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Perceptions of brazilian construction industry professionals regarding a BIM-based materials passport: A qualitative exploratory study

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ABSTRACT

The construction industry is responsible for approximately one-third of greenhouse gas emissions and over 50% of natural resource consumption. In this context, the Circular Economy (CE) emerges as a strategy to promote economic development while reducing dependency on natural resources. Tools such as the Materials Passport (MP) are crucial in facilitating this transition. The MP is a digital solution that collects data on materials, aiming to facilitate their recovery and reuse. In Brazil, it is still underutilized. Therefore, understanding the perceptions of Brazilian professionals regarding this tool is crucial for its broader implementation in the sector. This study analyzes the views of four professionals on the concept and process of modeling an MP, based on interviews. The interviews consist of a validation method defined as a functional test, which examines the desired parameters from the user's perspective without requiring the user to understand the system's internal structure. The results highlight two main obstacles. First, modeling processes and information management still need to evolve to achieve market applicability. Second, tools applicable to CE in construction, such as the MP, must be accompanied by greater awareness of CE, MP, and sustainability concepts within the sector.

1 Introduction

Since the Industrial Revolution, the Linear Economy (LE) has predominated as the model of production and consumption [1]. This model, characterized by the "extract–produce–use–dispose" process, remains widely applied in the built environment, even with industrial advances, improvements in energy efficiency, and the development of new construction processes [2]. As a result, the construction industry stands out as one of the largest consumers of natural resources and raw materials worldwide [2]. It is estimated that this industry uses more than 50% of the planet's natural resources [3]; is responsible for one-third of greenhouse gas emissions [4]; and that its demand is expected to grow due to population increase [5].

The Circular Economy (CE) emerges as an alternative model of production and consumption that decouples economic growth from the extraction of natural resources [5], [6], keeping materials and products in use for as long as possible and at their highest value [6]. The creation of circular solutions involves the development of the Materials Passport (MP), a tool for incorporating CE principles [7]. Similarly, Digital Product Passports (DPP) represent a broader regulatory-driven concept that aims to provide comprehensive, product-level information across multiple industries [8], whereas the MP, as adopted in this study, are construction-specific tools focused on material-level data to support circular economy strategies within the built environment. In the construction sector, the MP is still not widely adopted [1], and there are few studies dedicated to introducing circular practices in this field [8].

In the construction sector, the MP is still not widely adopted [1], and there are few studies dedicated to introducing circular practices in this field [9].

In the context of the built environment, the MP is a digital documentation tool [10], [11] functioning as a set of data and information detailing the characteristics of materials, assigning them value for recovery and reuse [7]. The information contained in an MP must be useful, accessible to users, and able to effectively communicate the level of information related to a product in a dynamic, living document. This document must be capable of reflecting the material's value throughout its entire life cycle and, therefore, requires an understanding of the Life Cycle Assessment of the material in question [12]. According to the Smart Waste Portugal Association (2021) [13], the data contained in an MP provide technical information about a construction

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product, enabling the identification of both its environmental impacts and its potential for recovery, reuse, and recycling.

Building Information Modeling (BIM) can be considered an enabler for integrating circular principles into building projects [14], as it encompasses technologies and processes for an integrated design practice. Modeling consists of creating a physical and operational representation of a building, with the capacity to store information and share essential data throughout the entire lifecycle of the project [15]. Thus, BIM has the potential to support the effective development and management of an MP [16]. Rahla et al. (2021) [17] highlight that many studies address issues related to the use of MP and BIM technologies to monitor and manage materials and components throughout the lifecycle in the construction industry, as well as to assess the level of circularity of these elements in buildings. Additional benefits of integrating BIM and MP have also been identified, such as error reduction, saving time and effort, and facilitating the sharing of sustainability information [18].

Despite the growing body of research addressing the technical development of MP and their integration with BIM, most existing studies primarily focus on conceptual frameworks, data structures, and technological solutions. However, there is still a limited understanding of how construction industry professionals perceive the applicability, usability, and practical value of the MP in real-world design and construction contexts. Since the successful implementation of digital and circular tools depends not only on their technical robustness but also on user acceptance and professional engagement, the lack of empirical studies exploring practitioners' perceptions represents a relevant research gap.

In this context, this article aims to investigate the perception of construction industry professionals regarding an innovative tool such as the Materials Passport. Understanding professional perception is critical, as designers, engineers, and decision-makers play a central role in the adoption and effective use of digital tools within the construction sector. To achieve this objective, a modeled MP is presented in the section "Application of Materials Passport," developed using Revit and Dynamo. This MP was conceptually proposed by Munaro and Tavares (2021) [1] and modeled in Revit by Alves (2025) [19] using automations developed with Dynamo. A validation protocol based on a functional test was conducted through interviews with construction industry professionals, enabling the identification of opportunities and challenges for incorporating the MP into the Brazilian construction industry.

