There are several **material reuse** strategies, stakeholders and processes that can facilitate material reuse. For example, Take-Back Schemes (lease / for reuse / for recycling), Material Reuse Schemes, Salvage Companies, Material Sharing Platforms.

According to our consultation, there is no need to create a new supply chain or **digital material reuse marketplaces** to facilitate material reuse in construction. While these reuse marketplaces are helpful as a starting point to demonstrate demand and enable case studies, they are better suited to domestic scale projects. Instead, we should be adjusting and adopting the **existing supply chain** to integrate reused materials and make this process as natural as possible. This would help us to reduce storage costs and create a more **resilient** market, capable of adapting and supplying reused materials as the new normal. It would also encourage the supply chain to consider future reuse, and design products to enable this.

A Roadmap to a Materials Passports Enabled Circular Ecolony

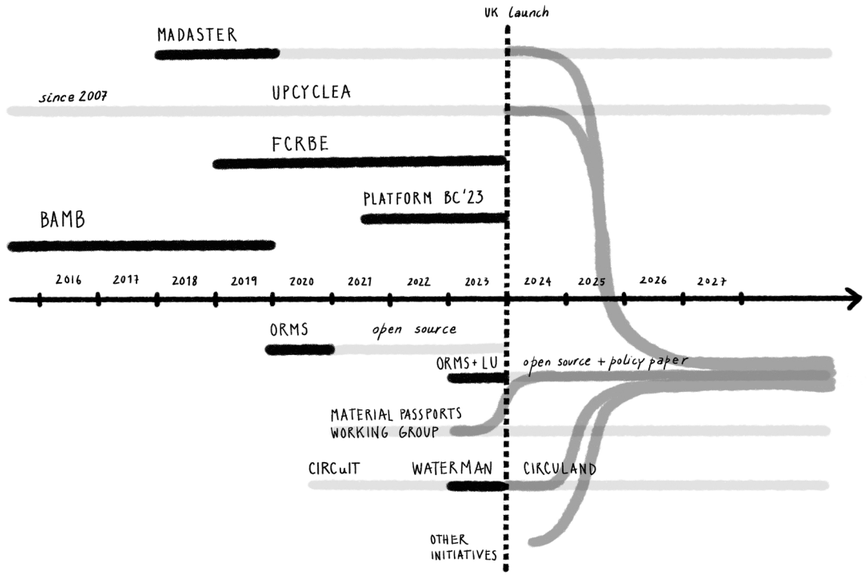

Figure 15 | *Roadmap to Materials Passports Adoption*

Based on the information provided in the previous sections, we propose that from 2025 onwards, every construction project should have materials passports as a key deliverable.

By using the proposed **materials passports database template** (Appendix C), we will be able to gather data in a semi-standardised way, which opens up the opportunity to create **interoperability** between the platforms. The proposed methodology allows users to gather data according to the level of information available, capacity and level of experience of the team, project programme and budget constraints.

This will facilitate the AEC industry to have a common understanding and implementation of materials passports. But it will also require stakeholders across the AEC industry to come together and work **collaboratively** to implement materials passports and maximise all of the potential opportunities that materials passports present.

It is acknowledged that many local authorities may already have policies or preferences in place for materials reporting, and a consultation and alignment piece may be required to support the proposed standardisation.

This paper outlines a process that can be followed by all projects, irrespective of scale and experience. Supplementary templates and tools have been developed as an **opensource resource** to support the process. The utilisation of a **cloud-based database** programme can facilitate organisation and linking digital passports to physical passports. However, this process is still somewhat manual, and is designed to be **adjusted** to the project team's requirements.

In the UK two existing platforms are commercially available to create and store materials

passports; Madaster and Upcyclea. The Building Passport platform is also available in the UK, currently dedicated to supporting delivery of Golden Thread requirements, but can potentially integrate materials passports. These subscription-based services offer enhanced automation, data management and graphical outputs plus additional bespoke benefits. Many clients may opt to use these, particularly for management of a portfolio of information. The process outlined in this guidance is a natural input for the platforms, and the platforms have provided valuable input into the Orms led **Material Passports Working Group**.

We are keen to see the development of an **interoperability agreement** between the platforms, to ensure that the data can easily port between platforms, if for example a building is sold to a user of another platform. This guidance starts to articulate the structure of the information to facilitate this process.

Future research should focus on **Materials Passports Data Sharing and Storage**

There are many benefits to providing a **centralised data storage system** where materials passports data is stored securely and shared at a regional or national level.

But such an approach raises many questions:

- Who owns the data?
- Who stores the data?
- How can it be shared at a regional or national level to facilitate liquidity in the materials reuse market?
- What are the data security and privacy considerations? And how can they be overcome?

Currently, the European Union is working on a **Digital Product Passports Framework** and some of the storage issues will be similar [35].

Furthermore, a 'Spanish-Norwegian Consortium supported by a large group of industry stakeholders will conduct a feasibility study on an **EU database** defined in the future Regulation for **Construction Products**. The objective is to define a system for a digital product passport considering the need of digital information from regulators, manufacturers and other actors in the construction value chain.' [36].

This will likely assist with the standardisation of **datasheet** information produced by manufacturers. This is beneficial in establishing minimum data inputs which will in turn support the rigorous population of the database and better enable future automation opportunities.

Stakeholders across the AEC industry have differentiating needs for data, yet the **exchange** of data and its supporting infrastructure for closing **resource loops** remain at low maturity [35].

From a UK legislative perspective, the development of the **Golden Thread** - a requirement to store digital information safely to improve building safety - establishes a process to organise and store data which could be expanded upon for sustainability purposes.

There is an advantage in utilising the capabilities of **enabling digital technologies**, e.g. scanning systems, artificial intelligence, machine learning, additive/ robotic manufacturing, blockchain technology, geographical information system [37] [38] [39] to support data collection.

However, 'multiple perspectives must be considered when DPPs are designed and implemented to achieve the overarching goal of **sustainable material flows**, energy use, and reduced emissions.' [40].

What Needs to Change?

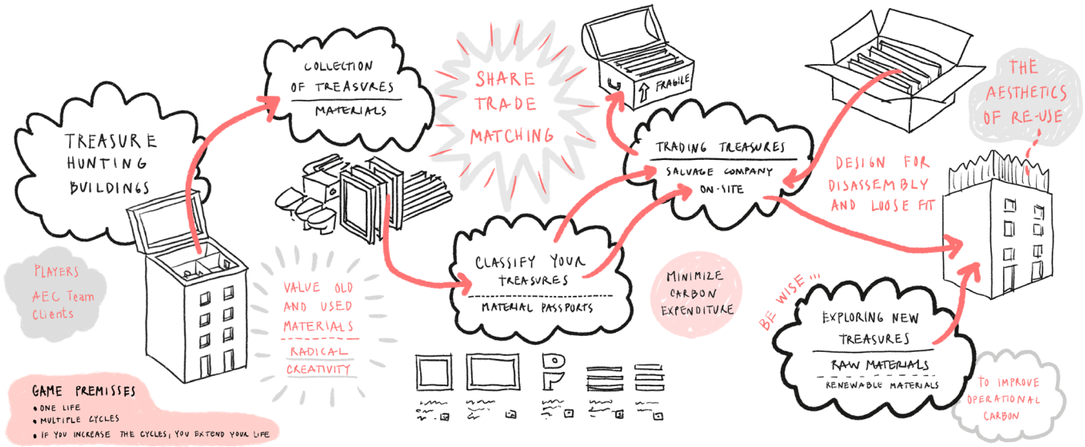

Figure 16 | *Searching for treasures*

The industry has already seen a dramatic step change in the consideration of sustainability principles and development of detailed **sustainability strategies** on construction projects. However, frustratingly these strategies don't always come to fruition as barriers around cost, time and risk still stand in the way. There is also an absence of a feedback cycle for data from buildings in use, which is critical to address knowledge and performance gaps.

The Government has largely relied on industry leading the way in demonstrating how **Net Zero targets** can be achieved.

A number of local authorities have spearheaded circular approaches through local policy which has led to the production of **Pre-Redevelopment Audits** and **Pre-Deconstruction Audits** to inform a **Circular Economy Strategy** for the project.

In the coming years, **as-built data** will start to accrue within the GLA and local authorities that have been requesting it. It is imperative that the **learnings** from this are shared with industry to improve knowledge and technique, rather than being used to criticise.

The prevalence of numerous **research groups** producing detailed guidance, and the **voluntary adoption** of such guidance has demonstrated the level of demand and interest within the industry itself. It also demonstrates that the most successful way of achieving Net Zero is to openly collaborate in a coordinated way.

By introducing encouragement through **local policy**, in the first instance, we can help trigger this widespread adoption of materials passports.

