Proposal for the integration of a Building Material part: (ISO 19152-7) within the Land Administration Domain Model

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Key words: LADM, Land administration, Circular Economy, Building Materials, Material Passport

SUMMARY

The growing global consumption of non-renewable resources is a significant societal concern. The shortage of primary raw materials and the decreasing availability of space for final waste disposal present an alarming situation. Improperly assigning materials to their recycling potential often results in high-potential materials being downgraded to lower potential uses. Transitioning to a Circular Economy, as proposed by the European Union (EU), offers an effective solution to this problem. A Circular Economy is an economic system designed from societal production and consumption patterns that maximizes the services derived from the linear flow of materials and energy between nature and society. It achieves this by utilizing cyclical material flows, renewable energy sources, and cascading energy flows. To ensure materials remain available indefinitely, they must be documented and registered while in use. The EU has proposed Material Passport for buildings which is an electronic set of data and evaluates the recycling potential and environmental impact of materials embedded in buildings.

Land Administration is the process of efficient management of land and its associated information, facilitating communication among various stakeholders both within one country and internationally. In this research, land administration is utilized because ownership information from the land administration can be applied to the registration of building materials. It also provides data on location and distance details. The registration methods used in land administration are well-suited to the concept of a material passport. Hence, this research combines the concepts of Circular Economy and Land Administration. The Land Administration Domain Model, LADM ISO19152–6 edition II contains six parts- Conceptual Model, Land Registration, Marine Georegulation, Valuation Information, Spatial Plan Information and Implementation. Building Materials registration has a lot of links to the Land Administration, like owner, valuation. Introducing the "Building Materials ISO 19152-7" standard can significantly contribute to the Land Administration Domain Model (LADM). It allows building materials registration to be aligned with (inter)national standards, ensuring consistency and improving the overall quality and reliability of land and property management. The main contribution of this study lies in evaluating the application of Building Materials and establishing a standardized Material Passport, including its basic requirements and conceptual information model. This research identifies and explores the connections between the Material Passport and its integration with the core LADM creating a multipurpose harmonized information model.

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1. INTRODUCTION

The building and construction sector significantly influences both the economy and the environment, contributing substantially to the Gross Domestic Product (GDP) and representing a major consumer of resources (Norouzi, 2021). According to Global Status Report for Buildings and Construction, a report by the UN Environment Programme (UNEP) and Global Alliance for Buildings and Construction (Environment n.d.), 21% of global greenhouse gases were emitted by the building and construction sector. By 2022, buildings accounted for 34% of global energy demand and 37% of energy and process-related carbon dioxide (CO2) emissions. The growing global consumption of non-renewable resources is a significant societal concern (Honic et al, 2021). In addition to consumption, Construction and Demolition projects are responsible for the solid wastes. The shortage of primary raw materials and the decreasing availability of space for final waste disposal present an alarming situation. The primary factor contributing to increased waste is the use of a linear economic model, where raw materials are extracted from the earth, processed, and assembled into buildings. However, at the end of the building's lifecycle, it is demolished, resulting in waste that is often disposed of in landfills without recycling (Korhonen et al, 2018).

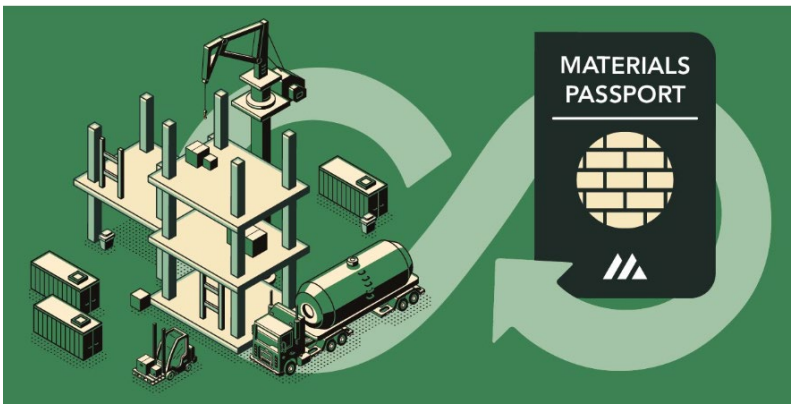

Figure 1. Materials Passport for tracking and reusing building materials (Malone, 2023)

Transitioning to a Circular Economy, as proposed by the European Union (EU) (McMillan, 2019), offers a solution to this problem. See figure 1, in the Circular Economy models, the end-of-life building materials should be reused and their components and parts deconstructed, to act as material banks for new buildings, keeping the components and materials in a closed loop (Benachio et al, 2020). Sometimes improperly assigning materials to their recycling potential often results in high-potential materials being downgraded to lower-potential uses. This is due to the inefficient transition from linear to circular economy which requires a

systemic approach that considers the entire building life cycle and construction value chain (Munaro et al, 2021). The Building as Material Banks (BAMB) project of EU's Horizon 2020 is an initiative that aims to enhance the value of used building components and materials through circular solutions. This has led to the creation of Material Passports, reversible building design, business model policy agendas to aid in the implementation of the circular economy. Materials Passports aim to optimize the value retention of materials, products, and components throughout their lifecycle by providing comprehensive information about their composition, properties, and potential for reuse or recycling. By providing transparency and traceability, Materials Passports can indirectly incentivize suppliers to prioritize the production of healthy, sustainable, and circular materials and building products, which aligns with the goals of Reversible Building Design. These passports simplify the decision-making process for developers, managers, and renovators in selecting healthy, sustainable, and circular building materials. They also facilitate reverse logistics and the take-back of products, materials, and components, promoting a more sustainable lifecycle for building materials (Materials Passports- BAMB — bamb2020.eu n.d.).