2 Methodology

2.1 Application of Materials Passport

Munaro and Tavares (2021) [1] propose an MP model that includes the information needed to recover and reuse secondary components and materials in construction. The passport data are structured into: (1) general data, including the manufacturer's name, material composition, commercial name, among others; (2) health and safety data, such as information on toxicity, flammability, and related aspects; (3) sustainability data, including life cycle assessment, renewability of the material, among others; (4) design and production data, such as manufacturing processes and techniques, type of installation, certifications, among others; (5) use and operation phase data, covering material cleaning and maintenance, location and position in buildings, monitoring of energy and water consumption, among others; (6) disassembly guidelines, including instructions for disassembly and transportation, among others; (7) data on the reuse and recycling potential of materials, including end-of-life destination and possible reuse/recycling types; (8) material use history, such as recent maintenance and previous uses; and (9) other information that complements the material data.

Alves (2025) [19] develops the modeling and visual programming of this MP using Revit software and the Dynamo tool for automation scripting, with the support of Microsoft Excel. Revit, developed by Autodesk, is used to design, document, visualize, and deliver projects in architecture, engineering, and construction. Dynamo, also developed by Autodesk, was created to expand Revit's capabilities. It is a tool that uses visual programming, eliminating the need for prior programming knowledge. This enables the creation of scripts to automate repetitive tasks, interact with the Revit model, and develop new models based on complex rules and external data [20]. Figure 1 shows the BIM-based MP.

The proposed MP [1], [19] is composed of 49 parameters divided among the nine categories of information. Table 1 presents the categorized parameters that make up the MP, specifying the input of data formats in the BIM platform, as defined by the authors. The parameters were defined according to the MP proposed by Munaro and Tavares (2021) [1], except for the Sustainability parameters, which were adjusted according to data availability. The parameters defined for Sustainability include the Product Environmental Declaration (EPD), embedded energy and water data, and the circularity index.

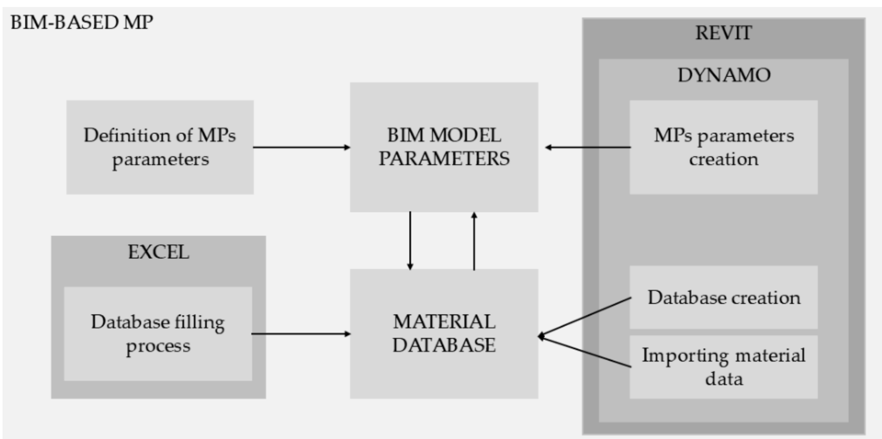

Figure 1. MP development [19]

Table 1 presents the MP parameters. The parameterization structure adopted for the MP in this study was developed by the authors and did not explicitly follow existing international standards for data templates and interoperability, such as ISO 23387 (Data Templates for Construction Objects) [21] or ISO 16739 (IFC) [22].

Initially, the parameters of the BIM model are specified and implemented directly within the BIM environment through visual programming routines developed in Dynamo (version 2021). Subsequently, a material database is structured using Dynamo scripts derived from the materials already available in Revit. This database is hosted in Microsoft Excel (version 2021), where the material information is manually entered. Once completed, the database is imported into the BIM model, and the information is embedded in the material parameters, enabling its use, exchange, and transmission among project stakeholders.

Figure 2 presents the Dynamo workflow along with the nodes employed in the visual programming process. Each node operates based on predefined input requirements. The concluding stage, referred to as “Material data import,” consists of a routine with two nodes: one responsible for transferring the Excel-based database into the BIM environment, and another for mapping the imported data to the corresponding material parameter. The subsequent sections provide a detailed description of the MP development process.