The **recommendations** in this paper enable design teams to demonstrate their ambition and strategy with full transparency, through two manageable deliverables – a **Materials Passports Strategy** and **Disclosure Page** - that local authorities can take into consideration during the planning process.

Underpinning all this work is the creation of the comprehensive **Materials Passports Database**, and starting the conversation about how the power of this data could unlock the circular economy.

Through adoption, the process and methodology recommended in this paper will naturally be adjusted

and revised to suit the various building typologies, local contexts, and realities of each project. This can then be written into future **Standards and Legislation**, to ensure consistency on all projects.

As a society, we must start treating **materials as treasures** and accelerating material reuse.

This starts with considering all **buildings as material banks**, which can be unlocked by the adoption of **materials passports**, the evolution of the **supply chain** to actively pursue material reuse, the adaptation of **infrastructure** to support the logistics and the creation of a **materials passports database** for all buildings.

Pioneering project teams and clients can lead the way by adopting the recommendations within this report, and demonstrating their exemplary performance to local authorities.

Policy makers have an opportunity to welcome the recommendations of this report, invite such pioneering strategies from applicants and collaborate with industry to support the evolution of materials passporting for projects.

On this basis, we propose that from 2025 onwards, every construction project should have materials passports as a key deliverable.

We make this recommendation with the understanding that the industry will need time to **upskill**, **debate** and **collaborate** to agree methodology and establish best practice.

It may mean that **materials passports databases** start out small, but these should focus on implementing **meaningful circularity strategies** and most importantly, prioritise **material reuse**.

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Appendix A : Materials Passports Strategy Guidance

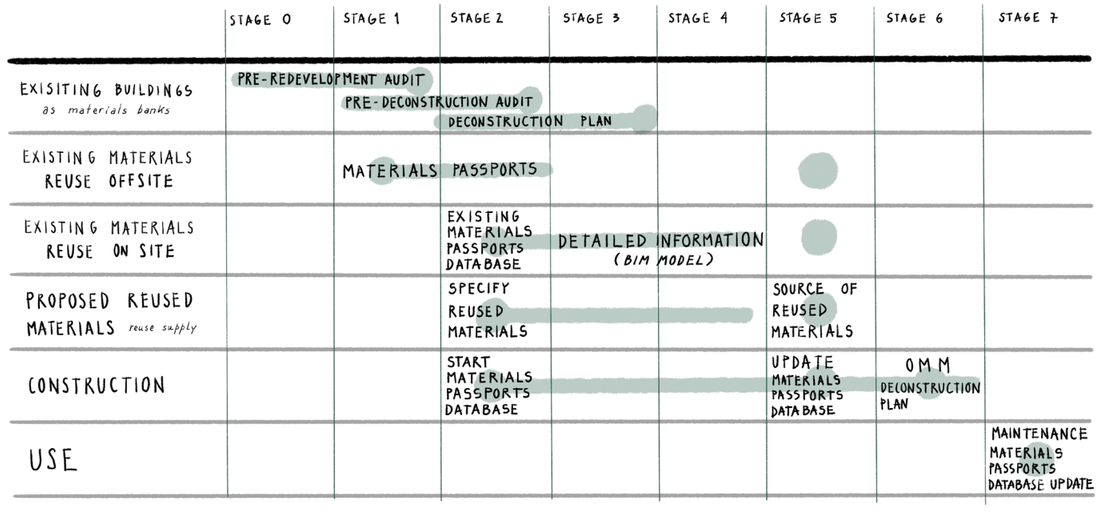

Figure 13 | *Materials Passports process within the RIBA Stages*

Before implementing Materials Passports, a strategy must be developed. Figure 13 illustrates the recommended process that should be followed throughout the RIBA stages.

However, it is recognised that projects will differ, and this process should be adapted by teams to best suit the needs, capabilities, ambitions and opportunities that each project presents.

The Materials Passport Strategy should clearly outline the aims, process, deliverables and responsibilities for delivering the Materials Passports on the project.

The strategy should be developed in collaboration with the design team and client, and focus on producing a meaningful deliverable that will either improve the deconstruction of an existing asset, construction of the proposed asset or future deconstruction of the proposed asset.

If a team are presenting the project to a local authority as an exemplary project because of the materials passporting strategy, a written summary of the strategy should be prepared and submitted at planning. For teams not pursuing planning, it will still be useful to prepare the strategy document. The written strategy may be developed as a standalone document, or included within a section of the main sustainability statement / report.

Suggested contents are provided below, to support teams in building a robust strategy:

Introduction:

- Explain the client requirements and aspirations for materials passports.
- Consider the client's wider portfolio, if applicable, and how the strategy could affect or enhance this.

Project Information:

- Confirm if a pre-redevelopment audit and pre-deconstruction audit (pre-demolition or pre-refurbishment audit) have been completed for the project. If so, articulate the opportunities identified.
- Identify project opportunities for materials passports. This should prioritise the gathering of data for materials with high reuse potential, high carbon and/or high residual value.
- Project deliverables. At a minimum this should include a materials passports database for the proposed materials. Ideally it would also include basic materials passports for any existing materials, if applicable. A deconstruction plan is also recommended, both for deconstruction of any existing assets (if applicable), and the proposed asset in the future.
- Confirm if the project will be pursuing BIM, and how the materials passporting process will be incorporated into the BIM process and documentation.
- Explain how the expected deliverables will be used to improve the deconstruction and construction process to accelerate material reuse on the proposed project.
- Explain how the expected deliverables will be used to improve the future deconstruction of the proposed project.
- Explain when the deconstruction plan will be prepared, and how it will be used to improve project circularity outcomes.

Digital Passporting Strategy:

- A digital passporting strategy should be developed with the client and wider design team. This may be developed over a series of workshops, or as part of the BIM briefing process if applicable.
- Teams should start by reviewing the spreadsheet template, and broadly scoping the different passport types within the project. Then the relevant data points should be identified for collection.
- Discuss the long term data strategy. Involve client operations teams wherever possible, to ensure that the data is organised in a way that is compatible with the likely Facilities Management strategy. Will the data be kept live and updated by the FM team? Or will it only be used for design and construction, then archived?
- Decide how the data will be shared during the design and construction process, and at what frequency. How can the team collaborate on this?
- Decide where the data will be stored during design, construction and operation. What format will it be held in?
    - The simplest option is using the spreadsheet in its current format. This is challenging from a collaboration perspective so it may be necessary to create supplementary 'mini' databases for each discipline to amalgamate at the end of each work stage, or host the spreadsheet on onedrive or equivalent.
    - A low cost option with better functionality would be to use a collaboration cloud based tool such as Airtable, which is described in the Materials Passports Handbook (Appendix B). If using a software such as Airtable, login details will need to be provided for each of the disciplines.
    - A more expensive, but more sophisticated option would be to use a subscription based materials passports platform, such as Upcyclea or Madaster which are currently available in the UK.
- Include a timeline for when the data points are due to be populated. For example, at Stage 2, focus on Element and System passports which may only include the Uniclass and Material Type fields. Start to include Product and Material passports, and add aesthetic and performance data from stage 3 / 4 as appropriate for the design evolution, with full data population expected at stage 5. Consider when is the most useful time to collect the data, and how it can positively shape the design and construction process.

- Nominate who will be responsible for gathering and populating the data, and who should be reviewing the data for accuracy. Each of the design team consultants should take responsibility for the materials within their discipline, so that the process of gathering and reviewing information can support design decisions. A sustainability consultant can take on responsibility for managing and supporting the process. During construction, responsibility should be shared with the contractor and sub contractors as appropriate.

- Ensure that copies of the database are distributed to the team and client at practical completion, as archives for future design teams.

Physical Passporting Strategy

- Although not strictly necessary, the introduction of a physical passporting strategy is highly recommended, as it provides a clear link between the digital and physical object.

- At a minimum, objects should have a simple label affixed with the unique identifier printed clearly. This enables someone to read the unique identifier, search the database and quickly locate the data. The label can be supplemented by a data carrier.

- Data carriers allow for a direct digital link between the physical object and the digital passport. Agree if, and which, types of data carriers will be used (QR codes, RFID tags, NFD tags). A mixture of types may be appropriate eg QR codes for FF&E, RFID tags for MEP.

- Consider the accessibility and visibility of the data carrier. On the simplest level, the presence of a QR code may encourage someone to scan it on a phone in the future. The data carrier should complement the FM strategy for the building, so it is more likely updated by the FM team during operation. Consider the longevity of the data within or connected to the carrier. For example, QR codes could fail if the licence for the hosting platform is not maintained.

- Identify what systems / products / materials will be receiving labels and data carriers and when. It may be logical to tag furniture for example, but not for walls. MEP systems typically receive tags at a frequency, e.g. every 5m of duct length.