The objective of this paper is to investigate how building materials registration can be implemented in accordance with (inter)national standards. The paper provides a comprehensive review of the literature on relevant topics focusing on the significance of building materials and their registration processes. This review included an examination of ongoing projects related to building materials registration, particularly the concept of the Material Passport, and an evaluation of its implementation. Simultaneously, consultations with experts using the Madaster platform and TU Delft's Circularity Hub, combined with insights from the literature, highlighted the necessity of establishing a standardized approach. Based on these findings, the fundamental requirements for creating a Material Passport were identified and subsequently refined to streamline the registration process for building materials. The Land Administration Domain Model (LADM), an international standard (ISO 19152), offers a conceptual framework for land administration systems. It is suitable standard as building materials registration is closely related to land administration, involving aspects such as ownership, registration and valuation. Subsequently, the building materials registration part were developed using the necessary components and integrated into the Land Administration Domain Model (LADM).

The paper is organized as follows: Section 2 provides the background relevant to the research. Section 3 provides the applications of the building materials registration. Section 4 presents the gap analysis and standardisation of MP. Section 5 outlines the development of the harmonized information model. Finally, Section 6 discusses the results and suggests directions for future research.

2. BACKGROUND

This section reviews previous research relevant to the topic of this paper, providing context to Land Administration and its international standard ISO, the Land Administration Domain Model. It also examines the concepts of Circular Economy and the Material Passport, concluding with an exploration of Madaster.

2.1 Land Administration

Land in Land Administration is defined as an area of the surface of the earth together with the water, soil, rocks, minerals and hydrocarbons beneath or upon it and the air above it. It is a combination of both physical, spatial or topographical and thematic attributes like legal status, value, tax data (Henssen 1995). Land Administration can be described as the process of efficiently managing the land and information about the land. Its two main aspects are Land Registration and Cadastre. The process of recording legally recognized interests (ownership and/or use) in land is called Land Registration which can be done through deeds or title registration. Cadastre is an official record of information about land parcels, including details of their bounds, tenure, use, and value (Zevenbergen, 2004). They both complement each other as the land registration answers the questions as to who and how, the cadastre answers the questions as to where how much. Land Administration is important as it supports economic development, environmental management and social stability of the country (Williamson, 2001). However, there is inadequate documentation and a lack of standardization in practice coupled with the global diversity and complex legal and administrative aspects of land administration. These challenges were addressed by developing an international standard, (Kalogianni et al, 2024).

2.2 Land Administration Domain Model

The Land Administration Domain Model, LADM is an international standard (ISO 19152: 2012) that provides a conceptual framework for land administration systems, aiming to align their design with societal demands embedded in national and state land policies, (Lemmen et al, 2015). It is a conceptual model delineating the information content of land administration, designed to be interoperable, extendable and adaptable to specific contexts (Kara et al, 2024). During revision of ISO 19152:2012, it was decided to make the standard multiparts based on the following packages. The packages of LADM are (Kara et al, 2024), see figure 1:

- **Party Package**- A party can be individual or organizations like companies, municipalities or a 'group party' comprises multiple parties forming a distinct entity.
- **Administrative Package**- It consists of Rights, restrictions and responsibilities (RRR) and basic administrative units (BAUnits).
- **Spatial Unit Package**- It can be represented as a text, a point (or multi-point), a line (or multi-line), area or volume based on the spatial extend.
- **Generic Conceptual Model**- It contains the basic requirements that form the basis for each part of Edition II.
- **Source Group Package-** It represents the inclusion and updation of data by integrating both administrative sources and spatial sources.
- **Valuation Information Package-** The Part 4, Valuation Information is organised into a single package.
- **Spatial Plan Information Package-** The Part 5 is organised into a single package based on definitions from Part 1 and 2.

And one subpackage, **Surveying and Representation subpackage** is included in the Part 2 allows the representation of spatial units.

The LADM is multipart, where each part constitute separate standards, with the latest edition comprising six parts. Each part will go through the full standardization process (Kara et al, 2024). See figure 2. The parts are as follows:

Part 1- Generic Conceptual Model- This part provides the scope, definitions, a general overview of the model, its core classes and its individual packages and a more detailed examination.

Part 2- Land Registration- This part introduces the Land Registration Standard incorporating a refined Survey and Representation package featuring various measurement techniques.

Part 3- Marine Space Georegulation- This part provides the structure and concepts for standardisation of georegulation in the marine space.

Part 4- Valuation Information- This part specifies the characteristics and semantics of data in valuation registries maintained by public authorities.

Part 5- Spatial Plan Information- This part includes planned land use (zoning) to be converted into rights, restrictions and responsibilities (RRR).

Part 6- Implementations- This part will address a range of topics needed for implementations of LADM: developing a country profile, modelling processes/ workflows, and encodings, (Unger et al, 2023).

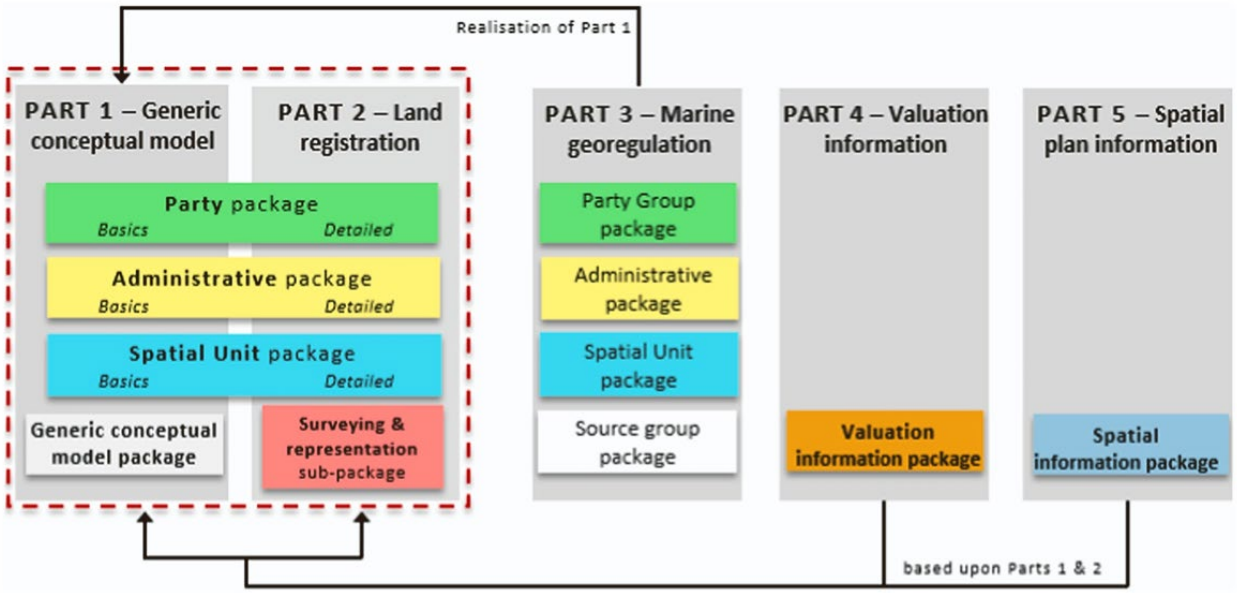

Figure 2. Parts and Packages of LADM II, (Kara et al, 2024)