Table 1. Materials Passport Parameters

Category	Parameter	Format
General data	Commercial name	Text
	Manufacturer’s name	Text
	Material composition	Text
	Physical properties	Number
	Chemical Properties	Text
	Biological Properties	Text
	Product image	Image
	Main function	Text
Material health (safe data sheets)	Warnings (safety information)	Text
	Recommendations (safety information)	Text
	Toxicity (material composition)	Text
	Fire hazard rating	Text
	Hazard rating (other)	Text
Sustainability	EPD (Environmental Product Declaration)	URL
	Embodied Energy (EE)	Number
	EE in transport	Number
	Embodied water (EW)	Number
	GWP (Global Warming Potential)	Number
	ODP (Ozone Depletion Potential)	Number
	AP (Acidification Potential)	Number
	EP (Eutrophication Potential)	Number
	POCP (Photochemical Ozone Creation Potential)	Number
	ADP-elements	Number
	ADP-fossil fuels	Number
	Circularity Index	Number
	Recycled/reused/renewable material?	Text
Design and production	Manufacturing process and techniques	Text
	Installation and handling instructions	URL
	Certifications (energy labeling, material testing)	Text
	Traceability (RFID tags, barcodes)	Text
	Transportation requirements	Text
	Packaging characteristics	Text
	Supply chain information	Text
Use and operate phase	Positioning and location in the building	Text
	Cleaning instructions	Text
	Maintenance instructions	Text
	Connections details and requirements	URL
	Warranties and expected use times	Text
	Water consumption	Number
	Energy consumption	Number
	External influences	Text
Disassembly guide	Disassembly instructions (removal/replacement of pieces)	URL
	Packaging/storage requirements	URL
	Transportation instructions	Text
Recycling and reuse potentials	End-of-life considerations (reuse/recycling/remodeling)	Text
	Disposal Options	Text
	Decomposability	Text
History	History	Text
Others	Others	Text

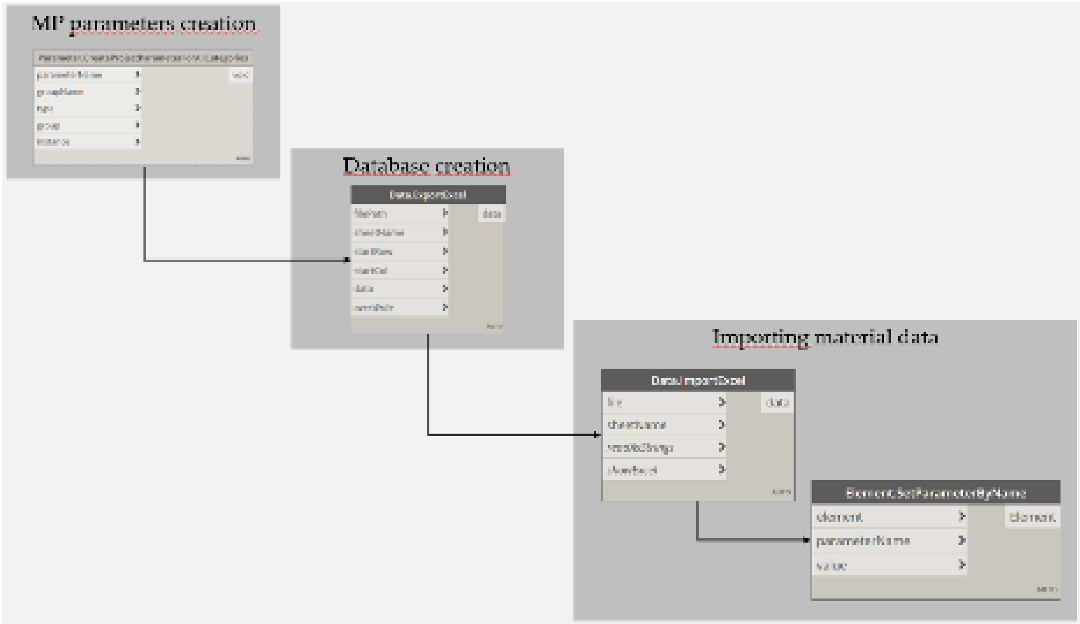

Figure 2. Dynamo workflow [19]

2.2 Functional test

The development of the proposed MP and its validation are part of the research conducted by Alves (2025) [19]. The author presents the step-by-step process of modeling the MP and validates it using validation strategies based on Dresch, Lacerda, and Junior (2015) [23]. Thus, this article presents only the proposed MP in the section "Application of Materials Passport" and applies one of the validation methods used in the study, defined as a functional test.

This type of validation, a black-box functional test, examines the desired parameters from the user's perspective without requiring the user to understand the internal structure of the system. Its purpose is to test the functionality and usefulness of the MP [24]. In addition, the functional test makes it possible to identify potential failures and detect defects in it [23]. To achieve this, an interview protocol was used to evaluate the MP.

