Building Material part: (ISO 19152-7) for Land Administration Domain Model

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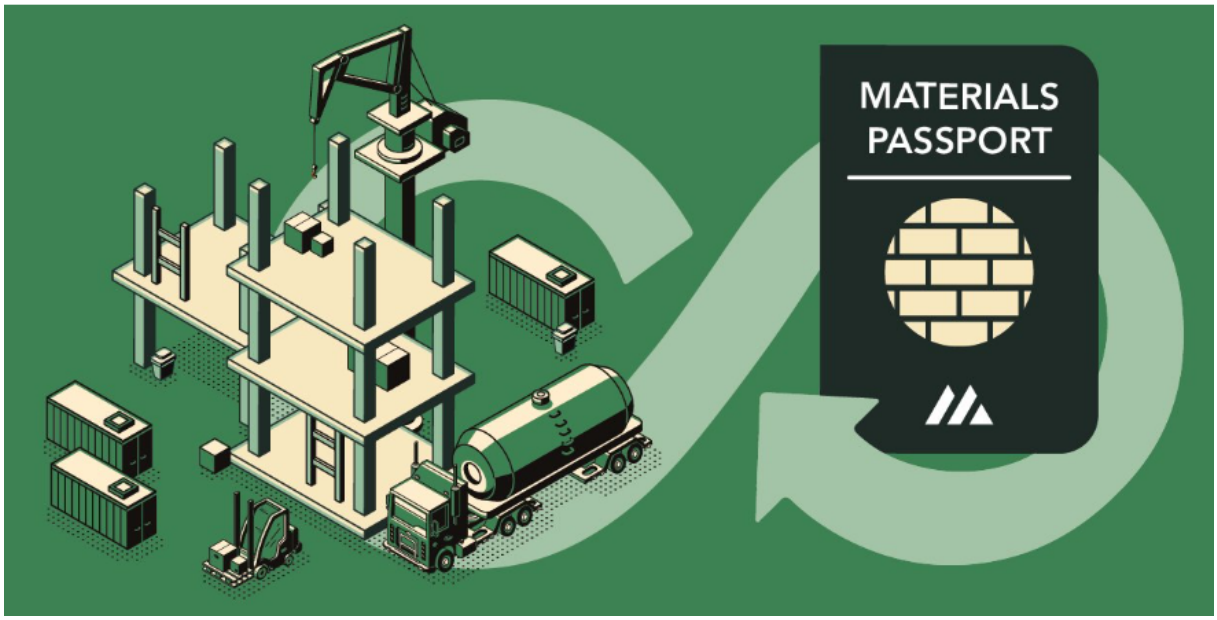

1. Introduction

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 et al. 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, Honkasalo, and Seppälä 2018).

Transitioning to a Circular Economy, as proposed by the European Union (EU) (McMillan 2019), offers an effective solution to this problem. 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, Freitas, and Tavares 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 and Tavares 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 enhance the value or maintain the worth of materials, products, and components over time. They create incentives for suppliers to produce healthy, sustainable, and circular materials and building products, supporting material choices in Reversible Building Design projects. 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.).

1.1 Problem Statement

The thesis 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. Therefore, adding this

new part "Building Materials ISO19152–7", can contribute significantly to the LADM. Through this research, the application of Building Materials is evaluated and subsequently, an Information Model is created reusing other parts of the LADM. The data collection and evaluation of the framework will be done using the case studies from the database of Madaster.

For creating the Information Model, the building materials are registered into a database. The applications of registration of the building materials are safety and security of the buildings, valuation of buildings based on the materials, energy performance of the buildings, circularity by means of the recycle potential and environmental impact of the materials. The main challenge for the circularity component will be to analysing the life cycle of the materials. While the location, quantitative and qualitative information of materials used in new buildings are available, but obtaining this information for materials used in old buildings are difficult to access. One of the key components of the success of material registration is its scalability. The Scalability require proper solutions for various aspects like legal regulations, data collection, financial economic model, and database. The model needs to be updated at a regular interval to ensure accurate representation of the data.

The developed Information Model will be tested using Madaster, which is a digital platform with an online library of materials in the built environment and Circularity Hub of TU Delft. Madaster link the material identity to the location and records this in a Materials Passport. The EU have Material Passport for buildings which is an electronic set of data and evaluates the recycling potential and environmental impact of materials embedded in buildings. Two case studies are used for this paper, which is to evaluate the performance of the framework on different set of data. The first case study of the research will provide registration workflow of data related to the new buildings. Design and construction information of such buildings are easily accessible. The second case study will provide registration workflow of data from old buildings. As there are limited data available on the materials of old buildings, this information will be based on the surveys and heuristics, related to other data.