2.3 Material Passport

Building as Material Banks (BAMB) was part of EU's Horizon 2020 research and innovation funding programme which aims to enable a shift to a circular building sector. As a part of BAMB's objective to enable the transition to a circular building sector, the availability of structured information on materials is crucial for the shifting from the linear economy. A Circular Economy is an economic system designed from societal production and consumption patterns that maximizes the services derived from the linear flow of materials and energy between nature and society. It achieves this by utilizing cyclical material flows, renewable energy sources, and cascading energy flows. Adopting Circular Economy principles in the

construction industry promotes the use of sustainable materials, maximizes material recovery, and reduces unnecessary waste generation and landfill disposal, (Korhonen et al, 2018).
Material Passports consist of digital datasets details including the quality, quantity, locality of materials and components within products and systems, enhancing their value for current utilization, recovery, and reuse. These digital datasets capture comprehensive information on the materials and components within a building, encompassing their quality, quantity, location, and potential for reuse or recycling. By exceeding the scope of traditional certifications and documentation, Material Passports provide valuable insights for material recovery assessments, disassembly instructions, and life cycle analysis. They address aspects typically overlooked by other documents or certifications concerning the circularity of building products, offering information that aids in assessment and certification by third parties, while also enabling the inclusion of existing assessments and certifications as source documents (Copeland et al, 2020). The Material passports comprise multiple hierarchical levels see figure 3, which include the level of materials, components, products and systems that make up the building. For the material level, material passport can define its value for recovery. At the material level, the passport can specify its recovery value, while at the product and system levels, it can outline both general and specific characteristics that render them valuable for recovery (Materials Passports- BAMB — bamb2020.eu n.d.).

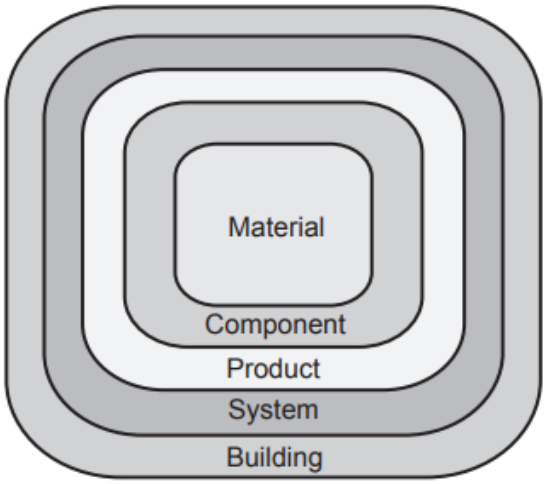

Figure 3. Hierarchy level in Material Passport (Materials Passports- BAMB,bamb2020.eu n.d.)

2.4 Madaster

Madaster is the brand name of the Madaster Foundation, which aims to ensure the availability of materials across all economic cycles. This objective is achieved by registering materials, thus facilitating their accessibility at the highest possible level. Madaster is an online Platform to create Material passport for building. The platform contains library of materials in the built environment and links the material identity to the location and records this in a Material Passport. By creating a comprehensive database of materials through material passports, Madaster contributes to resource conservation, waste reduction, and the overall circularity of the construction sector. With detailed information on material composition, properties, and quantities readily available, Madaster empowers stakeholders to make informed decisions

about material selection, reuse, and recycling. Currently Madaster operates in Netherlands, Germany, Belgium, Austria, Norway, Switzerland and UK.
To create a material passport for a new or existing building in Madaster, accurate and comprehensive building data is essential. The more precise and complete the input data, the more reliable and detailed the generated Material Passport will be. Madaster accepts two primary source file types, see figure 4:

- IFC files- derived from a 3D/BIM model.
- Madaster Excel template- Used when a 3D/BIM model is unavailable, ref Annex.

While various 3D CAD applications exist, the universal IFC file format enables data exchange. For buildings without detailed 3D models, the Madaster Excel template can be used.
Madaster then categorizes and summarizes the information contained in the source files, allowing for detailed insight into the types and quantities of materials present in a building or its individual sections. The geometric data and quantities are directly imported from the IFC model. All calculations within Madaster are based on this and inaccuracies in the results may arise if the source files contain incomplete or missing information, affecting the precision of the outcomes. Additionally, the platform enhances the Material Passport by assessing the financial residual value of materials, evaluating comprehensive circularity through material flow analysis and component detachability, and conducting a Life Cycle Assessment (LCA) to determine the building's Global Warming Potential (GWP) and overall environmental impact.