The questions were developed considering: (1) whether or not participants had prior knowledge of the topic; (2) whether these topics became clearer after the presentation of the MP; and (3) whether the presented MP is easy to use, efficient, and operational within the construction industry. Thus, the responses revealed the level of maturity and understanding regarding the topic, as well as identifying the positive or negative perception of the MP within the construction market.

Table 2 presents the interview protocol. It was divided into four stages. The first stage contained four questions, answered before the presentation of the MP. In the second stage, the concept of the MP and the modeling of the proposed MP were presented to each participant individually and remotely, in the form of a lecture. The content of the lecture begins with the concept of CE [2], [5], then it goes with the MP definition and examples in the literature [7], [10], [12], [25] and finishes with the application of MP as it is shown in section 2.1 "Application of Materials Passport".

The third and fourth stages consisted of 12 and three questions, respectively, which were answered after the presentation of the MP. All questions were answered remotely through online forms.

The term 'artifact' is adopted in accordance with Design Science Research terminology, referring to the developed MP [23].

DSR literature does not establish a minimum number of specialists for artifact validation, since the evaluation should be appropriate to the type of artifact, the maturity stage, and the research objective [26]. This perspective allows for the assessment of an artifact by one or more experts (e.g., Delphi study), as the sufficiency of evidence in DSR is often a matter of community agreement and persuasive argumentation rather than a fixed numerical rule [26]. In this study, the selection prioritized diversity of experience and mastery of the problem over sample size, aligning with recommendations on validity in DSR [27]. This choice is based on the application of criterion characteristic validity, which is considered ideal when human agents are involved in judging the properties and usefulness of the artifact, rather than relying solely on automated numerical measurements [27].

This study adopts an exploratory qualitative approach within a DSR framework, aiming to generate initial insights into the perception and applicability of the MP rather than statistically generalizable results. Thus, the professionals interviewed were selected through purposive (non-probabilistic) sampling. According to Creswell (2014) [28], purposive sampling is widely employed in qualitative research to intentionally select individuals with direct experience of or knowledge of the phenomenon under investigation. In this context, the selection of four participants was intentional, aiming to identify information-rich cases with diverse professional backgrounds that combine academic and industry perspectives. The focus was placed on depth of understanding and the richness of expert insights rather than sample size.

Furthermore, the study does not aim to achieve theoretical saturation, as commonly pursued in grounded theory approaches, but rather to explore early-stage perceptions and identify key challenges and opportunities for

Table 2. Interview protocol

INTERVIEW PROTOCOL	
STAGE 1	
Question 1	What do you understand by Circular Economy in construction?
Question 2	What do you understand by Materials Passport as a technological tool for the integration of Circular Economy in the construction industry?
Question 3	What do you understand by the use of technology and technological tools to achieve more sustainable building and construction projects in the construction industry?
Question 4	What do you understand by the use of BIM to achieve more sustainable building and construction projects in the construction industry?
STAGE 2	
Presentation of the Material Passport (the concept and modeling)	
STAGE 3	
Question 1	What do you understand by Circular Economy in construction?
Question 2	What do you understand by Materials Passport as a technological tool for the integration of Circular Economy in the construction industry?
Question 3	What do you understand by the use of technology and technological tools to achieve more sustainable building and construction projects in the construction industry?
Question 4	What do you understand by the use of BIM to achieve more sustainable building and construction projects in the construction industry?
Question 5	What do you understand by the use of technology and technological tools to incorporate circular concepts in the construction industry?
Question 6	What do you understand by the use of BIM to incorporate circular concepts in the construction industry?
Question 7	Is it possible to identify, based on your professional practice, how the presented approach can improve the sustainability of projects and constructions?
Question 8	Is it possible to identify, based on your professional practice, how the presented approach can improve the circularity of projects and constructions?
Question 9	Is it possible to identify flaws and/or defects in the resource?
Question 10	Is it possible to incorporate the artifact presented in the building design practice to make it more sustainable?
Question 11	Is it possible to incorporate the artifact presented in the building design practice to obtain a material database?
Question 12	How can this method improve the design practice of buildings?
STAGE 4	
Question 1	Suggestions for system improvement.
Question 2	Can you identify, based on the resource presented, professional practices that can be incorporated into your routine to promote more sustainable and/or circular constructions?
Question 3	Other comments.

future research. This approach is consistent with the exploratory and interpretive nature of qualitative inquiry, where the aim is not statistical generalization but the in-depth understanding of meanings, perspectives, and processes. The limited number of participants should therefore be interpreted in light of the exploratory nature of the study and the DSR-oriented validation of the proposed artifact.

