

## DYNAMIC MATERIAL PASSPORTS FOR SUSTAINABLE MATERIAL MANAGEMENT: A CONCEPTUAL FRAMEWORK

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### Abstract

The Construction sector faces a pressing need for whole life cycle sustainable material management. This paper presents the development of a theoretical framework for Dynamic Material Passports. Existing literature identified that Material Passports concept is new, lacking real-time updates and standardized methods with limited data and accuracy. Additionally, the current extensive manual input process discourages adoption. The framework, aligned with the ISO19650 standard, encompasses vital material information, environmental metrics such as Life-Cycle Assessment Data and Circularity Index, with real-time updates. This innovative framework enhances whole life material management, empowering industry stakeholders to make more informed Design and Procurement decisions.

### Introduction

The construction industry stands as a substantial contributor to environmental harm, encompassing issues like natural resource depletion, waste generation, and greenhouse gas emissions (MacArthur Foundation, 2022; UN, 2016). In response to these pressing challenges, there has been a growing emphasis on the adoption of circular economy principles in recent times. The Circular Economy (CE), as an economic model, aims to maximize the utilization of resources, minimize waste, and reduce adverse environmental impacts (MacArthur Foundation, 2022). In this context, Dynamic Material Passports (DMPs) emerge as a promising tool within the Architecture, Engineering, and Construction (AEC) sector.

In the Built Environment (BE), Material Passports (MPs) function as digital records, meticulously documenting the materials employed in construction, from their composition to their origin and location, throughout their lifecycle. This important information opens avenues for the efficient reuse, recycling, or repurposing of materials, significantly reducing waste, and promoting resource efficiency (Çetin, Straub, et al., 2022; Honic, Kovacic and Rechberger, 2019a, 2019b).

Nevertheless, considering its potential, the deployment of MPs faces certain challenges, particularly lack of standard methods of creation, compatibility, and currently have static form, without real-time updates (Honic et al., 2021). To address those obstacles, this research paper seeks to provide with a BIM-based framework for the development of DMPs, aligned with the information management processes described in EN ISO 19650, part

2 for a BIM level 2 project, that will promote CE practices in the BE. BIM is a form of digital technology that involves the creation and management of a digital model of a building, which include both its functional and physical properties (Becker et al., 2018). When it is used during design, construction, and operational stages, it creates a detailed and simple to access record of the materials used (M. Honic et al., 2019).

Hence, this research paper discusses the gaps based on the current state of MPs, the preliminary findings, and a proposed conceptual framework, which aims to fill the gaps identified from the literature review. The proposed framework involves four key stages: data collection, data management, data analysis, and data dissemination.

### Literature Review

#### MPs and CE

Over the past years, the construction industry is experiencing a significant transformation, and the emerging concept of MPs plays a crucial role to it (Çetin et al., 2022b). They have the ability to significantly improve resource management processes and the same time to simplify the transition of the BE to a CE perspective (Honic et al., 2021, 2019a, 2019b; Soman et al., 2022).

MPs, as comprehensive documentation systems, provide in-depth information about construction materials and products throughout their life cycle, covering details about their origin, characteristics, and environmental and sustainability attributes (Honic et al., 2019a; Kedir et al., 2021). Some example of data that may be included in MPs are manufacturing information, physical properties, chemical or biological properties, quality of material, design related information, location and transportation information, disassembly/ deconstruction manuals and sustainability information, such as embodied carbon and Circularity Index (Stella et al., 2023).

The Circularity Index or Indicator was developed by Ellen Macarthur Foundation (2016), as a tool for measuring the materials circularity, considering the amount of recycled material content the potential for reuse and recyclability of materials. It is calculated on the scale of 0% to 100%, with the higher percentage indicating the higher circularity. This indicator it can be used to assess the circularity of individual materials and products (Ellen Macarthur Foundation, 2016). Similarly, Madaster, a Dutch company that developed a digital platform for producing MPs, developed the Building Circularity Index based on MacArthur's Circularity Indicator, which measures the circularity of a building, taking into

consideration the amount of recycled materials used in a building (Madaster, 2018).