2. Related Work

This section reviews previous research relevant to the topic of this thesis, 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 the 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 are 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, Van Oosterom, and Bennett 2015). It is a conceptual model delineating the information content of land administration, designed to be interoperable, extendable and adaptable to specific contexts. The three main packages of LADM are, 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.

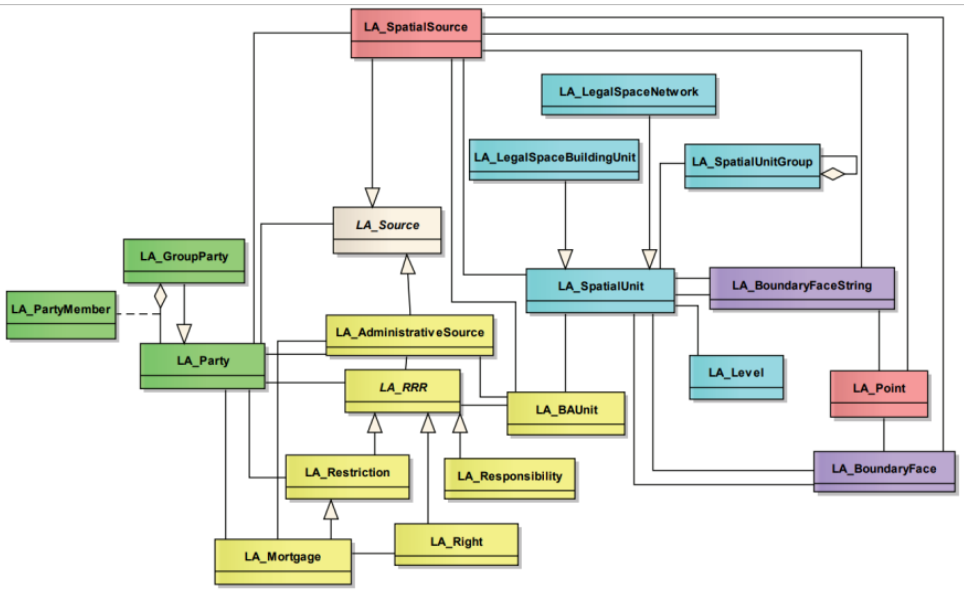

Figure 1: *Land Administration Domain Model, (Lemmen, Van Oosterom, and Bennett 2015)*

The LADM is currently being revised and consists of multipart, each constitute separate standards, with the latest edition comprising six parts. Each part will go through the full standardization process. See figure 2

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, (Lemmen, Van Oosterom, and Bennett 2015).

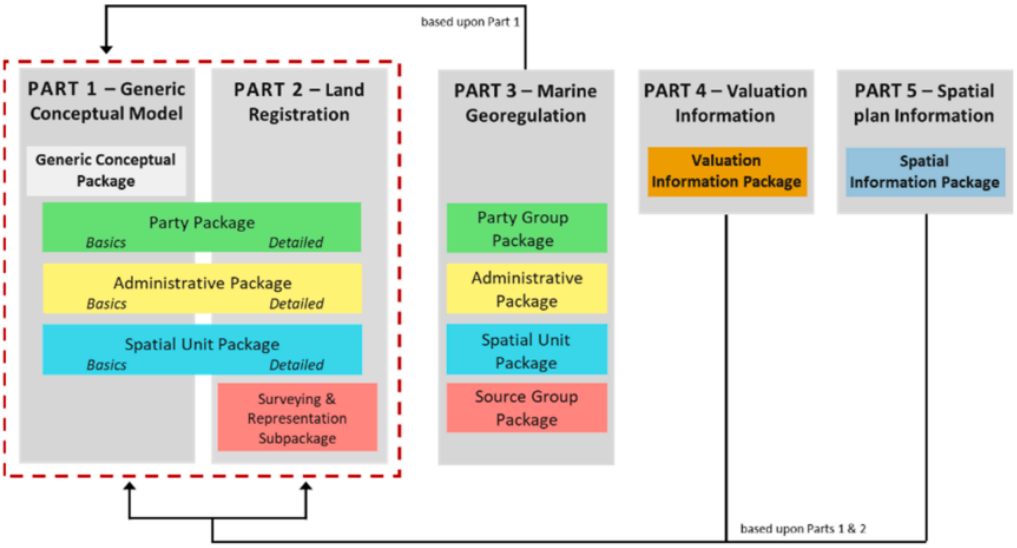

Figure 2: *Parts of LADM II, (Kalogianni et al. 2024)*

2.3 Circular 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, Honkasalo, and Seppälä 2018).

2.4 Material Passport

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. 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. 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 and Bilec 2020). The Material passports comprise multiple hierarchical levels, 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.).