The interviewed professionals had professional qualifications in the construction sector and prior knowledge of sustainability in the built environment and/or BIM. Also, the profiles selected for the interview combine Academy/Research and professional practice. The study intentionally focused on exploring and introducing MP concepts and modelling approaches in the Brazilian context, rather than statistically assessing the maturity of MPs in the construction sector.

The qualifications of each professional are presented in Table 3. Interviewee I is a civil engineer who is self-employed, primarily engaged in design work using Revit. His professional profile reflects a focus on technical design and BIM workflows, and adopts a more conventional, technically oriented approach to engineering practice rather than one driven by environmental considerations.

Interviewee II is an environmental engineer with a specialization in sustainable construction and a master's degree in civil engineering. He is a partner-owner of a sustainable architecture firm and actively integrates sustainability into their professional practice. His work involves design using Archicad, along with knowledge of

Table 3. Professional profiles of the interviewees

Interviewees	Professional qualification
Interviewee I	Civil engineer
	Self-employed professional
	Works as a designer using Revit software
	Is not involved with sustainability topics in professional practice
Interviewee II	Environmental engineer with specialization in Sustainable Construction and a master's degree in Civil Engineering
	Partner-owner of a sustainable architecture firm
	Works as a designer using Archicad and has knowledge of Revit and energy simulation software.
	Works with sustainability in professional practice
Interviewee III	Civil engineer holding a Ph.D. in Civil Engineering
	University professor invited to various institutions
	Partner and owner of a traditional construction company
	Partner and owner of a modular construction company
	Works with sustainability in professional practice
Interviewee IV	Civil engineer with specialization in Engineering Project Management and a master's degree in Civil Engineering.
	University professor
	Works as an independent designer using BIM and Revit software
	Works with sustainability in professional practice

Revit and energy simulation software, highlighting a strong command of digital tools for environmentally responsive design. His profile demonstrates a clear alignment between academic training and professional practice, with sustainability as a central component of his work.

Interviewee III is a civil engineer with a PhD in civil engineering and a university professor, invited to lecture at various institutions. In addition to his academic role, he is a partner and owner of both a traditional and a modular construction company, reflecting significant entrepreneurial activity and industry engagement. His professional activities include working on sustainability in practice and advocating for the integration of advanced academic knowledge with real-world applications, particularly across conventional and innovative construction methods.

Interviewee IV is a civil engineer with a specialization in engineering project management and a master's degree in civil engineering, currently working as a university professor. Alongside his academic responsibilities, he serves as an independent designer, using BIM methodologies and Revit. His professional practice incorporates sustainability, indicating a commitment to integrating environmental considerations into both design and project management. His profile reflects a balance between academic expertise, digital design proficiency, and sustainability-oriented engineering practice.

2.3 Data analysis and analytical categories

To analyze the interview responses, two analytical categories were defined: (i) maturity level and (ii) perception of the use of the MP. The maturity level category was used to assess the degree of conceptual understanding demonstrated by the interviewees and was classified into two levels: Good maturity and Partial maturity. Responses classified as Partial maturity were general in nature and/or contained conceptual inaccuracies, whereas responses classified as Good maturity were more specific, conceptually accurate, and demonstrated greater confidence and clarity regarding the topic. The responses from Stage 1 and the first four questions of Stage 3 of the interview protocol were analyzed using this category.

The perception of the use of the MP category aimed to evaluate whether the application of the MP in the construction sector was perceived positively or negatively by the interviewees. Responses were classified as Positive when no limitations or problems were identified; Partially positive when both challenges and positive perspectives were mentioned; Negative when the feasibility of using the MP was not recognized; and Partially negative when challenges outweighed the perceived benefits. The responses to Questions 5–12 in Stage 3 were analyzed using this category.

The interview responses were analyzed using a qualitative content analysis approach. Initially, the main researcher conducted a systematic reading of all responses and classified them according to the predefined analytical categories based on their semantic content, considering conceptual accuracy, level of specificity, and alignment with the objectives of the study. To enhance the reliability of the analysis, two secondary researchers independently reviewed the classifications. This triangulation among researchers contributed to increasing the credibility and rigor of the qualitative analysis.

3 Results

3.1 Perception of Maturity Level

Based on the responses of the interviewed professionals, it was possible to assess their level of maturity regarding the topics discussed. In Stage 1, in which none of the participants had previously been introduced to the concept of the MP or to the theoretical concepts presented by the authors, it became evident that the concept of CE (Question

1) is not well understood. In all responses, CE was limited to the idea of waste reduction, as illustrated by Interviewee I: “The issue of reuse and all forms of reducing environmental impact related to materials that encompass all stages of construction”.