Also, it was found that there are different levels of MPs (Çetin et al. 2023). At the product level, "Material-Level Passports" set the foundation, while at the "Building level", specific design stages come into play (Çetin et al. 2023a; Stella et al. 2023). During "Design for construction stage" detailed material specifications are introduced while at construction stage with documentation of "as-built" information is complied, and "in used" stage focusing on the operational phase with regular updates to the MPs. For "End-of-life" stage marks the identification of information crucial for the considerations (Stella et al., 2023).

Historically, the BE has followed a linear economic model defined by resource consumption, use and disposal of building materials with the creation of significant amount of waste (MacArthur Foundation, 2022). Such an approach is both ecologically untenable as well as financially inefficient. Considering the current concerns about resource scarcity, deterioration of the environment, and global warming to move to a more circular and sustainable system for managing construction materials (Çetin et al., 2022a; Charef, 2022).

Therefore, as a fundamental concept, CE aspires to reduce waste and increase resource efficiency by encouraging recycling, reuse, and repurposing of materials across their life span (MacArthur Foundation, 2022). It encourages to "close the loops", from a linear economy to a more circular, in which items and materials are continuously refurbished, reused, and remanufactured, lowering the demand for raw materials and reducing the ecological effects of waste disposal (Pomponi and Moncaster, 2017). Also, the implementation of MPs in the BE is completely compatible with the CE principles (Çetin et al., 2023; Çetin, Straub, et al., 2022). They can assist in the tracking, control and optimization of the use of building materials (Atta et al., 2021; Honic, Kovacic and Rechberger, 2019a; Munaro and Tavares, 2021). Additionally, they can provide comprehensive information on each material used in a building, providing accurate and thorough documentation through the building's entire life span. MPs can also assist stakeholders to make informed decisions about material procurement, selection and consumption with focus on sustainability and resource efficiency (Honic et al. 2019a; Munaro and Tavares 2021).

### **MPs and Building information Modelling (BIM)**

BIM constitutes an advanced technological method that effectively combines planning, design, construction, and asset management in the BE. This digital tool, which assist to the representation both the functional and physical features of building assets allow successful cooperation among stakeholders (Becker et al., 2018).

Furthermore, BIM encourages transparency, collaboration, and decision-making based on data throughout the life circle of a building boosting

sustainable practices and waste reduction (Pishdad-Bozorgi et al., 2018; Sacks et al., 2018).

The combined approach of BIM and MPs offer great potential for sustainable building practices, since it provides a digital basis for a detailed 3D model (Alshammari et al., 2021; Pehlken and Baumann, 2020; Shahzad et al., 2022). Hence, a BIM-based method of producing a MP can be employed to improve the building design by considering resource efficiency and detailed documentation of materials used. BIM is used as a resource of information regarding the material quantities, overall building geometry and location within the building, while linking secondary databases to obtain their physical properties and evaluate their environmental impact or recycling potential (Honic et al., 2019a).

Additionally, the combination of MPs with BIM contributes to the successful collection and storage critical information on building materials increasing transparency and efficiency (Atta et al., 2021). A good example of that is a case study in Egypt, where a parametric BIM model permitted the automatic development of sustainable metrics for a residential building. This demonstrated that BIM improved the sustainability of the project through the use of resources efficiently, decreasing waste and enabling material monitoring for reuse (Atta et al., 2021). The BIM-based method takes use of the technologies capacity to integrate environmental impact evaluations via Life Cycle Assessment (LCA) via, giving a holistic approach to developing of sustainable buildings (Atta et al., 2021; Honic et al., 2019a; Kadir et al., 2021). Additionally, this combination can foster CE concepts in the BE by increasing transparency, traceability and accountability during the asset's life cycle (M. Honic et al., 2019).