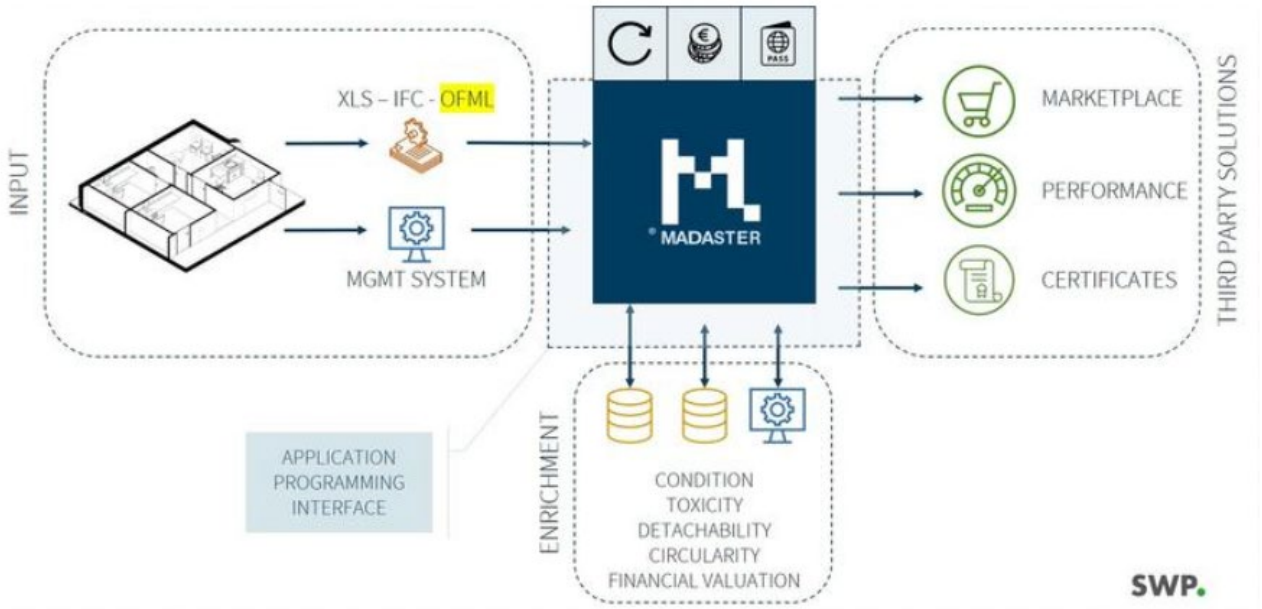

Figure 4. Madaster Framework (Honic et al, 2024)

3. APPLICATIONS OF THE BUILDING MATERIAL REGISTRATION

The registration of building materials has several different applications, below are some of the important applications and merits.

- *Circularity*- A detailed understanding of the materials used in buildings is essential for enhancing their recycling potential. Accurate classification of recycling potential is crucial to preventing material downgrading, enabling reuse at the highest possible quality. Also, proper registration allows easy identification and separation of reusable materials. Furthermore, reusing materials significantly reduces the demand for already depleting natural resources.
- *Valuation of Building*- When the materials are well documented, it will be easier to evaluate their quality and durability, which in turn facilitates accurate building valuation. This documentation also enables a comprehensive assessment of the long-term risks associated with the materials, allowing for informed analysis of renovation costs and more precise pricing of the building.
- *Environmental Impact*- The material used in the building have direct impact on the environment. Material passports contribute to understanding a building's environmental footprint by providing data on embodied energy, carbon emissions throughout its life cycle and material toxicity.
- *Safety and Security*- Maintaining an inventory of all the materials used in the building ensures compliance with safety standards and regulations. This inventory is instrumental in the identification and removal of hazardous materials within the structure. Documenting structural properties and the inclusion of fire-resistant materials are crucial for ensuring overall safety. In emergencies, having a detailed plan of the building and an inventory of materials is essential, as it provides critical information for first responders, facilitating effective and safe interventions.

This means that registration of building materials is serving multiple purposes, which all benefit from the efforts to set up this registration.

4. GAP ANALYSIS AND STANDARDIZATION

The Material Passport is a generally accepted tool for documenting building materials in EU, yet it presents certain ambiguities (Honic et al, 2019). For instance, when generating a Material Passport on the Madaster platform, the source file can either be a BIM model or a detailed Excel sheet. Although both files can represent the same building, the level of detail in the information they contain may differ significantly. Also, the source file can be provided in various formats, further contributing to inconsistencies. Moreover, there are no mandatory requirements for the creation of a Material Passport. Discussions with the TU Delft's Circularity Hub and Madaster consultant revealed that it is possible to generate MP with minimal informations. However, the level of detail in the Material Passport is directly proportional to the amount of information provided. Therefore, there is a need to establish standardized Material Passport guidelines with defined minimum requirements to ensure consistency and comprehensiveness.

The initial step in the standardization process involves shortlisting all the essential requirements necessary for the Materials Passport (MP). Following, the next step was to identify the most suitable data format capable of accommodating all or most of these requirements. Based on the source files of the Madaster platform, the two primary data formats considered were BIM and Excel, which were subsequently compared based on the requirements. The shortlisted requirements are presented in figure 5.

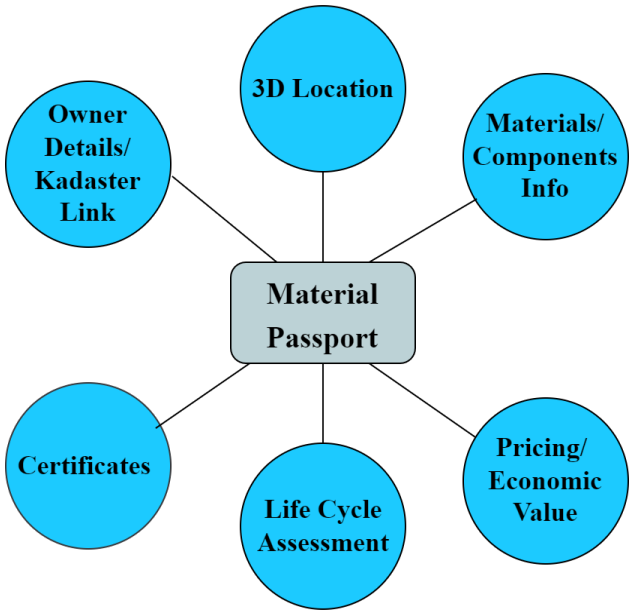

Figure 5. Material Passport and its essential requirements (own illustration)

The data must be maintained in a standardized 3D format that is compatible with visualization, manipulation, and integration processes. It will facilitate easy updates and ensure seamless access across various platforms and stakeholders, thereby ensuring that the information remains readily available and functional throughout the building's lifecycle. The main requirements for the standardised Material Passport are:

- Location is a critical requirement, which includes both the geographical location of the building and the precise placement of materials and components within the building. Accurate location data for materials within the building facilitates efficient retrieval and extraction during deconstruction, minimizing the risk of damage.
- Materials and components data are crucial requirements, providing detailed information about each material or component used in the building, including type, quantity, and quality. This data also includes information regarding the producer or supplier of the materials, ensuring traceability. Materials/components data is an important requirement, it includes detailed information about each materials/components used in the building including its types, quantity, quality. It specifies information about the producer or supplier of the materials to ensure traceability.
- Information about the current owner of the building along with the link to the Kadaster for legal property documentation. This ensures transparency and traceability, making it easier to manage ownership transitions and access necessary legal information.