Regarding the MP (Question 2), although all participants were able to express the concept, it was not entirely clear, as illustrated by Interviewee II: “One of the main objectives of the MP in construction would be awareness, information, and especially the validation of sustainability and circularity parameters of a given material.” In addition, a lack of confidence in the responses emerges, as indicated by Interviewee IV: “Honestly, I will say that I know very little about this subject. What I know comes from a lecture I once heard from a master's student in the same graduate program we attended. I would not say that it reflects what I truly understand, because I may be assuming premises that are not necessarily correct.”

On the other hand, when the topic shifts to technology and BIM (Questions 3 and 4), all participants demonstrate greater confidence and understanding, as evidenced in Interviewee III’s response: “The development of a new tool such as BIM was not designed with sustainability in mind. However, with this tool, it is possible to incorporate sustainability aspects into its use.” Interviewee IV’s response also reflects confidence and comprehension of the concepts, stating: “All the foundations of BIM, information, coordination, clash detection, data exchange, and integrated management, are fully aligned with the possibility of envisioning a more sustainable construction industry, with less impact and greater efficiency.”

In Stage 3, the authors repeated the four questions from Stage 1 (Questions 1–4) to verify whether there was progress in participants’ understanding of the topics addressed. Only Interviewee I had previously admitted not having sufficient knowledge when answering the questions in Stage 1. When analyzing this interviewee’s development, it was observed that the concept of the MP had been assimilated, as evidenced by the statement: “It is a means that enables the application of circular economy principles within the construction industry. The Materials Passport consists of a digital set of data containing information about a material. The idea is that, based on this information, the material can be directed to a new use or properly managed at the end of its life, thereby closing the loop. In this way, the more information the passport contains about a material, the better.” However, the understanding of CE remained limited to the idea of non-generation of waste, as shown in the response: “It is an economic model whose principle is the elimination of waste generation at any stage of construction processes.”

Questions 5 and 6 of Stage 3 address the relationship between technology, BIM, and circular construction. When analyzing these questions, Interviewees II, III, and IV provided more confident and assertive responses compared to Interviewee I, demonstrating a deeper and more structured understanding of how technological tools support circularity in construction. Interviewee I emphasized the role of technology mainly as a support mechanism for information management, stating that “to achieve a circular economy model, it is necessary to have information about materials, and in a sector such as construction, where products are often complex and designed to last for decades, the use of technologies and tools can greatly contribute, not only to storing but also to analyzing this information.”

In contrast, Interviewee II articulated a broader and more systemic perspective, highlighting not only the importance of technological development but also the need for organizational, educational, and regulatory alignment: “I believe it is essential to develop technologies and new tools to incorporate circularity in the construction industry. However, I only see the real feasibility of these tools within companies if there is first a broad process of awareness-raising and environmental education among stakeholders”. The interviewee further stressed that circularity requires coordinated action across the entire value chain, noting that “the circular economy does not work if only a few actors have the necessary knowledge and technology; everyone needs to understand its importance and participate for the chain to truly be circular.”

Similarly, Interviewee IV clearly linked circular construction to the effective use of technology and BIM-based methodologies, stating that “without technology and tools, the implementation of circularity concepts becomes much more complicated,” and emphasizing that while circularity begins as “a different way of thinking,” it ultimately requires “specific methodologies and techniques, making technology extremely necessary for the process.” These responses indicate a higher level of maturity among Interviewees II, III, and IV, as they connect technology and BIM not only to data handling but also to systemic change, professional practice, and the operationalization of circular construction principles. Table 4 presents the interviewees' level of understanding of the topics addressed in Stage 1 (Questions 1–4) and Stage 3 (Questions 1–6).

3.2 Perception of the Use of the Materials Passport

The analysis of Stage 3 (Questions 7–12) was conducted based on the interviewees’ perceptions regarding the use of the MP. These questions addressed the applicability of the MP in professional practice and within the design context of the Architecture, Engineering, and Construction (AEC) industry.

Interviewees I, II, and IV expressed perceptions that were classified as partially positive. Their responses indicated openness to the use of the MP, while also highlighting limitations or challenges for its practical application. For example, Interviewee I stated that “certainly, the artifact provides great benefits and makes it easier to assess the sustainability of the materials to be used,” but emphasized that sustainability in construction projects involves additional aspects beyond materials, such as “comfort and energy efficiency conditions, system performance, urban and social impact at the construction site, resource and labor optimization, [and] economic feasibility.” This type of response reflects recognition of the MP’s potential benefits alongside perceived constraints.

Interviewee II also demonstrated a partially positive perception, acknowledging the relevance of the MP while indicating that challenges related to implementation remain. Similarly, Interviewee IV recognized the potential contribution of the MP to professional practice but identified obstacles that prevent its immediate and full integration into routine workflows.