LCA is a standardised method for assessing the environmental impact of a product, throughout its lifecycle and is based on ISO 14040, It includes greenhouse gas (GHG) emissions which is measured through Global Warming Potential (GWP). GWP is expressed in the equivalent amount carbon dioxide (CO<sub>2</sub>) (McGrady, 2022). Other indicators that are used in LCA are Acidification Potential (AP) measuring the potential of emissions to cause acidification, and ISO 14040 describes that LCA is carried out in four steps: goal and scope definition, inventory analysis, impact assessment and interpretation (Muralikrishna and Manickam, 2017). However, BIM is more than 3D visual representation, they contain essential data about the building's structure and its elements (Volk et al., 2014). An effective exchange of information can be achieved through Industry Foundation Classes (IFC) (buildingSMART, 2023). IFC was created by BuildingSMART as an open standard for transferring building data amongst different BIM tools. It also assures the compatibility and vendor neutrality, allowing project teams to use their preferred software while ensuring data usability (Jiang et al., 2019) IFC classes are also specified in ISO 19650 series as an appropriate format of storing the BIM model, due to interoperability (Earley Michael et al., 2022). Moreover,

Madaster platform, allows uploading the BIM model in IFC format, in order to produce MPs (Madaster, 2023).

### **MPs and Artificial Intelligence (AI)**

The data compilation for creating MPs has been traditionally a time-consuming operation. As some researchers stated, manual procedures need precise data gathering, which is a laborious and inclined to errors (Honic et al., 2021, 2019a; Hunheviz et al., 2023; Kovacic et al., 2020). Hence, they are an urgent need for standardized protocols and tools (Atta et al., 2021; Göswein et al., 2022) which created the ground work for Deep Learning (DL), a particular type of AI. DL specializes in optimizing and automating complex procedures in MPs development (Akanbi et al., 2020; Oluleye et al., 2023), providing immediate updates and precision across the building's lifespan (Çetin et al., 2022a).

DL, was influence by the functions of human brain, emerging this way, as a transforming force in CE activities. Its forecasting ability is aligned with the requirements of sustainable material management (Lu and Chen, 2022), enabling the creation of a more sustainable BE adaptable to changing demands. Contrary, Machine Learning (ML), is based on algorithms that analyses and forecast based on data (Noman et al., 2022). ML is extremely useful for CE as it can assess material consumption patterns and foreseeing trends for enhancing resource (Çetin et al., 2023). Through sophisticated algorithms, both DL and ML provide possibilities for developing a circular BE, outcoming from technological, economic environment and social aspects (Akanbi et al., 2020; Oluleye et al., 2023).

The selection of an AI approach for developing an MP framework requires a considerable deliberation. Current research describes three approaches for developing MPs: the top-down, the bottom up and hybrid methods (Honic et al., 2021), that demand an extensive understanding of the building materials. As a result, such methods may be easier to be examined by DL given that they have higher accuracy, flexibility and capacity to handle large datasets, making it the best choice, enabling stakeholders taking better decisions.

### **Current state of MPs**

The present form of MPs in the BE includes technological, economic, environmental, and social factors. Current studies proposed that a standardized method for generating and managing MPs, pointing out the need of uniformity and accessibility (Atta et al., 2021; Honic et al., 2019a). Several studies restate the need for consistent guidelines and protocols across the sector (Göswein et al., 2022; Negendahl et al., 2022).

In respect to technological factors, current methods of creating MPs can be quite laborious. Their creation requires substantial time as it involves to extract material information from the BIM model to an excel file, collect information from material inventories and then manually input in the excel document, which will finally be linked

back to the BIM model, using unique identifiers (Atta et al., 2021; Honic et al., 2019a; Kovacic et al., 2020).

The implementation of MPs is also considered as economically feasible with possible cost decreases through material reuse (Smeets et al., 2019). Furthermore, significant economic benefits can be achieved through the digitalization of MP (Çetin et al., 2022a), in conjunction with the best practices (Heinrich and Lang, 2019).

From an environmental perspective, MPs are touted as catalysts for sustainability, enabling high levels of material recycling (Honic et al., 2019b) and stock flow modelling emphasize the potential to calculate circularity (Göswein et al., 2022; Negendahl et al., 2022).

On the social front, transparency, accountability, and stakeholder engagement take centre stage. Digital platforms integrating MPs with stakeholder engagement are recommended (Hunheviz et al., 2023; Kovacic et al., 2020). The importance of stakeholder engagement, especially in the end-of-life stage of buildings, is highlighted (Honic et al., 2021). Additionally, local scenarios play significant role on the choice of sustainable construction materials, as evidenced by a case study suggesting that a building MP for wood construction system in Brazil, could significantly reduce the environmental impact of construction versus more conventional materials, such as a concrete and steel (Munaro et al., 2019).