- Specify the requirements for the physical labels and data carriers in the specification for each discipline. Consider the size and placement of these, to ensure they will be found but without being visually intrusive that they may be removed by a building occupant.

Appendix B : Materials Passports Handbook

The following document has been prepared to support teams to develop the Materials Passports Database. It utilises the database template provided.

Materials Passports Handbook:

Creating a Database

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Orms Lancaster University

This Handbook has been produced as an output from a complementary research project funded by the Lancaster University Data Science Institute, in connection with a Materials Passports Data Research Workshop hosted at Orms in July 2023.

Disclaimer:

The authors of this paper have been using a cloud based database solution provider called Airtable to develop the materials passports database for projects.
The authors of this paper and their organisations (Orms and Lancaster University) do not have any partnership/commercial agreement with Airtable. The recommendations provided are solely based on our experience as Airtable licenced users/ clients.
This product was originally selected by Orms for its simple functionality and ability to provide proof of concept at an affordable price. There are numerous alternatives available, and teams are actively encouraged to explore these.

Introduction

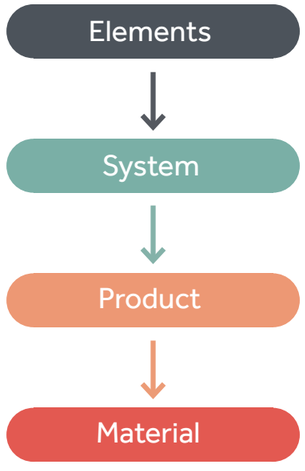
The process outlined in the Handbook is intended to support teams in establishing a Materials Passports Database, in line with the recommendations of the paper and using the templates provided. The Handbook offers a brief description of the functionality of the Airtable software, and demonstrates examples of how the data is structured, organised and populated.

Connecting the database to BIM models

The 2021 Orms research demonstrated a proof of concept for connecting the Airtable database to Revit. While this is still a viable process, in reality it hasn't been widely adopted as teams have naturally kept most of the information in the database and only selectively importing key information to Revit.

Switching from open source database to platforms

Teams may use the templates to establish a database in Airtable at any point of a project, and may choose to later transfer the database from Airtable to another Materials Passporting platform such as Upcyclea or Madaster. This can be facilitated by using the csv import and export function within Airtable.



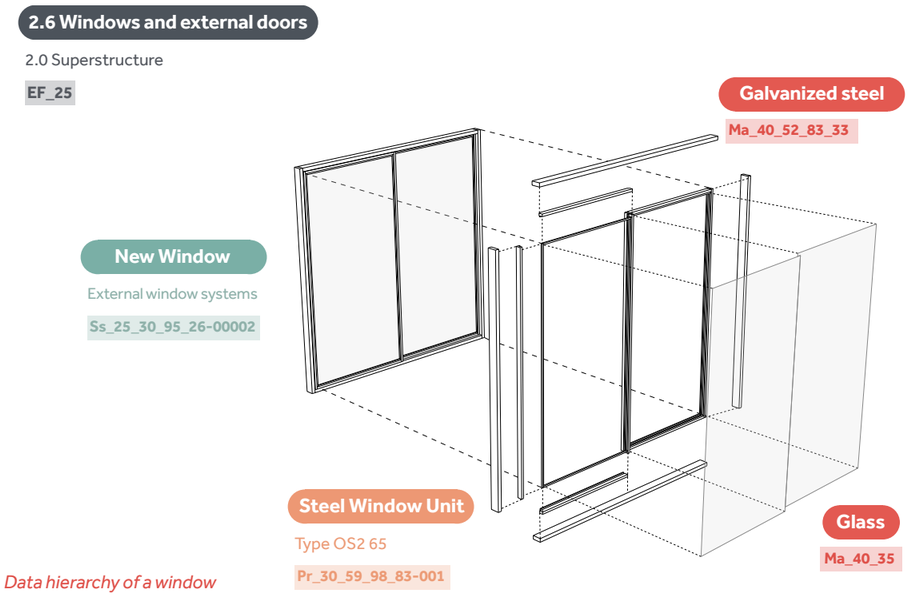
Materials Passports Types

Database template

The database template is set up for a typical project. It is structured to capture data from the pre-demolition audit, and then be expanded to include data on the new elements, systems, products, and materials being added to the building.

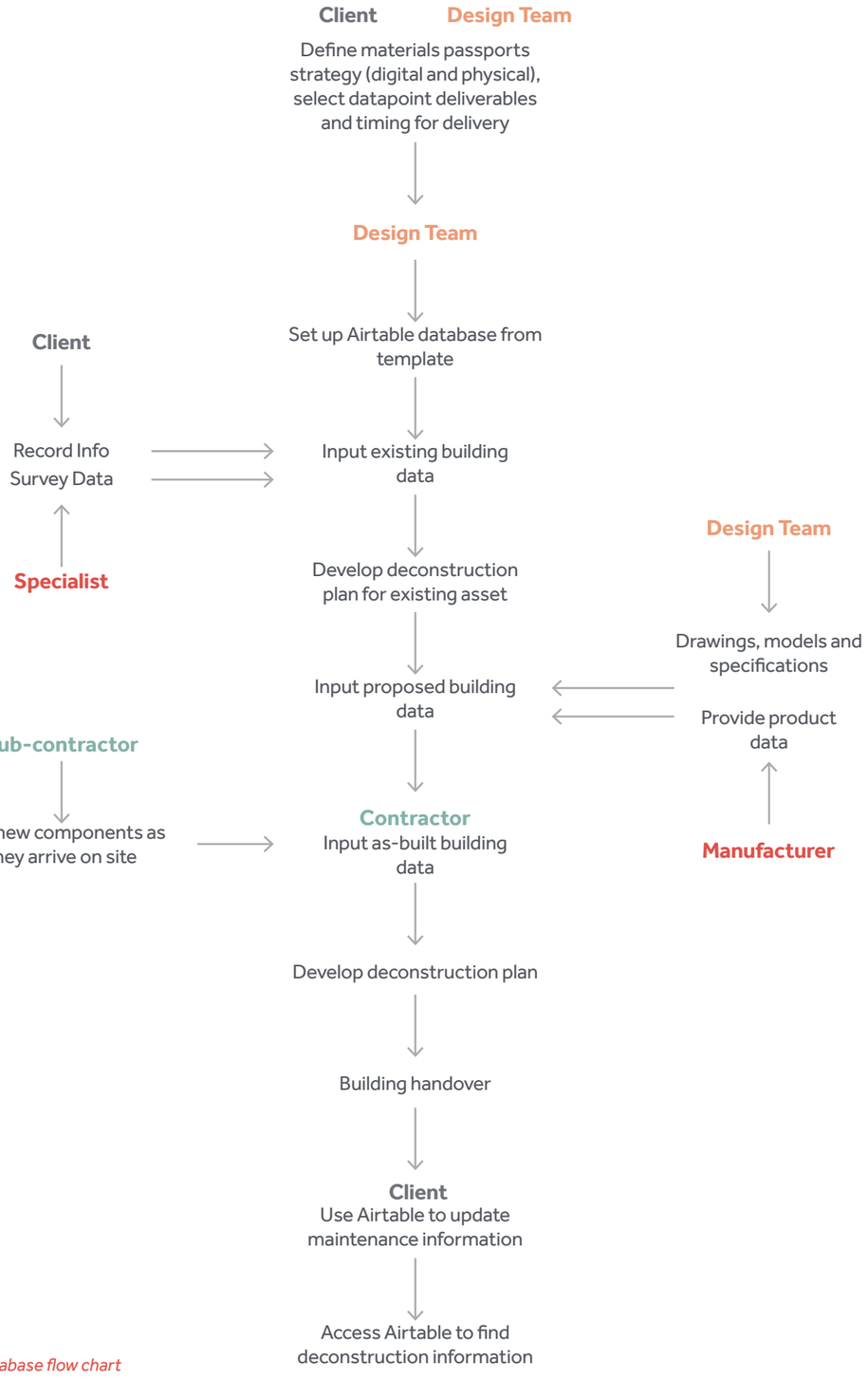
Data hierarchy and passport types

The graphic below illustrates how the data hierarchy can be applied to a building. In early design stages, it may be appropriate to prepare just element and system passports, with product and material passports following on as the design develops.