- The pricing and the economic value reflect the economic value of the materials, both at the time of installation and projected future value. Understanding the economic value helps in making informed decisions about material recovery and reuse.
- A comprehensive analysis of the materials throughout their lifecycle, from production to disposal. It includes carbon footprint, energy and environmental impacts. This is crucial for promoting sustainable building practices and minimizing environmental impact.
- Documentation of any certification standards met by the materials, such as sustainability labels (e.g., FSC for wood), safety certifications, or environmental impacts marks suitable requirement. These certificates validate the quality and sustainability of the materials, ensuring they meet required standards for reuse or recycling.

To compliment the generic requirements with more specific and detailed information, two different source files were analyzed. The second step involved comparing the requirements against the two primary source files: the BIM model and the Excel template. The BIM model is defined as a "shared digital representation of the physical and functional characteristics of any built object" (ISO, BS, 2010). It encompasses information on the geometry, spatial relationships, quantities, and properties of building elements, as well as cost estimates and material inventories. This model contains essential data required for design and construction activities. Table 1 presents a comparison between these two formats, evaluating their feasibility for the intended purpose. From table 1, it can be inferred that the BIM model is a more suitable source data format for the Material Passport.

The updated requirements based on the data derived from the IFC file are illustrated in Figure 6, the solid line represents the mandatory requirements while dotted lines represents optional requirements. While pricing and economic value can be extracted from the source, they are not directly provided. Instead, they are secondary information inferred from the details of components and materials. Therefore, this requirement is not included in the essential requirements.

Table 1. Comparing IFC and Excel data formats based on the requirements

Requirement	IFC	Excel
Location	✓	✗
Materials/ Components Info	✓	✓
Owner Details/ Kadaster Link	✓	✓
Pricing/ Economic Value	✗	✓
Life Cycle Assessment	✗	✗
Certificates	✗	✗

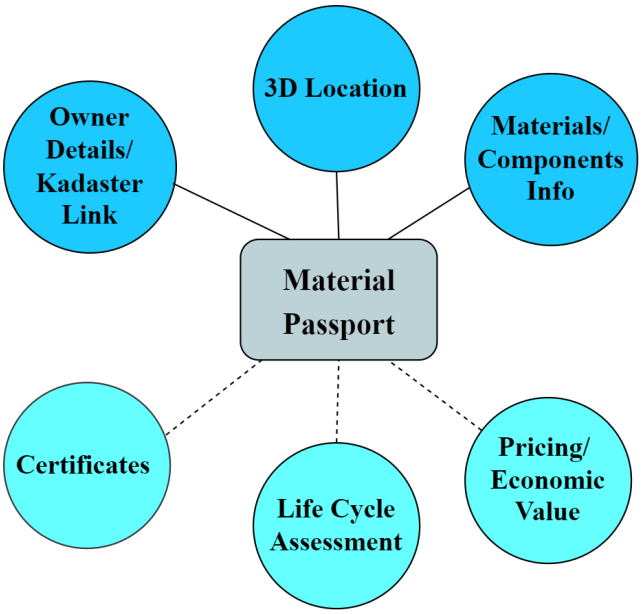

Figure 5. Updated requirements for Material Passport, the dark blue represents the mandatory requirements while light blue represents optional requirements. (own illustration)

5. HARMONIZED INFORMATION MODEL DEVELOPMENT

For Simplifying the Registration and Management of Material Passports and to increase their use both national and international levels, integration with the Land Administration Domain Model (LADM) is recommended. Building materials could be introduced as a new component within the LADM framework. The primary challenge will be integrating this new component with the existing key parts of the model. The new part can be developed using the VersionedObject and LA_Source classes as they supports the registration of building materials. and integrated into the LADM through the VM_Building class from Part 4.

The VersionedObject class is an abstract class in the LADM for the management and maintenance of historical data (ISO, 2012). History requires that both newly inserted and updated data be recorded with a timestamp. This class provides (optional) begin and (optional) end lifespan and real-world timestamps (optional) to the inheriting classes. All LADM classes are directly or indirectly subclasses of VersionedObject, with the exception of LA_Source and its subclass LA_AdministrativeSource. In this way, the contents of the database can be reconstructed, as they were at any historical moment (Kara et al, 2024).

The LA_Source class supports various types of sources and represents the event that triggers changes in the registration process. All dates and times associated with this class are recorded as system (or database) time, reflecting the moment when the event was processed and stored. The association between VersionedObject and LA_Source enables the versioning of source instances (ISO, 2012) see figure 6. Constraints are implemented to ensure that dates and times in VersionedObject and LA_Source correspond accurately. Both VersionedObject and LA_Source include a second set of optional temporal attributes which represent the relevant valid times in the real world (Kara et al, 2024).