### **Gaps and Challenges**

MPs have great potential with their deployment in the BE although they are facing significant challenges. Their major disadvantage is their static form, that limit them to no frequent updates, that are necessary to accurately reflect real-time changes in a material's composition, condition, and lifecycle, enabling informed decision making for sustainable resource management and end-of life strategies (Atta et al., 2021; Kovacic et al., 2020). Their stationary state compromises MPs' adaptive perspective, in terms or real-time updates, reducing their level of accuracy and efficacy through sustainable material management. Due to that static nature and high level of manual input for updating material data also their inability of optimizing and automate processes reduce their long-term effectiveness (Atta et al., 2021; Honic et al., 2019a; Kovacic et al., 2020) .

Another challenge for the development of MPs is the lack of a standardized methods for compiling MPs. MPs appear in a variety of formats, including paper-based and digital, with varied degrees of details, causing in inaccuracies and limiting sharing of data among stakeholders (Heinrich and Lang, 2019; Honic et al., 2021). Developing a consistent approach for producing MPs is critical that contributes to the reduction of errors and ensuring that correct information is exchanged between the stakeholders such as AEC professionals, waste managing and material suppliers (Kovacic et al., 2020).

Another challenge that affects the implementation of MPs in the BE, is the insufficient incentives for their

implementation. MPs adoption is not adequately motivated by the current economic and regulatory frameworks, but also the BE gives higher priority to the speed and cost reduction rather than sustainability (Göswein et al., 2022). In order to promote the broad use of MPs, policymakers must provide regulations and incentives, such as tax reliefs or financing green procurement for sustainable construction (Smeets et al., 2019).

A further obstacle involves the quality, accessibility and data administration. All building materials have different origin, making it difficult to collect and maintain their specific data (Atta et al., 2021; Honic et al., 2019a). To guarantee the accuracy and accuracy of MPs data, improved data management systems and quality control techniques are required. Additionally, the environmental implications of building materials are frequently neglected, when implementing MPs. There is no assessment of the materials' long-term environment impacts in the existing MPs frameworks (Heisel and Rau-Oberhuber, 2020). To provide a thorough understanding about their environmental effects, using standardized methods for environmental assessments into MPs frameworks.

MPs also face challenges related to the end-of-life state of buildings, such as disassembly or deconstruction instructions. Therefore, buildings are often thought to be demolished as the best solution, rather than carefully dismantled, leading to destruction of possible healthy reusable materials, creating this way construction waste. Hence, by integrating MP data into waste management strategies can help avoid unnecessary demolition and waste, preserving essential materials and resources (Honic et al., 2019b). Successful reuse and recycling necessitate improved coordination among stakeholders and waste management professionals.

## Methodology

The present research provides a conceptual framework for Dynamic Material Passports (DPMs) using a strong approach based on in-depth literature review. The main emphasis is on analysing the present status of MPs in recent literature understanding the data needs for constructing MPs, defining how their features could be implemented in the DMPs in accordance with existing standards and finally identifying the gaps in the current state. The process entails a comprehensive literature review, followed by an inductive research approach to develop this conceptual framework. The framework is refined by a comparison of various MPs approaches, as described in "current state". The compilation of qualitative data from different methodologies adds to a practical conceptual framework, providing useful insights for its future application in the BE.

## Proposed Conceptual Framework

The conceptual framework intends fill the gaps for the static data of current MPs approaches and to address the tracking of the material differenced in terms of future

retrofitting and refurbishment, through a project's life circle (See Table 1). The emphasis will be initially on the creation of DMPs at "Material level" with information that collected during the design stages. The DMPs will incorporate technologies such as BIM, GS1 barcoding standards and AI. This strategy addresses will address towards the improvement of data accessibility, accuracy and regular updating thought the building's life span.