Table 4. Assessment of interviewees' maturity level based on the classification of responses as "Partial maturity" or "Good maturity" across Stage 1 (Q1–Q4) and Stage 3 (Q1–Q6)

		Interviewee I	**Interviewee II**	**Interviewee III**	**Interviewee IV**
Question		**Stage 1**			
Understanding the concept of EC	Q1	PARTIAL	PARTIAL	PARTIAL	PARTIAL
Understanding the concept of PM	Q2	PARTIAL	PARTIAL	PARTIAL	GOOD
Understanding of technology for sustainable constructions	Q3	PARTIAL	GOOD	GOOD	GOOD
Understanding of BIM technology for sustainable construction	Q4	GOOD	GOOD	GOOD	GOOD
		Stage 3 – Q1 to Q6			
Understanding the concept of EC	Q1	PARTIAL	PARTIAL	PARTIAL	PARTIAL
Understanding the concept of PM	Q2	GOOD	PARTIAL	PARTIAL	GOOD
Understanding of technology for sustainable constructions	Q3	PARTIAL	GOOD	GOOD	GOOD
Understanding of BIM technology for sustainable construction	Q4	GOOD	GOOD	GOOD	GOOD
Understanding of technology for circular construction	Q5	PARTIAL	GOOD	GOOD	GOOD
Understanding of BIM technology for circular construction	Q6	PARTIAL	GOOD	GOOD	GOOD

In contrast, Interviewee III expressed a perception classified as negative regarding the use of the MP. This interviewee emphasized the complexity of the MP and the effort required to compile and manage the associated information, stating that "the MP is complex and requires a lot of time to make use of this information and compile all the data." The interviewee further noted that such demands do not align with the current dynamics of the construction industry, highlighting limitations related to available time, human resources, and the scale of material information involved: "there are no resources available to dedicate time to information such as embodied energy via MP in a universe of three thousand different types of materials."

Across all interviews, references were made to barriers associated with the use of the MP. These included difficulties related to data collection, availability, structuring, and organization, as well as constraints related to time and financial resources. Table 5 summarizes the interviewees' perceptions of the use of the MP, classified according to the predefined analytical categories.

Table 5. Interviewees' perceptions of the use of the Materials Passport based on Stage 3 (Questions 7–12)

		Interviewee I	**Interviewee II**	**Interviewee III**	**Interviewee IV**
Questions		**Stage 3 – Q7 to Q12**			
Applicability of the artifact in professional practice	Q7, Q8	PARTIALLY POSITIVE	PARTIALLY POSITIVE	NEGATIVE PERCEPTION	PARTIALLY POSITIVE
Applicability of the artifact in the practical design of the AEC industry	Q9, Q10, Q11, Q12	PARTIALLY POSITIVE	PARTIALLY POSITIVE	NEGATIVE PERCEPTION	PARTIALLY POSITIVE

4 Discussion

The responses from construction professionals raise relevant discussions about the applicability of the MP, which are not addressed in the tool's practical development. First, the questions from Stage 1 reveal that the interviewees have only a superficial understanding of the definitions of CE and MP, although they recognize the importance of technology and BIM in this context. This limited baseline awareness directly influences the perceptions expressed throughout the interviews, as initial evaluations of the MP may partially reflect conceptual uncertainty rather than a fully informed assessment of the tool itself. When the Stage 1 questions were repeated at the beginning of Stage 3, it was observed that only the interviewee who does not work directly with sustainability was able to advance in the understanding of the concepts presented. Thus, tools applicable to CE in construction, such as the MP, must be accompanied by greater awareness of CE, MP, and sustainability concepts within the sector, so that professional perceptions are based on a clearer understanding of the proposed approach.

The analysis of questions five and six from Stage 3 indicates that the interviewees generally recognize technology and BIM as essential enablers for implementing the MP and supporting the transition from a linear to a circular model. These elements are seen as enablers that can accelerate the process, and they are not the main limitation factor, at least at a conceptual level. However, when considering questions seven and eight, the perceptions shift toward the limited feasibility of introducing the MP into professional practice, particularly in large-scale project. In this context, it is important to note that part of this perceived infeasibility may also be related to the interviewees' limited prior exposure to CE and MP concepts, which affects how they interpret the tool's potential and limitations. The interviewed designers acknowledge the relevance of the MP but do not perceive its full applicability, identifying several stages that must be overcome before its direct implementation. The contractor's representative, in turn, does not see how the tool can be incorporated, as it would require time and financial resources that the market currently lacks. These differences indicate that professional role and prior experience shape how the MP's potential and limitations are interpreted.