Data hierarchy of a window

Creating a Building Passport Database

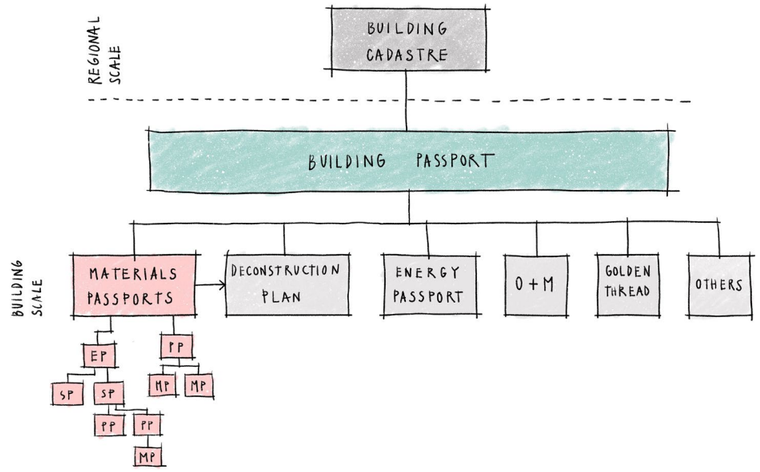


Building a database flow chart

Data Structure

Building Passport

At the moment, the whole database is considered to be the building passport. It is likely that a summary page will be developed in the future. Two additional sheets have been developed with their own sets of data points, to capture key building information and energy passport, which will also be developed further.



Element Passports

The Element Passport is structured using the RICS NRM1 Format. This allows it to align with Whole Life Carbon reporting, and the Building in Layers approach. The element passport also has its own set of data points, which are aligned to the disclosure page and the deconstruction plan contents. It is recommended that the element passport is used as the basis of the deconstruction plan. The element classification follows the Uniclass classification system which is explained in further detail on the next page.

Group Element	Element
1 Substructure	1.1 Substructure
2 Superstructure	2.1 Frame 2.2 Upper floors 2.3 Roof 2.4 Stairs and ramps 2.5 External walls 2.6 Windows and external doors 2.7 Internal walls and partitions 2.8 Internal doors
3 Internal finishes	3.1 Wall finishes 3.2 Floor finishes 3.3 Ceiling finishes
4 Fittings, furnishings & equipment	4.1 Fittings, furnishings and equipment
5 Services	5.1 Sanitary installations 5.2 Services equipment 5.3 Disposal installations 5.4 Water installations 5.5 Heat source 5.6 Space heating and air conditioning systems 5.7 Ventilation systems 5.8 Electrical installations
	5.9 Fuel installations 5.10 Lift and conveyor installations 5.11 Fire and lightning protection 5.12 Communication, security + control systems 5.13 Specialist installations 5.14 Builder's work in connection with services
6 Prefabricated buildings	6.1 Prefabricated buildings and building units
7 Work to existing buildings	7.1 Minor demolition and alteration work 7.2 Repairs to existing services 7.3 Damp-proof courses/fungus and beetle eradication 7.4 Facade retention 7.5 Cleaning existing surfaces 7.6 Renovation works
8 External works	8.1 Site preparation works 8.2 Roads, paths, pavings and surfaces 8.3 Soft landscape, planting + irrigation systems 8.4 Fencing, railings and walls 8.5 External fixtures 8.6 External drainage 8.7 External services 8.8 Minor building works and ancillary buildings

NRM1: New Rules of Measurement

System, Product and Material Passports

The system, product and material passports are structured using the Uniclass format, and share a common set of data points. Further detail on the selection of data points contained within these is available in Appendix C: Materials Passports Database template.

Uniclass: Delivered by NBS Chorus

Uniclass is a unified classification system for the built environment covering all sectors and roles, delivered by NBS. It provides classification for all stages of a project from concept, design and construction, in-use asset management and FM, development and re-use, demolition, and land management.
Construction projects contain large amounts of data inputted by numerous stakeholders, which can lead to confusion, mistakes, and discrepancies in data on the project documentation and specification. The Uniclass classification system helps to organise and manage large amounts of information related to the built environment, by keeping the organisation of data under one logical structure that is identifiable by a range of stakeholders. This improves communication and minimises discrepancies between different stakeholders on the project.
The classification system is comprised of a set of tables which each contain a set of codes that are used to categorise different items. Designers can also use Uniclass codes to structure building specifications in platforms such as NBS Chorus, which can be used to link specifications to 3D models and drawings. Construction manufacturers can classify their products using the system, making it easier for designers to find and categorise products within their specifications.
The different tables within Uniclass align with buildings layers; site, skin, structure, services, space, stuff, and system and are highlighted in the diagram below.
For the Materials Passports Database we will use the Elements/ functions (EF), Systems (Ss), Products (Pr), and Materials (Ma) tables.
The current NBS tables are included within the template, however these are regularly updated. Before starting a project, please download and replace with the latest tables. Available at: www.thenbs.com/our-tools/uniclass

AC Activities	Co Complexes	En Entities	SL Spaces/locations
EF Elements/ Functions	Ss Systems	Pr Products	TE Tools and Equipment
PM Project Management	FI Form of Information	Ro Roles	MA Materials
PC Properties and Characteristics	Zz CAD		

Uniclass Tables

NBS Chorus

NBS Chorus is a cloud based, construction specification platform. Designers can use NBS specification writing software to generate structured and accurate specifications.
NBS Chorus creates specifications that classify the parts of a building and construction project using the standardised Uniclass codes. Items can be easily searched for using either a brief description or their Uniclass code improving the accuracy and efficiency for all stakeholders involved with the project.

Data Structure

Using Uniclass throughout the Project

By applying Uniclass codes to the building objects, the building data is categorised in hierarchal levels, separating the population of data into different levels of complexity, from building elements down to materials. Uniclass codes can be assigned to the new or existing elements, systems, products, and materials of a project.

Specification using Uniclass

Uniclass extension for Revit

Uniclass is compatible with BIM projects, and can be added to most BIM / 3D modelling softwares using a plug-in, ensuring digital objects are appropriately classified. This enables projects to be 'read' by softwares, for example when uploading to a materials passports platform and also allows for cross-referencing the materials passports database.
Quantities and statistical information of the building layers contained within the Revit model can be linked to the classification system, by assigning every item with a unique code. The statistical information included in the Revit model can also be downloaded, creating a spreadsheet that can be imported into Airtable.

Classifying a model

Getting Started in Airtable

Airtable: A Cloud-Based Platform for Creating Databases

Airtable is a centralised data platform that can be used to create itemised inventories. We are using it to create a database that contains information about the assets within a building, inputted into Airtable during its design and construction, by the nominated parties - typically designers or contractors. The database can be accessed through the building's whole life cycle, from design to demolition, as long as a subscription is maintained. A csv file can be downloaded at any time from Airtable, as an archive or as an input to a Materials Passports platform

Airtable provides a relational database which allows for the connection of data across multiple tables, this is particularly useful for creating the different types of passports. The material passport is linked to the products, linked to the systems, through to the building elements, creating a flow of information through the database.

Accessing Airtable

Please start by going to airtable.com

Users will first need to create an account and select a pricing option. There are a number of tiers of pricing, each offering improved levels of functionality, scale of storage and support solutions. A free plan is available, which is useful to trial the software but it would be likely that the one of the paid-for plans would be required.

While the different pricing options do offer bespoke support, Airtable offers very good free resources. Detailed user guides can be found in the Help Centre, this can be accessed at: support.airtable.com. The Resource Centre has a number of webinars which may also be useful: www.airtable.com/lp/resources

Setting up a Database

Once logged in, a 'workspace' will need to be created, then databases or 'bases' can be created within the workspace. Workspaces have a sharing restrictions feature which is useful to manage access for collaborators. Bases can be moved between workspaces.

A 'base' should then be created for the project. Click the 'create base' button, and go to the 'getting started' side bar on the right. Use the 'import your work' function and use the 'excel' option to upload the database template. Airtable will process the document and offer a preview of how it is mapping the data. Review this preview and adjust if necessary using the bar at the bottom of the page. Then click the 'import' button. Now you have the template in Airtable. You might have noticed that Airtable offers their own templates in the 'getting started' side bar. It might be useful to create a few bases from templates to explore the different functionality.

Navigating the Base

The User Interface

The base is structured around a series of 'tables' which would be called 'sheets' in excel. The import function should have mapped each of the sheets in the template to a table, with the name of the sheet now appearing in the 'table headings'

The columns in Airtable are called 'fields'. Each of the data points in the template should have mapped to a field. The primary field should always be the unique identifier.

The rows in Airtable are called 'records'. Creating a new unique identifier will create a new record.

Database Title

The title of the database is chosen at the beginning of the project when the database is created. The title should relate to the name of the project that the database is for. This may be standardised in future.