Table 1: "Current State" Vs "Future State"

Feature	Current State (MPs)	Future State (DMPs)
<b>Definition</b>	Tracks and documents materials used in construction or manufacturing	Real-time, digital tracking throughout the lifecycle
<b>Scope</b>	One-time documentation at construction/manufacturing	Continuous monitoring and updates
<b>Data Update</b>	Static information; that cannot update	Dynamic, allows real-time updates
<b>Tech. Integration</b>	Relies on traditional methods with substantial manual input	BIM, AI, QR codes
<b>Use</b>	Snapshot for end-of-life recycling/reuse	Critical for asset management throughout life cycle

In the context of this study, a BIM model for a proposed new building is generated as the initial step (Step 1, Fig.1). This involves creating a digital representation of the physical structure using BIM tools like Revit and adhering to the ISO 19650 for "BIM Stage 2" modelling guidelines. Clause 5 of the ISO 19650-2 describes in detail the processes and processes that are necessary to compile the Project Information Model (PIM) during the design stages. Also, the information that will be required for DMPs will be included in the Project Information Requirements (PIR) and Exchange Information Requirements (EIR), both compiled during the process 5.1: Assessment for Need, as described in the relevant clause.

Following the PIM creation, the primary components for constructing the DMPs are identified. Recognizing the absence of a standard method for data requirements, the material data considered is refined in subsequent stages, drawing from recent literature. The data encompasses three categories: material information (type, physical properties), sustainability indicators (such as the Circularity Index), and component information (including manufacturing, installation, maintenance, disassembly instructions, and expected lifespan and performance data). Simultaneously, while setting up the initial BIM model, a material inventory is established based on information for each piece, using unique identification and names specified in ISO 19650 (Step 2, Fig.1). Also, is worth

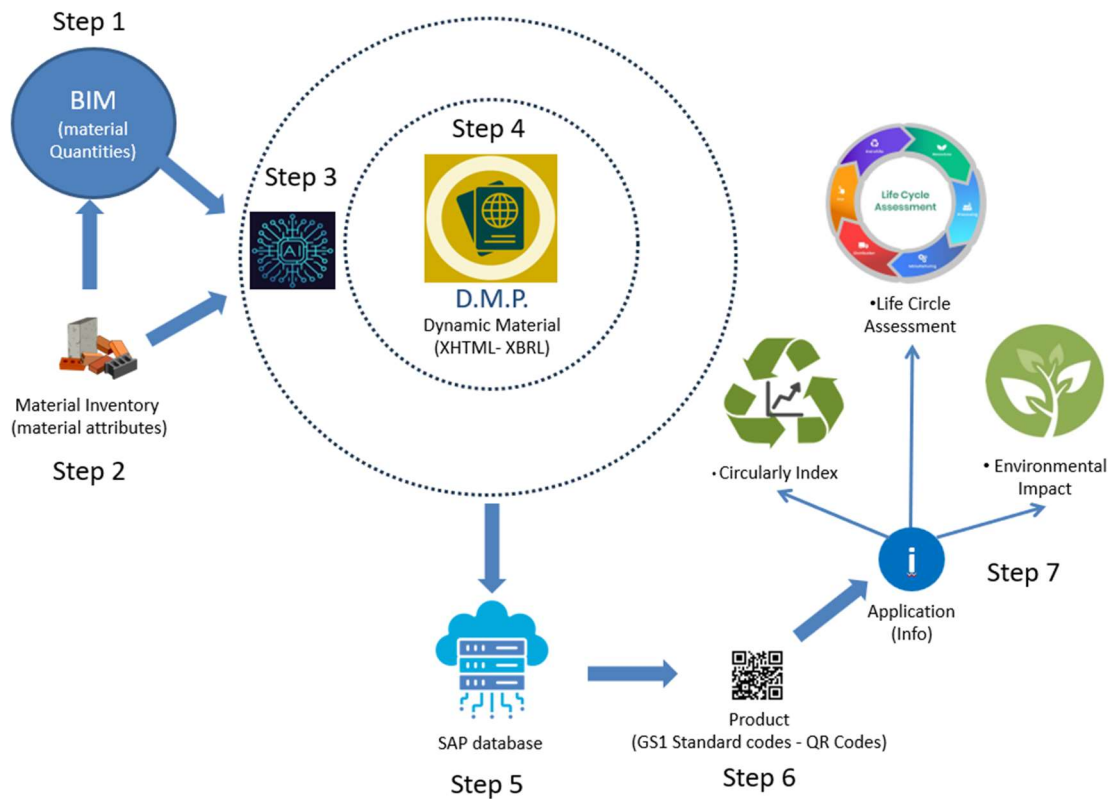


Figure 1: Conceptual framework for DMPs (own illustration)

mentioning, part of the dynamic nature of DMPs, it would require to be linked to 4D ontology. 4D ontology refers to the integration of time (the fourth dimension) into the digital representation of a building. This will enable the capturing and visualisation of how elements of the project change and interact over time, but also simulate and anticipate future changes throughout the lifecycle of the project.