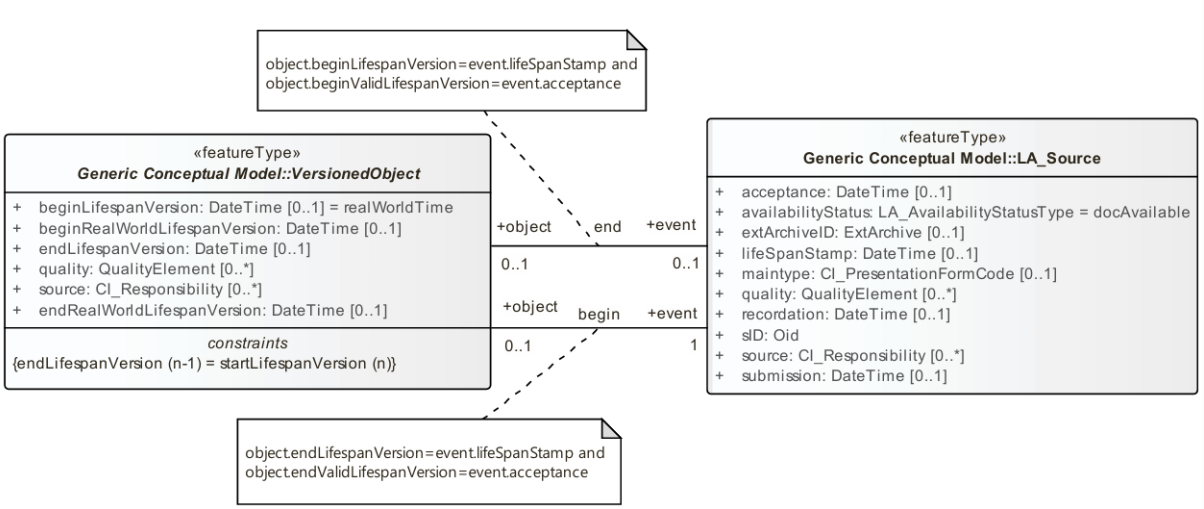

Figure 6. The association between the LA_Source class and the VersionedObject class

The four fundamental classes of the LADM are LA_Party, LA_RRR, LA_BAUnit and LA_SpatialUnit. For simplified registration, it is preferable to integrate the source file through a one-to-one mapping of all requirements of the Materials Passport (MP) to the LADM classes. The LA_Party can be mapped to the IFC attribute classes IfcPerson, IfcOrganisation, and IfcPersonAndOrganisation, depending on the nature of the party involved. For LA_RRR and LA_BAUnit there is no equivalent IFC attribute. The LA_BAUnit refers to multiple spatial units, this can be represented as its attributes are specified as a property set that can be applied to IfcSpatialZone and IfcZone entities. The LA_SpatialUnit can be represented by a wide range of attributes, IfcSite, IfcSpatialZone, IfcSpace, IfcAreaMeasure, IfcCartesionPoint and boundaries reprensing the topological relation can be represented by IfcConnectedFaceSet and IfcPolyLoop (Atazadeh et al, 2018).

To develop the building material part, the requirements for the material passport (see Figure 5) were reviewed. The person involved and their relationships will be recorded in the LA_Party and LA_RRR classes, respectively. The 3D location will be represented in the LA_SpatialUnit. For material and component data, two new classes—BM_ComponentLevel and BM_MaterialLevel were created. The VM_Building class will aggregate instances of the BM_ComponentLevel class, while BM_ComponentLevel will aggregate instances of the BM_MaterialLevel class. The BM_Certificates class will be optional for the VM_Building class, as it is not mandatory and is issued based on specific needs. Additionally, the VM_Building class includes a codelist to account for different building types, each with distinct purposes and taxation requirements. Refer to Figure 7 for further details.

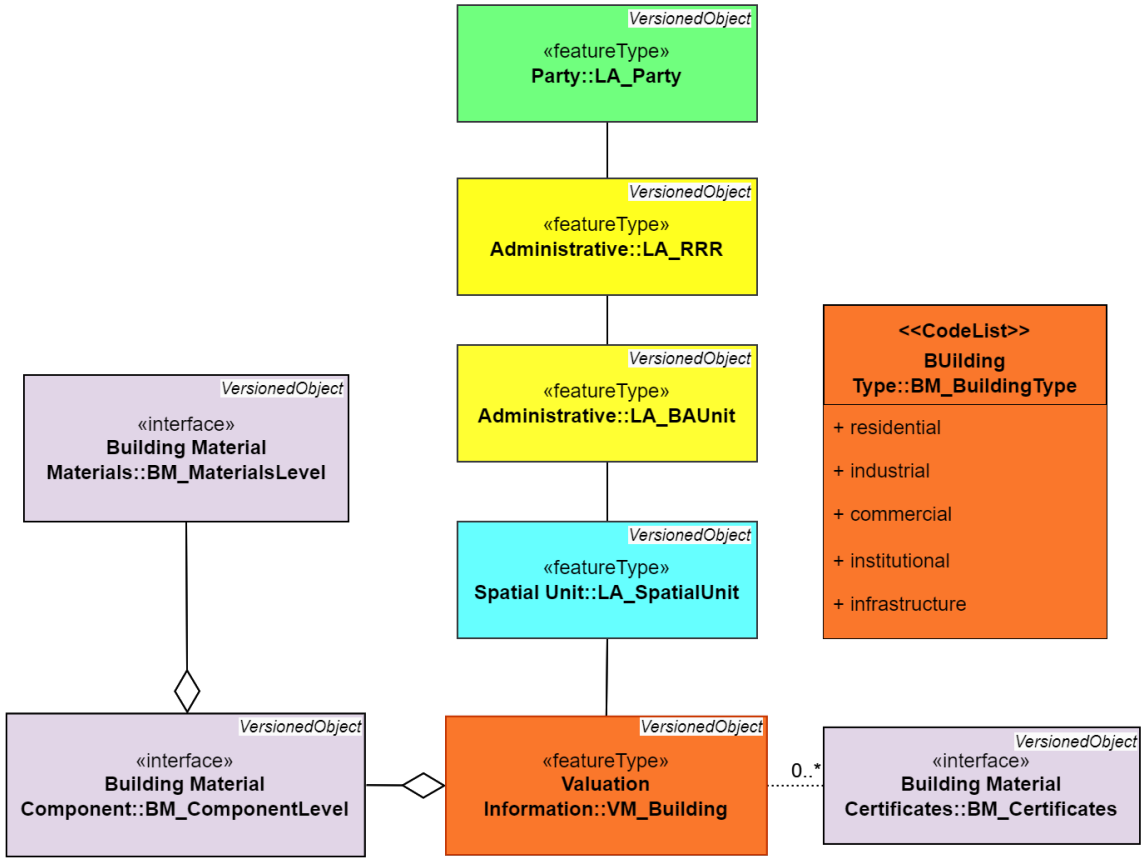

Figure 7. UML diagram showing the classes of Building materials part and its relation to the core LADM classes