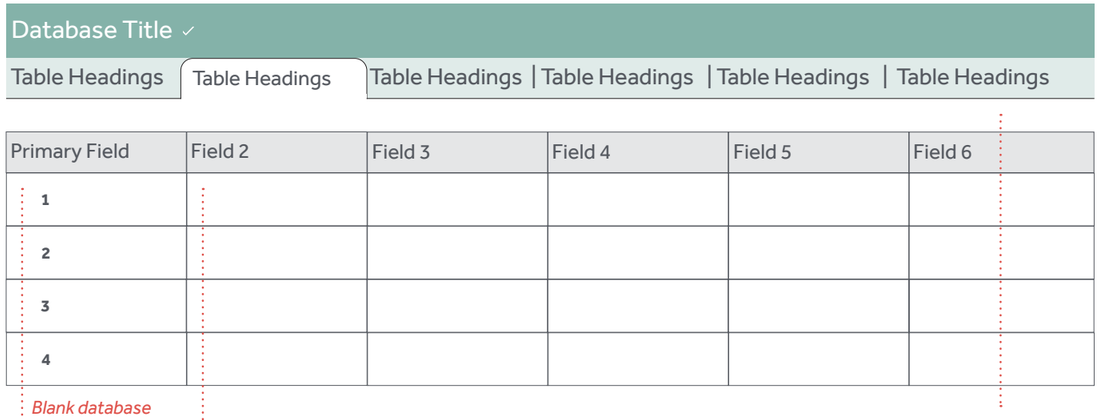


Table Headings

Within the database, different tables can be created to contain organise information about the building. This separates data so it easier for the user to locate and read.

The tables can be linked together, connecting related data on different tables.

Within the template there are different tables of data for each passport type, plus the tables for the building passport. The table headings include; element passport, system passport, product passport, and material passport. A table for basic building information and energy passport is included to support the use of the database as the building passport. Copies of the uniclass tables have also been imported to facilitate referencing. These are regularly updated by NBS so the latest tables should always be downloaded at the start of a project.

Fields

Fields in a database store record of the same data type in columns. The fields on Airtable store different 'types' of data including, text, attachments, checkbox, multiple select, date, email, URL, number (quantities), currency, percent, duration, formula, lookup, barcode, rating (out of 5) and fields stating when and who modified the database. Some of the fields relevant to the materials database are; 'text' for name and product details, 'multiple select' for manufacturer, 'date' for dates of manufacture and installation, 'lookup' for linking to other passports, and 'number' for dimensions.

Primary Field

The primary field is the first column of any table and cannot be deleted, hidden, or moved. The primary field of the materials database is the unique identifier code. The primary field can be used to link different tables together. Products/ systems can also be explored using their unique identifier code.

Navigating the Base

Top Toolbar

Beneath the table headings is the top toolbar. This offers a number of quick access features to control the fields

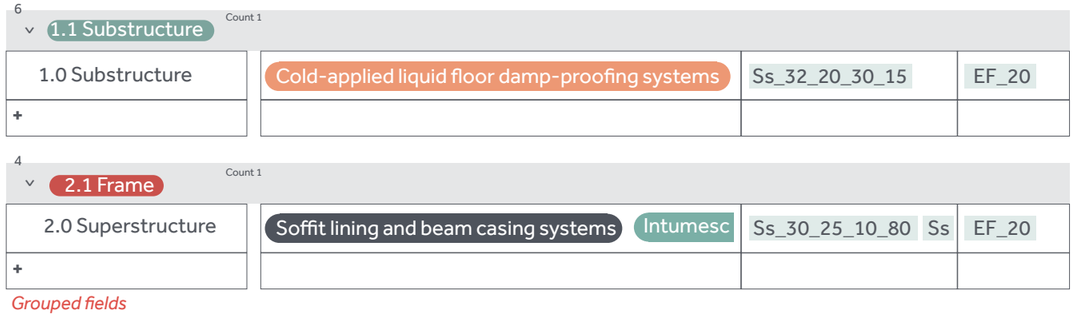
Group

The grouping function on Airtable enables the user to group the data on a table by a specific field. For example, data on the element passport spreadsheet can be grouped by the field 'group element category.' This creates groups such as element 1.1 Substructure, containing all the data specific to that group. Groups can be maximised to reveal data required, while others can be minimised, hiding data specific to that group, improving the readability of the database.

Top Toolbar

Hidden fields

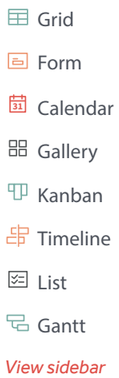
The database can become busy with lots of information. To reduce the amount of information shown and improve ease of use, fields that are less populated or not due to be populated can be hidden. Relevant, populated fields that have lots of valuable information remain visible. If for example the database contains little to no information about the operation and maintenance strategy then these fields should be hidden, improving the readability of the spreadsheet. Data held in hidden fields can be made visible again if required and no information is lost.
Once the template has been imported, fields should be reviewed against the required data points (defined in the materials passports strategy), and hidden if not due to be populated.



Grouped fields

Additional Views

To the left of the base, you will find the 'view sidebar'. This offers different viewing options for how the records within the base can be displayed. By editing the information in one view, it will edit it on all views. Anything controlled by the top bar will not transfer to other views.
The database is set to default grid view. Additional views include; form view, calendar view, gallery view, kanban view, timeline view, list view, and gantt view. Project users can alter the views to improve the legibility of the spreadsheet. Note that adjusting the views adjusts it for all users.



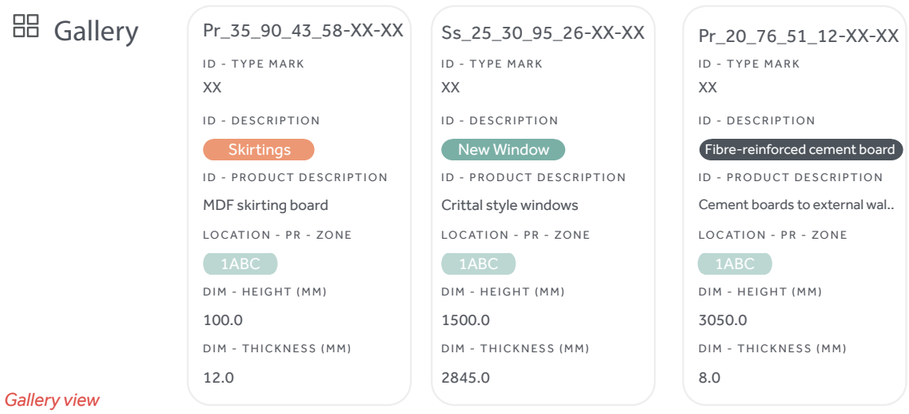
View sidebar

All tables will automatically generate a grid view. This is primarily used when configuring the database and adding data into the tables.

From the existing table, a form view can be created. Form view generates a shareable web based form using the fields of the database as categories. This may be useful for the sub-contractor to input information about the products arriving onsite. This further populates the database without requiring a user login or training.

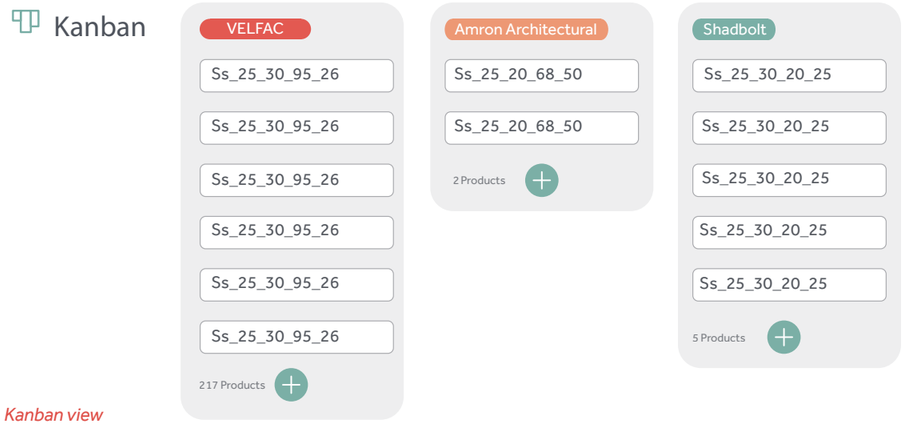
Navigating the Base

Gallery view is a visual way of displaying data, turning the individual records into cards, organised by their primary field. As illustrated below, the cards display information on singular systems/ products within the building, organised by the unique identifier code. It is recommended that this view is heavily filtered to improve readability. Gallery view is also good for displaying images associated with each record. **These are the individual passports for objects.**



Gallery view

Kanban view also displays the data as cards. Kanban view can be used to manage work, highlighting completed work, work in progress and work to begin, helping visualise the workload and improve work efficiency. Unlike, gallery view that groups records by the primary field, Kanban view can group information by multiple field types. For example, the cards can be grouped by manufacturer, enabling the user to view all the products made by a specific manufacturer (as shown in the diagram below). It can also be grouped by the products suitability for recycling or reuse or whether they have been designed for disassembly, if the fields have been populated. This could form part of the deconstruction strategy and help visualise the future of the products, prolonging their circulation before final disposal.