AI techniques, including ML and DL, may be deployed to collect diverse attributes of the supplied content (Step 3). ML algorithms can analyse existing data sources, such as supplier documentation and manufacturing records, to identify patterns and relationships. Additionally, ML predictive models can assist in forecasting potential gaps and areas of uncertainty, prompting proactive measures. On the other hand, DL models, equipped with neural networks, are advance in processing complex and unstructured data. Furthermore, DL models, can handle sequential data, ensuring a more refined understanding of materials' dynamic attributes over time. These techniques contribute to the identification, categorization, and tracking of materials, assessing their origins, environmental impact, and even predicting future performance (Çetin et al. 2023b). DL algorithms automate material-related data acquisition from various sources like product databases, material suppliers, manufacturers, and construction documents. They can navigate websites to extract essential data from digital sources, eliminating the need for extensive manual labour.

DMPs may be created as an Extensible Hypertext Markup Language (XHTML) document adorned with eXtensible Business Reporting Language (XBRL) tags (Step 4, Fig.1). XHTML, as opposed to HTML, has more rigid syntax and formatting restrictions. It is also guaranteeing that web browsers and interpreter programs can process it seamlessly. Usually, it is standard practice to combine XHTML with XBL in order to ensure data integrity and interoperability across systems, particularly on the internet (Stewart, 2020).

In financial reporting, XHTML formats interconnected with XBRL tags are commonly employed, giving a dual-readable structure for both people and machines. XBRL tags are used to insert standardized and machine-readable data into an XHTML file, facilitating financial report processing and analysis. This unified technique reduces inconsistencies and simplifies the filing process, resulting in a strong resolution for financial reporting requirements (Siddle 2020; Stewart 2020). The use of XHTML with XBRL tags is an effective form for storing and evaluating material and sustainability data. Hence, the ability of XBRL to stipulate context, combined with XHTML is quite beneficial for DMPs.

The next step is proposed that store the files in Single Access Point (SAP) database, similar to European Single Access Point (ESAP) which is used for (Step 5, Fig.1). As in ESAP, SAP will provide access to publicly available information related to MPs data. Therefore, this will be consistent with the EU' Digital Strategy and the targets of

European Green Deal, fostering transparency and accelerating decision-making for stakeholders (European Commission 2023).

SAP will constitute a regulated platform, will encompass various features, including a web portal, API for data retrieval, multilingual search function, information viewer, machine translation service, download service, and notification service for updates. This can be particularly crucial for Small and Medium Enterprises (SMEs), for future sustainable related decision-making (European Commission 2023).

The subsequent step involves exporting BIM model and data related to building elements, their layers, volumes, thicknesses, and individual components to be linked to a Quick Response code based on GS1 standards (Step 6, Fig.1). Essential standards include the Global Trade Item Number (GTIN), GS1-128, Global Location Number (GLN), and Global Data Synchronization Network (GDSN) to ensure accurate and updated data accessibility across the supply chain (GS1 2023).

A method of barcoding involves Quick Response (QR) codes, with dynamic QR codes being considered for this research. Dynamic QR codes have the capability to employ an intermediate concise URL for redirecting, enabling modification of stored data within the same printed QR code. Recent research highlights the effectiveness of QR codes in tracking materials, providing essential information about each building element (Byers et al., 2022). These QR codes improve material tracking in the construction process, offering real-time updates to the MP, especially concerning location.

Real-time update is crucial will be enabled by scanning the QR code, especially during and construction phases, or refurbishments which allows access to the material's geo-location through GIS, by scanning by using a phone or tablets. Some of the building materials like concrete, steel, and brick exhibit relatively stable properties over time. Unlike dynamic assets that undergo frequent changes or degradation, the characteristics of these materials remain largely consistent throughout their lifespan. Therefore, the need for real-time updating to capture sudden variations or anomalies may be minimal, as gradual changes can be adequately monitored through periodic assessment. AI techniques, including computer vision, enable the scanning of QR codes and linking to relevant data, facilitating estimations such as embodied carbon due to transportation.