6. CONCLUSION AND FUTURE WORK

The integration of a Building Materials registration in the LADM through the proposed Building Materials ISO 19152-7 makes a significant advancement in the sustainability and circular economy. Having a standardised MP improves the circularity by increasing the recycling potential of the building as the materials are recorded accrately it prevents the downgrading of the materials and reusing high quality materials. Additionally, a detailed materails registration helps track what is available for future use, which can reduce the environmental impact of the building , simplifies valuation processes, and supports the implementation of effective safety measures. This research addresses existing gaps in standards and data requirements by developing a standardization for the MP with essential requirements for its creation. By having a standard MP set up, and link to the LADM data model, you increase interoperability between data repositories like local/governmental land administrations and cadasters and international market initiatives like Madaster. With better interoperability, the chance that data stays available and supports circularity increases. Also it improves benchmarking and ‘competition’, ergo it increases overall value and quality. The paper also highlights that incorporating building materials into the LADM information model

can make the materials/components registration process smoother, improve data consistency, and support informed decision-making. Harmonized information model was devolped .
Future research could investigate the testing multipurpose harmonized information model using Madaster platform for different types of building see figure 7 evaluate its effectiveness for new and old building. Another Additionally, future studies might explore the integration of resources and information regarding materials through a unified procedure involving various levels of public administration, including tax offices, which frequently handle the standardized calculation of base rates for taxation.

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BIOGRAPHICAL NOTES

Aswathy Chandran is an MSc in Geomatics at Delft University of Technology, the Netherlands and her master thesis research is reflected in this paper.

Peter van Oosterom obtained an MSc in Technical Computer Science in 1985 from Delft University of Technology, the Netherlands. In 1990 he received a PhD from Leiden University. From 1985 until 1995 he worked at the TNO-FEL laboratory in The Hague. From 1995 until 2000 he was senior information manager at the Dutch Cadastre. Since 2000, he is professor at the Delft University of Technology, Chair GIS Technology, the Netherlands. He is the current chair of the FIG Working Group on the 'Land Administration Domain Model/3D Land Administration (LADM/3D LA)'. He is co-editor of the International Standard for the Land Administration Domain, ISO 19152 and co-chair of the Land Administration Domain Working Group of the Open Geospatial Consortium.

Wilko Quak has an MSc in computer science from Utrecht University, The Netherlands (UU). He worked for several years (1993-2001) as a researcher at the Dutch research center for mathematics and computer science (CWI) and University of Amsterdam (UvA) on Spatial DBMS performance. Since 2001 he has been a researcher at the Section GIS Technology, Delft University of Technology. At Delft University his research focus is moving towards spatial data modeling, data interoperability and standardization. Since 2007 he has been working part-time for Geonovum (the National Spatial Data Infrastructure (NSDI) executive committee in the Netherlands).

Pablo van den Bosch has an MSc in public administration from Erasmus University Rotterdam, The Netherlands. He was the founder of Double Effect BV in 2003, a consultancy firm that works for the financial services industry. In 2013 Double Effect joined Synechron, where Pablo was Managing Director until 2016 growing the business consulting activities for clients in the financial services industry. He also started two other companies: CI Zeist (2016) and Return on Projects (2017). Since 2017 he is Director of Madaster aiming to empower humanity to stay within planetary boundaries so that everybody can live in an environment without waste.

Frederique van Erven has an Master of Architecture from Delft University of Technology (2019, Cum Laude). After working at various architecture firms (HOH Architecten, Atelier van Berlo, Marc Koehler Architects, Turner & Townsend), she joined now Madaster in 2024 as Expansion Manager, committed to embedding circularity within the construction industry. By harnessing the power of digital tools and collaborating across borders, we are driving the adoption of circular economy practices to create a more sustainable built environment.

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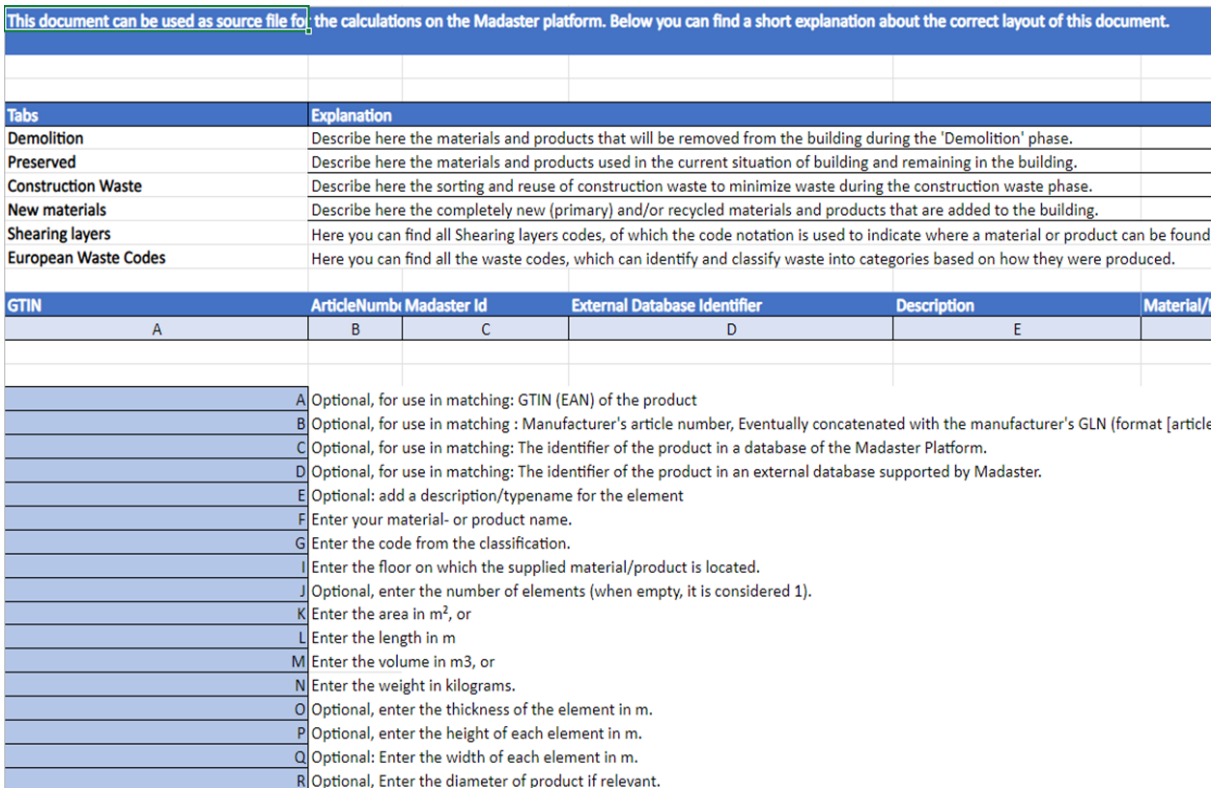
ANNEX. MADASTER EXCEL TEMPLATE