The responses to questions nine through twelve highlight that the main obstacle lies in data collection. First, the artifact suggests a manual data-gathering process; additionally, such data are not widely available in the market. These limitations were perceived both as technical constraints of the MP and as challenges related to the broader context in which the tool would be applied, particularly given the interviewees' varying levels of conceptual maturity regarding CE. Preliminary issues must be resolved before the tool can be effectively used. Questions such as: "At which stage of the design workflow should the MP be used?"; "How can the MP be integrated with other sustainability tools (such as energy efficiency analyses)?"; "Will the MP technology simplify or increase bureaucratic workload in professional practice?" raised from the interviewees' responses and indicate the need for continued research on CE and MP in the construction sector, since the present study did not aim to answer them. Problems related to the use of the MP in professional practice therefore extend beyond the artifact itself and are also associated with the current level of awareness and systemic organization of the construction industry. Consequently, isolated solutions may mitigate part of the problem, but they are unlikely to fully resolve it. As a recommendation, cooperation among governmental decisions, regulations, and market actors is essential for tools like the MP to have a practical impact on everyday construction workflows.

Another important point highlighted in Stage 3 was financial cost. One of the obstacles to adopting the MP in design practice is the process's monetization. On one hand, time and financial resources are limited, and work must remain productive, especially for construction companies. On the other hand, building users must understand the relevance of sustainability, CE, and the MP to be willing to pay for these concepts and services, which is not yet a market reality. This reinforces the argument that professional perception of the MP is closely linked not only to its technical characteristics, but also to the broader dissemination of CE-related concepts within the sector. Nevertheless, environmental certifications such as LEED (Leadership in Energy and Environmental Design), BREEAM (Building Research Establishment Environmental Assessment Method), and AQUA-HQE may encourage the use of such solutions, by providing market-driven incentives for the adoption of tools that support sustainability assessment.

Finally, Stage 3 suggests that more sustainable practices, including those related to circularity, are already present on the professional agenda. However, the effective application of these practices remains conditioned by both systemic constraints and the current level of conceptual awareness within the Brazilian construction context, indicating that broader educational and institutional efforts are necessary alongside the development of technological tools.

5 Conclusion

This study contributes to the literature by providing an empirical assessment of construction professionals' perceptions of a BIM-based Materials Passport in the Brazilian context, highlighting how baseline conceptual maturity and systemic industry conditions shape the evaluation and potential adoption of circular economy tools. The research was conducted to bring professionals closer to CE and the MP, and, through this approximation, advance investigations into the tool. Moreover, the interview responses, used to validate the artifact, revealed the MP's flaws and shortcomings, whether as a concept or in its practical application.

Based on the interviewees' responses, it is possible to propose that the implementation of the MP still faces challenges in the AEC sector. Despite the importance of the tool for the transition from a linear economy to a circular one [7], modeling processes and information management still need to evolve to achieve market applicability. Other issues were identified, including the need for training in sustainability in the built environment, as well as the integration of additional sustainable and circular practices into the market. The findings indicate that professional perception of the MP is strongly mediated by baseline awareness of CE concepts and by systemic conditions of the construction sector.

This study presents limitations to consider. First, the number of interviewees is not significant and, consequently, does not determine how the Brazilian construction sector understands CE and the MP. The answers obtained in the interview protocol are qualitative and do not represent the broader context of the Brazilian construction industry. However, the protocol provides a foundation for future research to obtain increasingly robust results. In addition, the

MP was developed independently of international open standards. New development cycles are required to incorporate standardized data structures into the MP.

The main findings of this qualitative analysis, considering the entire research (including Alves (2025) [18]), highlight the need to improve materials data management within the construction sector. Future studies may further advance automation in the MP modeling process, particularly by enhancing materials data collection through the use of artificial intelligence (AI). As indicated by the interviewees, the perceived unfeasibility of the MP is strongly associated with limitations of time and financial resources; in this context, technological solutions can play a key role in streamlining routine processes and facilitating data collection. Therefore, the integration of digital automation and intelligent data management emerges as a critical pathway for increasing the practical viability of the MP in professional practice.

CRediT authorship contribution statement

Conceptualization, G.F.A., M.R.M. and S.F.T.; Data curation, G.F.A.; Formal analysis, G.F.A.; Funding acquisition, S.F.T.; Investigation, G.F.A., M.R.M. and S.F.T.; Methodology, G.F.A., M.R.M. and S.F.T.; Project administration, S.F.T.; Resources, S.F.T.; Software, G.F.A.; Supervision, M.R.M. and S.F.T.; Writing - original draft, G.F.A.; and Writing - review & editing, G.F.A., M.R.M. and S.F.T. All authors have read and agreed to the published version of the manuscript.

Conflict of Interest

The authors declare no conflicts of interest.

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