Kanban view

List view organises the layers of data into a list that is easier to read than the default grid.
Calendar view arranges data by a date field of the user's choosing such as the installation date or product manufacture date if required.

Timeline view is great for visualising a project over time, mapping out a timeline for each element of the building and helping to determine the timeframe of building maintenance and end of building life.

Airtable Field Types

Editing Fields
To adjust a field, click the drop down arrow to the right of the field name, at the top of the sheet. This opens a drop down list which offers typical spreadsheet functionality such as edit field, duplicate, insert field etc. The primary field can also be changed here.
To adjust the field type, select the first option 'edit field'. This opens another pop up where you can edit the field name, select the field type or add a description to the field that will create an information button beside the field name and hovering will display the text.
Field types should be applied to all fields, as it significantly enhances the user experience. The link to another record is especially important, as this is how the passports get connected.

Single Line Text
Can be used for descriptions of product codes to list specific product details. The descriptions must be written out individually for each instance.

Doorset systems

Multiple Select
Used primarily for brief product descriptions or manufacturer name, where the same manufacturer or description may be used for multiple product codes. This makes it easier to select a name or description that has previously been inputted instead of repeatedly writing it out. For example; the brief product description of a 'window' is used repeatedly throughout a database to categorise all the windows within the building. The manufacturer will also likely be consistent for all the windows in the building and therefore, can be easily selected from the multiple select list.

Steel Window Unit
Metal Doorset

Attachments
Documents in pdf format can be attached. These could include data sheets, health, safety, and performance declarations, environmental declarations, technical information, fire testing certificates and acoustic certificates. Some of the data may be copied into the database record, but the pdf acts as a reference allowing further detail to be copied in the future, should it be necessary.

Date
The date of product manufacture or installation can be inputted, providing record of the products age, enabling future stakeholders to understand when maintenance is required and estimate when the product will reach its end of life. Products can then be tracked back to the manufacturer warranties to check if they are still valid.

23/08/2023

Number
Product/system quantities and dimensions can be inputted. Formulas can also be added, which can produce overall calculations for grouped elements within the building (such as total window area), or total amount of reused material within the building by mass. Individual quantities are listed in the systems and products passports. Total quantities are listed in the element passport.

26.20

Link to Another Record
Records can be linked between tables, creating a data flow through the database. For example, when viewing the element passports; windows and external doors (element passport) is linked to the system codes of windows and will display the linked system passport if double clicked. To create a 'link to another record', adjust the field type and select the table you wish to link to. Permit 'linking to multiple records' and click the 'save' button. This will update that field to show the primary field of the table selected. Saving will open a popup which allows you to select which additional fields you wish to 'look up' from that table. For example, linking to a uniclass table, you may also want to create a look up field to the title field.

Pr_30_59_24_52

Checkbox
The checkbox tool can be used to indicate a simple yes or no response. For example, the tool has been used to indicate whether specific assets have been designed for disassembly. This data can be easily retrieved at the product's end of life, indicating its reuse potential for future stakeholders involved with the demolition of the building.

Building the Database: Populating the Fields

Sample Database

Energy Dashboard | Element Passports | System Passports | Product Passport | Material Passports

ID - Unique Identifi..	Type	Instan..	ID - Description	ID - Manufacturer	ID - Product Details	ID - Uniclass Linked
Pr_30_59_98_83-001	W01	00.01	Steel Window Unit	Secco Sistemi	Type OS2 65	Pr_30_59_98_83...
Pr_30_59_24_52-001	D01	00.01	Metal Doorset	Secco Sistemi	EBE65	Pr_30_59_24_52...

Field Population

ID - Unique Identifier
The unique identifier is the primary field, combining the Uniclass naming classification and selected specific naming system as suffixes. The suggested suffixes are _TypeMark_Instance. For example; a window type WT01 might have an instance of W00.01, representing its location on the ground floor and window number. The uniclass code for a window system is Ss_25_30_95_26. These codes are combined to produce a unique identifier Ss_25_30_95_26_WT01_W00.01. This code enables designers in the project to identify the system or product, and allow for easy referencing in drawings and specification, in addition to other users outside of the project, who can identify it by the universal uniclass code.

ID - Type and ID - Instance
The code or name given to a specific system or product by the designer, so it is easily identifiable. This field will vary between disciplines and companies, who can implement their own unique naming system to identify the systems and products within their buildings. As an alternative, barcoding could be used with the GTIN providing the suffix to the Uniclass code.

ID - Description
A brief description of the item is given, enabling stakeholders to easily locate the element, system, product, and material they are searching for. The description is used in addition to the uniclass code of the item.

ID - Manufacturer
The name of the manufacturer is listed in the database to enable the system, product, or material to be tracked back to the manufacturer for information. Manufacturer details and further documentation can be attached into the database. Providing manufacturer information enables the building assets to be reused or disposed of accordingly.

ID - Product Details
More in depth product details are listed including; manufacturer product code and a description of what the product is and its uses within the building. Product details enable future stakeholders to identify the items within the building and improve the probability of future reuse following building handover.

ID - Uniclass Linked Products
The hierarchy passport levels from building elements through to complex materials passport can be linked to improve ease of use. The building elements passport is linked to the systems within the element. The products within the system are linked back to the systems passport and the materials used to produce the product are linked to the products passport. This creates a linked flow between the passports, increasing the potential of reuse.

Element Passport

Sample Database

Energy Passport | Element Passports | System Passports | Product Passports | Material Passports

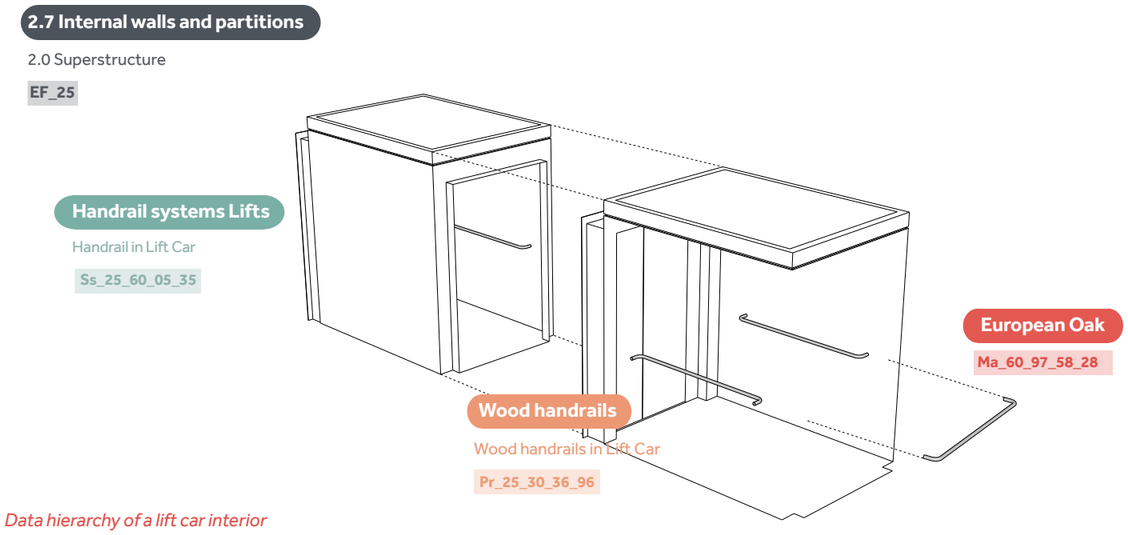
Group Element	Element Category	Description of Element Construction and Oper...	Notes on Condition
1.0 Substructure	1.1 Substructure	We understand from the drawing that the buil...	
2.0 Superstructure	2.1 Frame	RC frame with RC end walls and cores ...	A specialist struct...
2.0 Superstructure	2.2 Upper floors	The typical floor plate consists of large contin...	

Change(s) Since Construction	Building Function	Reference to Documents - 1	Gross Internal Area, m²
The proposed Below Gro...	Administrative offi...	XXX-XXX-XX-XX-PP-A-23012 - Clie..	7500
Lift core - new lift shaft w...			
		XXX-XXX-XX-XX-PP-A-23012 - Clie..	

Element passport view

Element Passport

The passports are completed in hierarchal levels starting with the element passport, and contains all of the elements within the building. RICS NRM 1 was used to form the elemental categories following the approach to building layers. Building elements are grouped by category, divided into sub element categories. For example: 2.0 superstructure is a group category, separated into sub-element categories, 2.1 Frame, 2.2 Upper floors, etc.
The systems incorporated within the elements are linked through a lookup field on the element passport.