The first sheet of the Madaster excel template provides an instructions on how to use the excel template giving an overview of the process. It is categorized into 6 more sheets/tabs: 4 for data (Demolition, Preserved, Construction Waste, and New materials) and 2 for code lists (Shearing layers and European Waste Codes); see tophalf of Figure A1. All the properties (attributes/ columns) of data tabs are same and used to document the actual bulding instances (see bottom half of Figure A1 wih properties overview). A brief description of the data tabs:

- **Demolition** phase of construction data is added in the Demolition sheet.
- **Preserved** focus on materials or components that are to be preserved during renovation or construction.
- **Construction Waste** sheet deals with the waste generated during the construction process, includes data on types of waste, methods of disposal, recycling options.
- **New materials** lists new materials that are being introduced into the construction project.

A brief description of the code list tabs:

- **Shearing Layers** sheet likely provides a detailed breakdown of the different layers in a building; see Figure A2 with 6 classifications.
- **European Waste Codes** (EWC) are standardized codes used across Europe to classify different types of waste; see Figure A3. Note that this tab contains 2 more code lists: **Nature of waste** and **End of life scenario**.



This document can be used as source file fo the calculations on the Madaster platform. Below you can find a short explanation about the correct layout of this document.

Tabs	Explanation
Demolition	Describe here the materials and products that will be removed from the building during the 'Demolition' phase.
Preserved	Describe here the materials and products used in the current situation of building and remaining in the building.
Construction Waste	Describe here the sorting and reuse of construction waste to minimize waste during the construction waste phase.
New materials	Describe here the completely new (primary) and/or recycled materials and products that are added to the building.
Shearing layers	Here you can find all Shearing layers codes, of which the code notation is used to indicate where a material or product can be found
European Waste Codes	Here you can find all the waste codes, which can identify and classify waste into categories based on how they were produced.

GTIN	ArticleNumb	Madaster Id	External Database Identifier	Description	Material/
A	B	C	D	E	

A	Optional, for use in matching: GTIN (EAN) of the product
B	Optional, for use in matching : Manufacturer's article number, Eventually concatenated with the manufacturer's GLN (format [article
C	Optional, for use in matching: The identifier of the product in a database of the Madaster Platform.
D	Optional, for use in matching: The identifier of the product in an external database supported by Madaster.
E	Optional: add a description/typename for the element
F	Enter your material- or product name.
G	Enter the code from the classification.
I	Enter the floor on which the supplied material/product is located.
J	Optional, enter the number of elements (when empty, it is considered 1).
K	Enter the area in m², or
L	Enter the length in m
M	Enter the volume in m3, or
N	Enter the weight in kilograms.
O	Optional, enter the thickness of the element in m.
P	Optional, enter the height of each element in m.
Q	Optional: Enter the width of each element in m.
R	Optional, Enter the diameter of product if relevant.

Figure A1. Madaster Excel Source file

Classification code	Classification name
1	Surroundings
2	Structure
3	Skin
4	Services
5	Space plan
6	Stuff

Figure A2. Classifications of Shearing layers

Waste codes	
Classification code	**Classification name**
16 02	Wastes from electrical and electronic equipment
16 02 09*	transformers and capacitors containing PCBs
16 02 10*	discarded equipment with PCBs other than those in 16 02 09
16 02 11*	discarded equipment containing chlorofluorocarbons, HCFC, HFC
16 02 12*	discarded equipment containing free asbestos
16 02 13*	discarded equip. with haz. components other than 16 02 09 to 16 02 12
16 02 14	discarded equipment other than those mentioned in 16 02 09 to 16 02 13
16 02 15*	hazardous components removed from discarded equipment
16 02 16	components removed from discarded equip. other than those in 16 02 15
17 01	Concrete, bricks, tiles and ceramics
17 01 01	concrete
17 01 02	bricks
17 01 03	tiles and ceramics
17 01 06*	mix. or separate fractions of concrete, brick, tile&ceramic cont. dang. subs
17 01 07	mix of conc., brick, tile&ceramic other than those mentioned in 17 01 06
17 02	Wood, glass and plastic
17 02 01	wood
17 02 02	glass
17 02 03	plastic
17 02 04*	glass, plastic & wood containing or contaminated with dang. substances
17 03	Bituminous mixtures, coal tar and tarred products
17 03 01*	bituminous mixtures containing coal tar
17 03 02	bituminous mixtures other than those mentioned in 17 03 01
17 03 03*	coal tar and tarred products

Nature of waste	
Id	**Name**
NonHazardous	Non-hazardous
Hazardous	Hazardous
Inert	Inert

End of life scenario	
Id	**Name**
10	Reuse of OO element/material
15	Reuse of CW (preparation for)
20	Onsite recycling
25	Offsite recycling
30	In-situ remediation/recycling of contaminated soil
35	Ex-situ remediation/recycling of contaminated soil
40	Onsite recovery as backfill/ landscaping
45	Offsite recovery as backfill/ landscaping
50	Waste to energy plant
55	Incineration plant
60	Inert waste landfill
65	Non-hazardous waste landfill
70	Stable non-reactive hazardous waste landfill
75	Hazardous waste landfill

Figure A3. Classifications of European Waste Codes