For example, a DMP for items such as electrical motors within ventilation systems which have relatively shorter lifecycle than the building structure and envelop, will allow instant access to current data on the origin, composition, and quality of its components. As the motor has been replaced, then with DMP will be easier to be tracked in order to obtain the embodied carbon. With the aid of AI, the DMP will be able to collect missing information, in respect to the physical or manufacturing characteristics, as well as LCA calculations, and updated information. The combination of the BIM 4D ontology will enable to track the motors' state over time, such

operation and maintenance stages, capturing crucial details about the history and condition of motor. Also, the use of the QR codes will facilitate easier retrieval of the motor information using mobile devices, as well as tracking the geolocation. In this way, informed decision-making is enabled, in respect to the motor's maintenance, repair, or end-of-life options and ultimately will assist to reduce the environmental impact of the motor's lifecycle. Additionally, the DMPs will include automated sustainability indicators such percentage of recyclable materials, waste, and environmental impacts, LCA calculations expressed by the use of algorithms, in terms of Global Warming Potential (GWP), Acidification Potential (AP), and Potential Energy Index (PEI) (Step 7, Fig.1). Also, the inclusion of Circularity Index created by McArthur Foundation to DMPs will allow to score the circularity of the building based on the percentage of recycled materials used. AI plays a significant role in enhancing the accuracy of these environmental impact assessments. ML algorithms process large datasets to identify patterns and correlations, providing insights into material performance and environmental impact.

### **Limitations and Challenges for Implementing the Conceptual Framework**

DMPs implementations in the BE faces significant limitations. Those major challenges include industry's opposition, anchored in old procedures, necessitates careful positioning to explain the benefits of DMPs while addressing concerns from moving traditional approaches. A further challenge is the financial limitations, particularly for SMEs, that need to deliberate cost reductions. Also, interoperability concerns between many stakeholders who use different BIM software, demand careful planning and possible plugin development. In addition to that, maintaining data accuracy among the supply chain is difficult, requiring coordinated collaborations common data dictionaries. In relation to data, concerns about privacy and security is another limitation.

Finally, the lack of standard and regulations for creating MPs and educating professionals in the use of new technologies such as DMPs could be really challenging. Considering these problems as possibilities for improvement, can lead to a more robust implementation of DMPs in the BE.

### **Conclusions and Future Work**

The proposed conceptual framework of DMPs intends to fill the gaps of current state of MPs, such as its current static form, lack of regular real-time updates for the material information throughout a buildings life cycle which current requires a lot of manual input. This is may lead to errors and included information to be included in the MPs current state.

DMPs is proposing the use of BIM model, in conjunction with the BIM standards of ISO19650-2 "Delivery phase of an Asset", which give a detail the processes of creating a BIM model in addition to information management for

a BIM level 2 project. The BIM model will provide the quantities and specific location of materials in the building. In conjunction to AI techniques of collecting and analysing complex data, and also scanning codes based on GS1 standards, will enable the DMPs to provide up-to-date information of about the construction materials. Furthermore, the incorporation of LCA into DMPs will add sustainability aspect to the framework, contribute to the reduction of the carbon footprint of the BE.

The future research will focus on the creation of the prototype DMP and further investigation of the use of appropriate AI techniques. Following the creation of the prototype, collaboration with industry will take place to run a Pilot Case study for the DMPs implementation in the BE that will allow the assessment of its effectiveness. This will allow feedback from industry that will be assessed and contributes to the continues improvement of the prototype and based on the lessons learned from this pilot study.

## Acknowledgments

The Author would like to thank the co-writers of this paper for their assistance in completing this paper. Also, the author would like to express his sincere gratitude to Ms. Anastasia Stella, Sustainability Associate at Waterman's Group (UK) and co-founder of "CIRCULAND", for her support during this research. The research is funded by "Build Digital Project" from Department of Public Expenditure, Republic of Ireland.

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