Data hierarchy of a lift car interior

System Passport

Sample Database

Energy Passport | Element Passports | System Passports | Product Passports | Material Passports

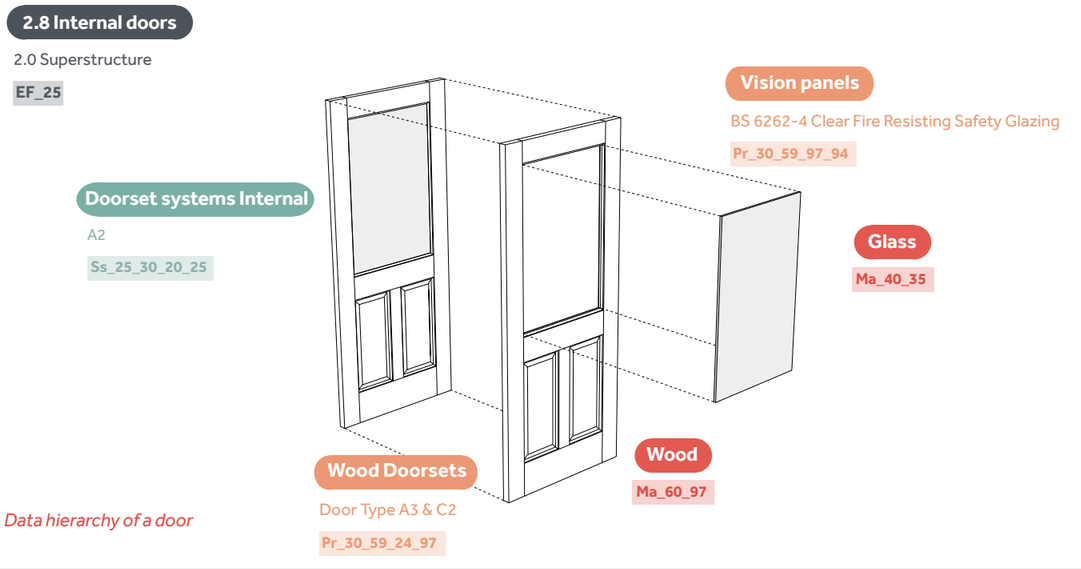
ID - Unique Ide...	ID - Instan..	ID - Description	ID - Manufacturer	ID - Product Details	ID - Uniclass Linked
Ss_25_10_35_35..	CW02	Glazed Screen Systems	Manufacturer A	117 PLUS ...	Ss_25_10_35_35
Ss_25_30_20_25..	DG.109	Wood doorsets	Manufacturer B	A7 Concealed do...	Ss_25_30_20_25
Ss_25_32_35_90..		Turnstile systems	Manufacturer C	Reception securi...	Ss_25_32_35_90

Installation Date	Location - Level	Dim - Height (mm)	Dim - Width (mm)	Dim - Thickness (mm)	Surface Finish
01/01/2024	01	2730.0	1840.0	122.0	Powder Coated
02/01/2024	03	2750.5	2890.0	100.0	Sprayed lacquer
03/01/2024	01	1500.0	1500.0	25.0	Brushed stainle..

System passport view

System Passport

The system passport splits the sub-element categories into individual systems. Examples of systems include glazed screen systems (part of element 2.7 internal walls and partitions) and wood doorsets (part of elements, 2.6 windows and external doors and 2.8 internal doors).
The systems passport can establish general characteristics that make them valuable for recovery during the building's deconstruction. To understand the system's value for recovery it is necessary to outline how the system is installed in the building, if it can be disassembled without damage and reuse potential. General information about the system is also provided including the dimensions, location within the building etc. The products that connect to complete the system are linked through a lookup field on the systems passport.



Data hierarchy of a door

Product Passport

Sample Database

Energy Passport | Element Passports | System Passports | Product Passports | Material Passports

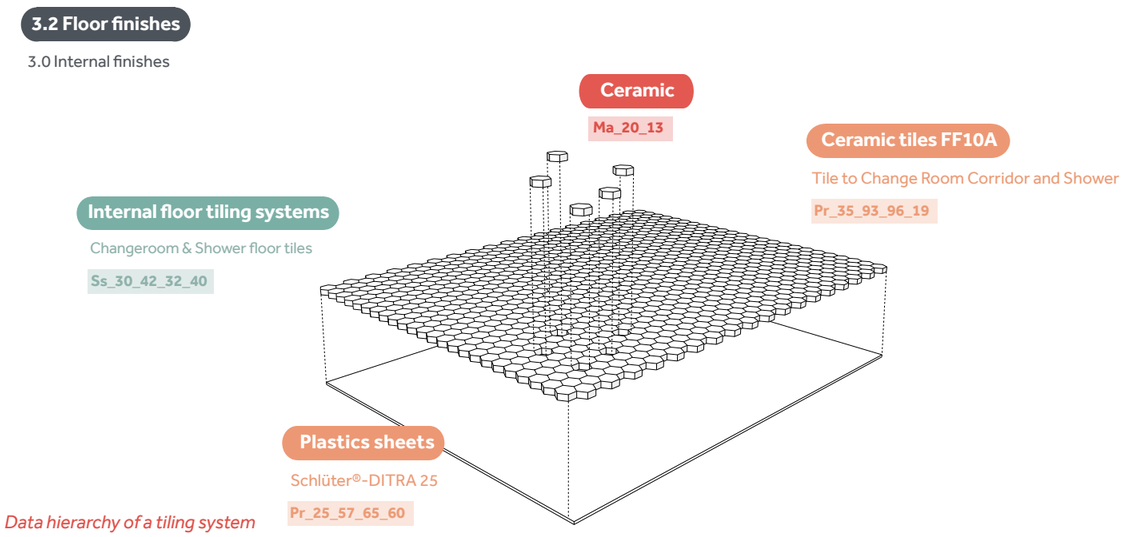
ID - Unique Identifier	Instance	ID - Description	ID - Manufacturer	ID - Product Details	ID - Uniclass Linked
Pr_40_20_96_15		Ceramic sinks	Vanesta	S593001 Birch 51 ...	Pr_40_20_96_15
Pr_35_57_71_46		Linoleum sheets	Forbo flooring sys..	Reception desk w..	Pr_35_57_71_46
Pr_30_59_24_15	CW05	Glazed doorsets	Forster Profile Sys...	30min Fire rated d..	Pr_30_59_24_15

Installation Date	Location - Level	Dim - Height (mm)	Dim - Width (mm)	Dim - Thickness (mm)	Surface Finish
04/09/2023	01	2730.0	1840.0	122.0	Powder Coated
31/08/2023	03	2750.5	2890.0	100.0	Polyvinylidene flu...
01/09/2023	01	1500.0	1500.0	25.0	Sprayed lacquer

Product passport view

Product Passport

The product passport contains the individual products that complete the system. For example, ceramic sinks are some of the products incorporated in the sink systems. The sink systems form part of building element, 5.1 sanitary installations. Similarly, to the system passport, the product passport outlines general characteristics that make the product valuable for recovery once the building has reached its end of life. General information about the product is also provided including the dimensions, manufacturer, and product description. Product data sheets provided by the manufacturer can be attached, providing increased detail on declarations, certificates, and testing that the product has undergone.
The materials incorporated within the products are linked through a lookup field on the product passport.



Data hierarchy of a tiling system

Material Passport

Sample Database

Energy Passports | Element Passports | System Passports | Product Passports | Material Passports

ID - Unique Identifier	ID - Description	ID - Uniclass Linked	Title (Uniclass Linked)	Finishes
Ma_40_52_83_33	Galvanised steel	Ma_40_52_83_33	Galvanized steel	Powder Coated
Ma_40_52_83_33	Glass	Ma_40_35	Glass	
Ma_60_65_28	Polyethylene	Ma_60_65_28	Polyethylene (PE)	

Material passport view

Material Passport

The final type of passport is the material passport connected to the product passports. The materials incorporated within the individual products is classified. For example, glass is listed as material in the passport. Glass is one of the materials found in the window unit product (window and frame) which is part of a window system. This system is part of the building element, 2.6 windows and external doors, demonstrating how all passports are connected through each level, creating a linked flow between the tables in the database.

Material passports should contain all the information about the origins of the material, including data describing their characteristics that make the products and systems they created valuable for reuse and recovery.

Data hierarchy of a window

Creating Basic Materials Passports

Basic Materials Passports

The creation of basic materials passports uses the documents contained within a pre-demolition or pre-refurbishment audit to support the process of assessing the reuse potential of existing materials.
The audits follow a clearly defined methodology, with a report produced as the deliverable. This typically include tables listing all of the materials contained within the building. Quantities of material, a commentary on the condition and advice potential waste routes will also be available. More detailed audits may include the estimated embodied carbon within the material, which assists with the justification for prioritising one material over another.