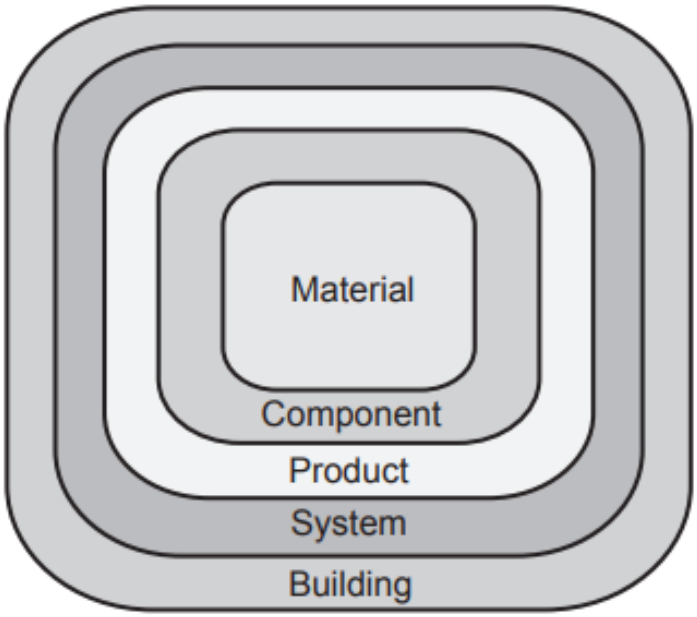

Figure 3: *Hierarchy level in Material Passport, (*Materials Passports - BAMB — bamb2020.eu *n.d.)*

2.5 Madaster

Madaster is the brand name of the Madaster Foundation, which aims to ensure the availability of materials across all economic cycles by registering them, thereby facilitating their availability at the highest possible level. Madaster is an independent online Platform contains library of materials in the built environment. The links the material identity to the location and records this in a Materials Passport. Currently Madaster operates in Netherlands, Germany, Belgium, Austria, Norway, Switzerland and UK.
To register a new or existing building in Madaster, detailed information about the building is required. The more comprehensive and complete the data provided (input), the more detailed and accurate the report generated by the Madaster Platform will be, particularly in the Materials Passport. The Madaster Platform accepts two types of source files:

- IFC files (derived from a 3D/BIM model).
- A Madaster Excel template (used when no 3D/BIM model of the building is available)

Various 3D CAD applications currently used for digital building modeling each have their own file formats, but they can communicate using the universal IFC file format, which can be exported by all 3D CAD applications. If a building is not modeled in 3D or if certain elements are not detailed in the 3D model, the Madaster Excel template can be utilized.

3. Research questions

The research conducted in this thesis combines the concepts of Circular Economy and Land Administration. The main research question of this thesis is:

How can Building material part: (ISO 19152-7) be integrated for LADM ?

To achieve this the following sub-questions are relevant:

1. What are the applications of the building material registration?
2. Developing link or reuse from other parts for the Building material part: (ISO 19152-7)
3. Load data from the database of Madaster and Circularity Hub of TU Delft
4. Test using the typical queries like time, location, quality and quantity
5. Evaluate the Information Model.

4. Methodology

This section describes the methodology to address the main research question and sub-research questions of the thesis. The first step involves conducting an extensive literature review on related topics. Using the insights gained, an information model will be developed for the Building Material part, ISO 19152-7, defining the necessary packages, data collection methods, and database structure. The finalized information model will then be tested through case studies. The first case study will use data from new buildings, as their design and construction information is readily available. The second case study will utilize data from old buildings, relying on surveys and heuristics due to the limited availability of material data. Test the information model with frequently used queries. Evaluate and correct the information model when required.

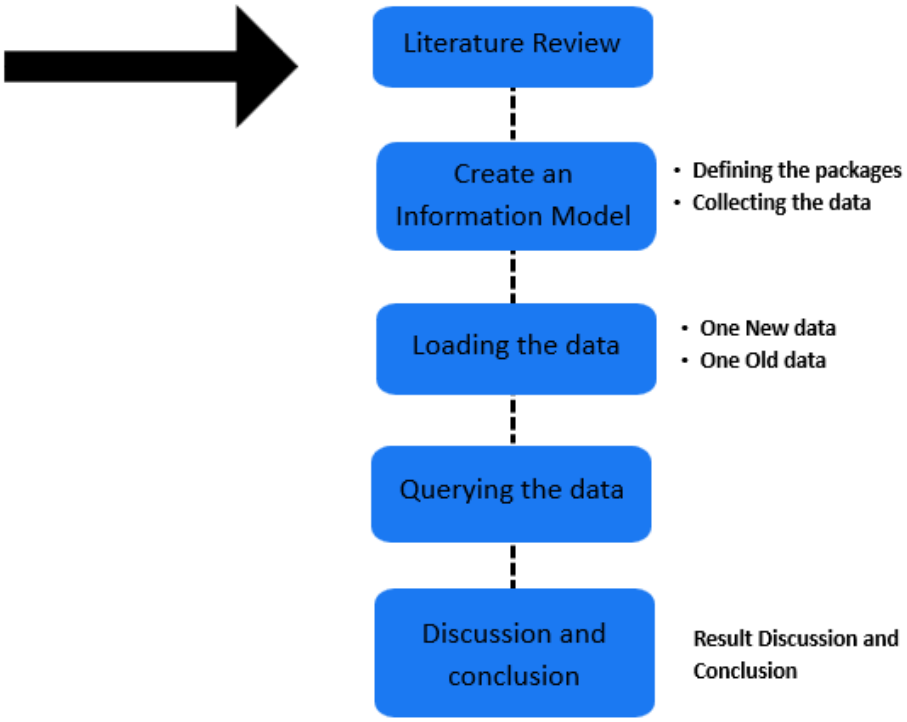

Figure 4: *Methodology*

5. Time planning

The preliminary graduation calendar and project schedule for the thesis are outlined below. The specific details for P4 and P5 will be determined as the timeline progresses.

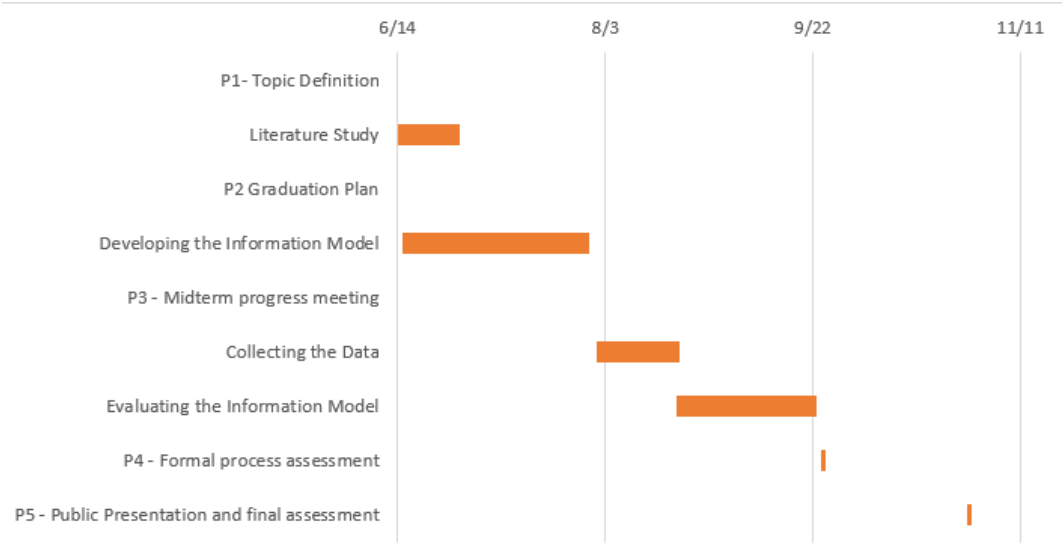

Figure 5: *The Graduation Plan*

Bi-weekly meetings were held with both of the supervisors as this was time for literature review and understanding basic concepts.

Activity	Date
P1 - Topic Definition	**19/04/2024**
Literature Study	18/06/2024 - 30/06/2024
P2 - Graduation Plan	**14/06/2024**
Developing Information Model	15/06/2024 - 30/07/2024
P3 - Midterm progress meeting	**31/07/2024**
Collecting Data	1/08/2024 - 21/08/2024
Evaluating the Information Model	20/08/2024 - 24/09/2024
P4 - Formal process assessment	**25/09/2024**
P5 - Public Presentation and final assessment	**30/10/2024**

6. Tools and datasets used

- **Softwares** - The software used will be PostgresSQL, Open IFC viewer, FME
- **Dataset** - The new datasets will be BIM/IFC. While the old dataset will be laser scans, floor plans, documents.

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