Data Requirements for Basic Materials Passports

In order of priority;

- Unique identifier - this can be determined with visual inspection alone
- Uniclass - this can be determined with visual inspection alone
- Description - what is it?
- Quantity - assessed by a suitably qualified person
- Unit - of the quantities, this may differ between material types
- Type mark - may be useful to help organise materials
- Instance mark - may be useful to help define the refurbishment requirements if pursuing reuse option
- Condition - notes on aesthetic condition and performance if applicable. Eg a damaged fire door will have a poor performance condition
- Destination - what is the current plan for the material? Reuse in situ, reuse on site, reuse off site, recycling, disposal
- Physical passport (y/n) - QR codes can be particularly useful for items earmarked for reuse, as the QR code can be scanned while on site and information added live. When deconstructed, the material can then be identified and kept connected to the digital passport. This is quite a manual process, so it is best to be selective.

Process to Create Basic Materials Passports

1. Procure a pre-demolition or pre-refurbishment audit
2. Set up the database as previously described
3. Assign Uniclass, type mark and instance marks to materials in the building
4. Supplement with data from the pre-demolition or pre-refurbishment audit
5. Add any photos of the items
6. Add any other information discovered e.g. o+m information
7. Create Gallery view and hide fields as necessary
8. Decide which materials would benefit from being physically tagged
9. Create QR code for each record
10. Create label for each record with QR code and unique identifier printed underneath
11. Stick label to object
12. Use phone to access the passport on site, and update with condition information during site walkarounds

Creating QR Codes

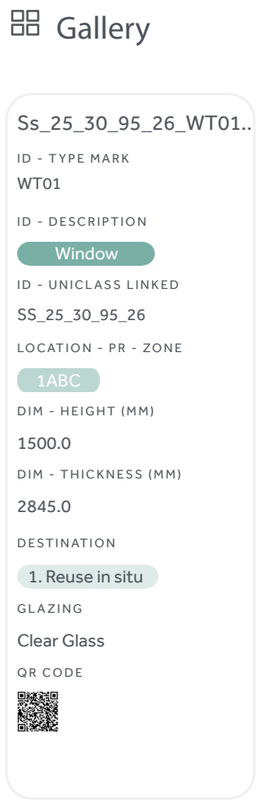
Printing QR Codes for Passports

The QR codes can be attached to the materials within a building either pre-deconstruction or at practical completion. The codes can be scanned by a phone with the Airtable app installed, providing access to the live digital passport. This can be referenced, updated or edited as appropriate. Edits made to the passport in this way will be saved back to the main database, so it is important to control who has access to it and ensure they have had training.

Physical passport on an object

How to Create a QR Code

QR codes can be generated using a free QR code generator online and stored in the database.



System passport example

1. Display your database in gallery view, splitting the records into individual passports. Adjust the visibility of fields

2. Click onto an individual system and copy the URL link.

https://airtable.com/123456789abcdefgh

3. Paste the URL link into the online QR code generator.

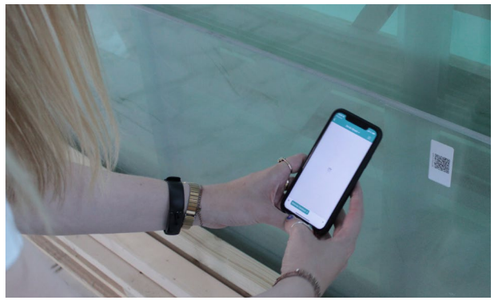
https://airtable.com/123456789abcdefgh →

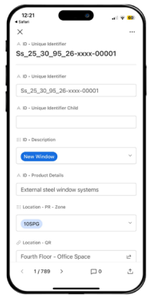
4. The software will generate a QR code, that can be downloaded onto your laptop, computer, or tablet as a jpg or png.

5. Attach the QR code to the corresponding passport on the database.

6. Create a label with the QR code and printed unique identifier on it. Print and stick to the object.

7. The QR code can be scanned using your phone, providing a link to the individual system.
The Airtable app must be downloaded to your phone in order to access the passport on the database.





Accessing the system passport on site

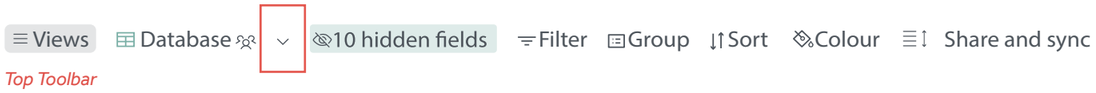
Extensions and Exporting

Extensions in Airtable

Airtable extensions are plug-ins that add extra functionality to the base.
They can be accessed by clicking on the 'extensions' tab, which is adjacent to the field headings. Extensions do require a paid licence to activate, although trial options may be available.
There are various types of extensions, plus collaborations with other softwares like Miro. It is also possible to add scripts and build a custom extension.
Useful extensions include 'csv import' which can be useful to transfer data from a BIM model into the database, or the QR code generator which automatically creates QR codes and pastes them into a field in the base. However, the QR code can only link to a specific field, so is not useful for creating the passports. Extensions also exist for producing graphics such as charts or tables to visualise the data within the base.

Exporting the Base

The base can be exported table by table. To do this, navigate to the top toolbar click the drop down adjacent to the view name. Then, download the csv.



Top Toolbar

Further Information

For further information on Airtable functionality, please visit :
Help Centre: support.airtable.com
Resource Centre: www.airtable.com/lp/resources

END

Appendix C : Materials Passports Database Template

Please refer to the spreadsheet template available at:

orms.co.uk/insights/materialspassportspolicypaper/

This template has been developed and shared to provide teams with a starting point for the Materials Passports Database. It is anticipated that this template will evolve as adoption broadens and feedback is provided.

Template Structure

The template is structured into six sheets, with the current relevant Uniclass tables provided in reference sheets. Note that the Uniclass tables are regularly updated, so the latest table should always be downloaded from the NBS website prior to starting a project.

The sheets:

1. Building Information
2. Energy Passport
3. Element Passports
4. System Passports
5. Product Passports
6. Material Passports

The building, energy and element passports were developed in collaboration with the University of Sheffield. These will likely be developed further in the coming years.

The system, product and material passports share the same template for simplicity.

The system, product and material passports have been built from:

- BAMB Materials Passports Best Practice Guide [15]
- Orms Material Passport template (2021)

They have been developed further with reference to:

- Feedback from the Materials Passports Working group (since 2022)
- Guidance from the Materials Passports Data workshop (July 2023)
- Waterman Materials Passports Framework (2023)

It is acknowledged that the number of data points in the template may appear overwhelming but teams are reminded to start small, that the materials passports database is something that grows over the life of the project. Start by selecting the most relevant data points, and expand from there. The template is deliberately provided in an open source way,

to enable teams to add, subtract and amend data points as applicable to their specific needs. However, it is noted that the standardisation of the template is useful for allowing future consolidation of project materials databases.

It is recognised that more specialised templates will be developed for different materials, passports and systems. This is already starting with steel and glass, and is being led by specialists such as manufacturers and suppliers, with support from design teams. These are typically generating spreadsheet or pdf based passports.

Ideally these specialised templates would be nested within the main sheet, and only activated when necessary. However to do this in the spreadsheet format is complicated, and likely to be confusing. Therefore, the recommendation is to add any fields that are absolutely necessary to the main database, and to attach the pdf version from the specialist for future reference.

Basic Materials Passports

For Basic Materials Passports, a smaller range of data has been highlighted for collection. This aligns with what is usually feasible to gather for existing materials, where the original supplier or manufacturer is unknown. The suggested data should be able to be procured through a Pre-Demolition or Pre-Refurbishment Audit, and supplemented with the Uniclass classification to generate a unique identifier.

While this is considered an appropriate starting point for the database, there may be additional information that can be gathered from record information, design team or specialist expertise. Where this exists, it should be added.

Appendix D : Materials Passports Disclosure Page Template

Please refer to the Disclosure Page template available at:

orms.co.uk/insights/materialspassportspolicypaper/

This template has been developed and shared to facilitate a culture of transparency and learning. It will enable projects to quickly demonstrate the scope and comprehensiveness of their databases.

It will provide local authorities with a single page overview, which can be easily understood and therefore facilitate rapid implementation of the recommendations in the paper.

The Disclosure Page can also be captured for benchmarking purposes. It will help identify which areas are particularly challenging to capture data for, and enable tracking of progress across the industry.

It is anticipated that this template will evolve as adoption broadens and feedback is provided.

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